Mangaheka

Integrated Catchment Management Plan

Hamilton City Council
Te kaunihera o Kirikiriroa

Version 4.0 – January 2019

Revision No	Date	Status	Approved (Stormwater)	TRIM link to authorisations
1.0	Feb 2018	Draft for targeted consultation		
2.0	Sept 2018	Final for issue to Waikato Regional Council		
3.0	Dec 2018	Revision following WRC comments		
4.0	Jan 2019	Incorporating WRC comments		

Mangaheka Integrated Catchment Management Plan

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ABBREVIATIONS

ARI = Average Recurrence Interval (Rainfall event)

CSDC = Comprehensive Stormwater Discharge Consent

WRC= Waikato Regional Council (formerly Environment Waikato)

GEC = Guardian Establishment Committee - Vision and Strategy

GRMP = Gully Reserves Management Plan

ICMP = Integrated Catchment Management Plan

ITS = Infrastructure Technical Specifications

LOS = Levels of service

ODP = Hamilton City Operative District Plan

Proj Water = Waikato River Catchment Services – Level of Service and Funding Policy (Project Watershed)

RPS = Regional Policy Statement

RRMP = Riverside Reserves Management Plan

SP = Structure Plan

Sust Strat = Hamilton City Council Environmental Sustainability Strategy

SWMP = Stormwater Management Plan

WDC= Waikato District Council

WRA = Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act

Executive Summary

This Integrated Catchment Management Plan (ICMP) provides guidance on how stormwater, wastewater and water supply need to be managed considering future landuse in the Mangaheka catchment, specifically the impacts from urbanisation. The document has been developed utilising commissioned technical studies which include assessments of the catchments' flood carrying capacity, water utilities infrastructure, ecology, stream morphology and erosion, and water quality.

Catchment Description

The greater Mangaheka catchment covers an area of approximately 2,080ha with around 86% of the catchment (the "lower catchment") being within the Waikato District Council boundaries and the remaining 14% (the "upper catchment") being within Hamilton City Council boundaries. Hamilton City Council is required to control the effects of landuse within its city boundaries and manage any effects of these activities on adjacent territories.

The Mangaheka Stream comprises modified watercourses in the upper catchment as well as in roughly the upper half of the lower catchment, with the Tangirau Wetland present in the lower half. The upper catchment area is generally flat-lying and represents one of the higher parts of the catchment. From this area the topography slopes generally to the northwest towards the Waipa River which then joins the Waikato River.

The land use within the catchment is predominantly rural in nature (mainly dairy farming or grazing) with commercial / light industrial development in part of the upper catchment. On-going development of the upper catchment will replace rural land with light industrial and commercial land uses.

Catchment Issues and Mitigation Measures

General and catchment specific issues and objectives have been identified for the management of stormwater, wastewater and water supply and are provided in Section 3 (Issues and Objectives) of this report. For each of these issues, this ICMP identifies a number of management options. The options are evaluated to identify their suitability and a Best Practicable Option (BPO) is developed. The full list of BPOs is provided in Sections 4 (Stormwater Management) and 5 (Water and Wastewater Management). Assessment of the water supply and wastewater infrastructure, both existing and proposed to serve the Mangaheka Catchment have sufficient capacity to service the anticipated development of the catchment.

A summary of the catchment issues identified in the ICMP and the measures to be implemented in order to mitigate their effects is provided below:

Flood Carrying Capacity

1D flood modelling of Mangaheka Stream catchment was undertaken to assess the effects of development on stream flood levels, peak flows and flooding duration and to size attenuation devices to mitigate these effects. The results of the modelling show that four attenuation devices with a total combined volume of approx. 110,000m^3 will be sufficient such that there are no more than minor increases in water levels and peak flows downstream, in up to a 100 year rainfall event.

Overland flow paths (OLFP's) have been considered in three main locations, which are anticipated during high water flows, two of which enlarge the contributing catchment. These locations are: discharge from Mangaheka Stream to the Te Otamanui catchment; discharge from the Rotokauri catchment into Mangaheka Stream; and potential breaching of the stream banks downstream from Porters Wetland. These OLFP's require consideration during the development of the respective land on which these flow paths are located. No primary stormwater from the Mangaheka catchment enters the Te Otamanui catchment at the current time, however this overland flow path could be properly commissioned (ensuring clear and appropriate sizing of drainage channels downstream) for partial overflow/diversion downstream of Device 6. This is discussed further in Section 2.6.6 (Overland flow).

In order to maintain the flood-carrying capacity; Operations and Maintenance Plans for devices shall recognise the flat gradient of the upper catchment channels and ensure downstream restrictions (due to e.g. weed growth or sediment deposition) are identified and removed on an on-going basis. This will maintain hydraulic capacity and control water depth to allow plant growth in the upstream devices.

On lot stormwater reuse is required for all industrial/commercial developments to assist in managing peak flow downstream water levels

Parameters have been defined to direct stormwater management requirements during development. These are described in Section 6.4 Design Parameters and Section 6.5 Means of Compliance.

Future actions and opportunities have also been identified and will be assessed for inclusion in ongoing Council programmes and subsequent 10 year Plans and 30 Year Infrastructure Strategy.

Summary
Increases in flows, stormwater discharge volumes and stormwater drainage pathways could potentially lead to increased flooding.

Key mitigation measures include:

- Centralised devices to manage the stormwater volumes anticipated with no more than minor increase in downstream peak flows and water level results.
- Peak flow is generally required to 70% of the pre-development rate
- Reduce impervious surfaces as far as practical to manage volume increase
- Secondary overland flow paths need to be considered during the design of developments
- Rainwater re-use tanks plumbed into on-lot non-potable water systems are required for volume control (in addition they provide potable water reduction benefits)
- Maintenance Plans for devices shall recognise the flat gradient of the upper catchment and ensure downstream restrictions are removed to maintain hydraulic capacity and control water depth
- Re-connection of Te Otamanui Stream to be investigated

Water Quality and Contaminant Removal

The Mangaheka stream has been identified as having poor overall water quality. This mirrors the condition of other urban streams in the Hamilton City area. Nonetheless, some important native species of fish have been identified in the stream including the banded kokopu, the long fin and short fin eels and black mudfish, giving the stream ecological significance under the provisions of the Regional Policy Statement.

However, the expected water quality of the industrial stormwater discharges from future development is likely to be improved for nutrients and sediment, maintained for zinc, and slightly degraded for copper but within the tolerances of the aquatic species present (Boffa Miskell, 2018).

New wetlands are proposed to provide the greatest potential for treatment of the anticipated contaminants. In addition, on-lot contaminant removal and treatment can be used to form a treatment train approach to reduce impacts on stormwater quality. Within the industrial area in the upper catchment, four stormwater management devices are currently under construction and a further four are proposed to be developed. Individual sub-catchments have different requirements for pollution control which reflect: the presence or otherwise of a proposed downstream centralised device; or the presence of an existing downstream centralised device.

Individual pollution control plans will be required for sites with high risk activities[1]. Details of the requirements for each sub-catchment and any stormwater management devices are provided by the Design Parameters and Means of Compliance with this ICMP.

Summary
Change in landuse from rural to commercial / light industrial is anticipated to lead to increased/changes in contaminant loads in stormwater with potential knock-on effects for aquatic habitats and species

Key mitigation measures include:

- Water quality and contaminant removal needs to be managed by a combination of centralised and on-lot devices (treatment train approach)
- Retro-fitting existing centralised devices with litter traps and hydrocarbon exclusion on outlets is to be considered
- Pollution control plans are mandatory for developments ‘high risk activities’ (as per Appendix M)
- No exposed zinc or copper building products
- Programme of works will enhance conditions that will encourage and support important native species of fish and other aquatic species

Stream Erosion/Watercourse Management

Localised erosion has been identified on stream banks in various locations within the Mangaheka Stream, downstream of the upper catchment area. The erosion identified is in the form of bank slumping and undercutting. The undercutting is considered to be caused by erosion of over-steep bank sides from water flows during storm events and this is contributing to the degradation of the banks which are also affected by this is contributing to the degradation of the banks which are also affected by stock access and fencing installed too close to the bank crest.

To manage this existing erosion together with the anticipated stormwater flow associated with Maximum Probable Development

[1] High risk activities are those which have the potential to generate contaminants which can cause harm to natural systems such as aquatic ecology - see Appendix M and F.

(MPD), targeted remediation works are required with localised erosion protection and battering of banks to a shallower angle, placement of stock fencing at an appropriate distance from the bank crest and a programme of riparian planting to assist improving of long term bank stability. A concept programme of works has been recommended to stabilise the banks together with maintenance and monitoring in the long term. The implementation and cost share is to be agreed between Waikato Regional Council, Hamilton City Council, Waikato District Council and relevant landowners, and discussions around this have been started.

A restoration vision has been prepared by Boffa Miskell in 2012, to reflect a long term vision of the catchment and any erosion mitigation works will need to align with the intent of the vision. This is included in Appendix L.

Summary
Increases in peak flows/velocity and stormwater volumes/ flow duration could potentially lead to erosion downstream

Key mitigation measures include:

- Reduce impervious surfaces as far as practical to manage volume
- Rainwater re-use tanks plumbed into on-lot non-potable water systems
- Erosion protection works targeting current identified areas of erosion
- Stock fencing and riparian planting to reduce future erosion risk
- Where matching pre-development runoff volume through reduced runoff practices and sub catchment management stabilisation and/or a financial contribution for downstream erosion prevention works

Conclusion

Implementation of the above is considered to result in no significant cumulative downstream effects on the Mangaheka Catchment.

This ICMP is intended to be consistent with central and regional government policies, plans and resource consents, and Hamilton City Council policies and plans. Non-statutory policy and planning documents have also been considered during the development of this document. It is recognised that policy and legislative requirements are evolving in the Waikato and this ICMP has been developed with provisions included which are intended to address the requirements of near-future changes (such as Healthy Rivers Plan Change 1) as well as identifying future actions intended to capture other policy changes currently anticipated. This ICMP and its provisions will require periodic review in order to maintain relevance with future legislation and policy developments.

The ICMP encompasses best practice stormwater management in the Mangaheka catchment as recommended in Hamilton City Council's Infrastructure Technical Specifications (ITS) and in the context of the existing strategic legislative framework. Implementation of the guidance provided in this ICMP is considered to result in no significant cumulative downstream effects on the Mangaheka Catchment. Future changes or updates to external drivers and best practice will be considered in reviews of the ITS and any subsequent reviews of this ICMP.

1 Introduction

1.1 Purpose

This ICMP covers the Mangaheka catchment which comprises approximately 2,080ha of land which straddles the boundary of Hamilton City Council and Waikato District Council. The upper catchment lies within the City Council boundary and the majority of this area is part of the Rotokauri Structure Plan which indicates that much of the upper catchment is designated for industrial development. The lower catchment is within the District Council boundary and comprises predominantly agricultural land. The lower catchment also lies within the boundaries of both the Waipa zone management plan and the Central Waikato zone management plan implemented by Waikato Regional Council.

This ICMP also includes reference to the neighbouring Te Otamanui sub-catchment which comprises approximately 500ha of predominantly farmland lying along the southern boundary of the Mangaheka catchment and includes the Te Kowhai village. The Te Otamanui sub-catchment was previously connected via a small stream channel feeding from the upper Mangaheka catchment. This connection is no longer present and an initial feasibility study has been completed assessing the potential for reconnecting the catchments to divert some flow from Mangaheka to Te Otamanui in the future. This option is referred to within this ICMP and modelling work is underway to assess its feasibility. This is being undertaken as a future action to this ICMP.

This ICMP and its prescribed best practicable options predominantly focuses on managing urbanisation effects of development area under Hamilton City Council jurisdiction, however, due to the extent of the catchment area some best practicable options extend into Waikato District Council territory and therefore development in this area should recognise these options.

The purpose of this ICMP is:

a. To provide an integrated management approach based upon the best practicable option(s) to avoid as far as practicable and otherwise minimise the cumulative adverse effects of all stormwater discharge activities in this developing catchment.
b. To comply with relevant regulatory requirements including those associated with:
    - The Hamilton City Council District Plan
    - The comprehensive stormwater discharge consent (CSDC) number 105279 issued by Environment Waikato (now called Waikato Regional Council).
    - Rotokauri Structure Plan (RSP)
    - Waikato Regional Policy Statement
    - Waikato Regional Plan
    - Vision and Strategy for the Waikato River
    - Heathy Rivers Wai Ora

c. To provide guidance[2] on how water, wastewater and stormwater management in the catchment can accommodate growth in an integrated manner and in accordance with proposed new land uses.
d. To ensure that the level of Service (LoS) of the existing three water networks and the Waikato Regional Council administered drainage area are not compromised and to provide a platform for considering the implementation of water sensitive devices to reduce demand for water, minimise wastewater generation and minimise need for three water infrastructure where appropriate.

The duration of this ICMP is the “planning horizon” of the Rotokauri Structure Plan which considers development over the next 30 years. However, the ICMP will necessarily extend beyond the full development of the Structure Plan area to allow for on-going decision making on management and maintenance of water, wastewater and stormwater infrastructure, and to allow for connectivity to adjoining land and catchments. As discussed in Section 8.5, this ICMP is to be reviewed periodically to ensure that it remains relevant. The means of compliance should also draw on best practice and consider the results of any ongoing monitoring and changes within the catchment, the ITS and any strategic or legislative changes driving stormwater management in the Region.

Development of this ICMP has been led by Hamilton City Council with content contributions from Waikato District Council. The Waikato District Council process for dealing with cross boundary issues is described in the Waikato Operative District Plan Chapter 17[3].

In accordance with Condition 30 of the CSDC, Table 1-1 shows where each requirement is addressed within this document. The CSDC is included in Appendix J.

[2] Guidance from this plan is generally to developers, internal HCC Units (City Waters, City Transport, City Planning, Parks and Open spaces, City Development) and regulators (HCC Planning Guidance Unit, Waikato Regional Council and Waikato District Council officers).

[3] https://www.waikatodistrict.govt.nz/Documents-Library/Files/Documents/District-Plan/Waikato-District-Plan/Chapters/Chapter17_LocalAuthorityCrossBoundaryIssues.aspx

Table 1-1: Comprehensive stormwater discharge consent checklist

Condition 30	Status
In accordance with Condition 3(c) of this consent (CSDC), Catchment Management Plans which are prepared to guide new stormwater diversion and discharge activities in developing catchments shall be to a standard acceptable to the Waikato Regional Council and shall be submitted to the Waikato Regional Council for written approval in a technical certification capacity, prior to the establishment of these activities. Catchment Management Plans shall determine and recommend an integrated catchment management approach which is 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.	The Mangaheka ICMP has been developed to provide an integrated approach to the management of stormwater in the catchment. The ICMP contains BPOs aimed to give effect to Strategic Objectives identified as applicable to the catchment.
As a minimum, catchment management plans shall include the following information:	
a) Catchment maps/drawings of the catchment delineating the catchment boundary, catchment topography, natural features, surface water bodies, existing drainage systems and infrastructure (if any) and current land uses;	Maps relevant to the catchment have been developed and are included within the ICMP document.
b) Classification of the surface water bodies within the catchment as detailed in the Waikato Regional Plan;	Provided in Section 2 (catchment Description), specifically Section 2.3.2 (Watercourses) and Figure 2-5 : Mangaheka waterway classification)
c) A description of the social, economic, ecological, amenity and cultural objectives being sought for the catchment (likely to stem from a concurrent structure planning process);	The strategic objectives relevant to the catchment are provided in Section 1.7 (Strategic Objectives). A description of the social, economic, ecological, amenity and cultural values as relating to these objectives is included in Section 2.4 (Values).
d) A description of proposed urban growth, development and land use intensification within the catchment;	Provided in Sections 2.2.3 (Proposed land-use) and 2.2.4 (Major transport links)
e) A list of the key stakeholders associated with the catchment, and details of their respective views on providing for new stormwater diversion and discharge activities within the catchment;	Provided in Section 7 (Consultation). This also includes details of all other internal and external stakeholders.
f) An assessment of the current status of the catchment and its environs, together with a description of the geological, hydrological, ecological and existing infrastructural characteristics of the catchment, including any existing resource use authorisations within the catchment;	Provided throughout Section 2 (Catchment Description).

Condition 30	Status
g) An assessment of the environmental effects of all new stormwater diversion and discharge activities on the catchment, in such detail as corresponds with the scale and significance of the effects that these activities will have on the catchment, including but not limited to, effects on: i) Natural features, surface water bodies and aquifers, ii) Sites of cultural and/or historical significance, iii) Public health, iv) Flooding hazards, v) Receiving water hydrology, including base flows and peak flows in rivers and streams and long-term aquifer levels, vi) Receiving water sediment and water quality, vii) Receiving water habitat, ecology and ecosystem health, viii) Receiving water riparian vegetation, ix) The extent and quality of open stream channels, x) Fish passage for indigenous and trout fisheries (refer to the Waikato Regional Plan Water Management Classes for applicability), xi) Natural and amenity values, xii) Existing infrastructure, xiii) Existing authorised resource use activities;	Provided in the Mangaheka ICMP Assessment of Environmental Effects (AEE) provided in **Appendix F** and referenced in Section 2 (Catchment Description).
h) An assessment of the cumulative environmental effects of all new stormwater diversion and discharge activities on the catchment over time;	Provided in the AEE provided in **Appendix F**
i) In response to the environmental effects assessment information, an assessment of the available management options (including Low Impact Urban Design measures and stormwater management devices), for all new stormwater diversion and discharge activities within the catchment.	The assessment of available management options is provided in Section 4 (Stormwater Management).
j) Recommendations on an integrated catchment management approach which is based upon the Best Practicable Option to avoid as far as practicable and otherwise minimise actual and potential adverse effects of all new stormwater diversion and discharge activities on the catchment;	BPOs and the integrated management approach are described in Sections 3.5 (Operational Objectives), Section 4 (Stormwater Management), 5 (Water and Wastewater Management) and 6 (ICMP Implementation)

Condition 30	Status
k) A description of proposed education and promotion initiatives to be carried out by the Consent Holder to support the integrated catchment management approach recommended by the Catchment Management Plan.	Initiatives and options for education related to the ICMP is provided in Section 6.1 (Implementation Methods) and Section 6.6 (Future Actions).
l) A description of key infrastructure works to be carried out by the Consent Holder to support the integrated catchment management approach recommended by the Catchment Management Plan;	Planned infrastructure works are detailed in Section 2.5 (existing Utilities and Network), Section 3.3 (Key Operational Issues – Water) and Section 0 (Key Operational Issues – Wastewater).
m) A prioritised infrastructure works schedule for implementing the integrated catchment management approach recommended by the Catchment Management Plan;	Prioritised infrastructure works are described in Section 6.6 (Future Actions).
n) A list of performance measures by which the implementation of the integrated catchment management approach recommended by the Catchment Management Plan will be gauged.	Performance measures are provided in Section 6.4 (Design Parameters) and Section 6.5 (Means of Compliance)
Any approved Catchment Management Plan that needs to be updated following changes to the integrated catchment management approach recommended by the Catchment Management Plan, shall be reviewed, updated and submitted to the Waikato Regional Council for approval in a technical certification capacity, prior to any such changes being implemented within the associated catchment.	
Advice Note: It is recognised that Catchment Management Plans may also include information that provides for the integration of municipal water and wastewater services. Such information and the integration of these services are generally encouraged by the Waikato Regional Council, particularly where they result in environmentally sustainable catchment management outcomes.	Three Waters Management is considered throughout the ICMP

1.2 Strategic Context

Development within the catchment is influenced by central and regional government policies, plans and resource consents, Hamilton City Council policies and plans and WDC policies and plans. Most policies and rules ultimately flow out of the Regional Policy Statement (RPS) which is given effect through planning documents such as District Plans and Regional Plans. The RPS also reflects iwi aspirations for the region and National Policy Statements.

The ICMP relies on the current best practice stormwater management in the context of the existing strategic and legislative framework. Any changes to these external drivers will be considered in the future reviews of the ICMP and Hamilton City Council's ITS to maintain alignment of objectives.

Key planning documents relationships for catchment management planning are shown in Figure 1-1.

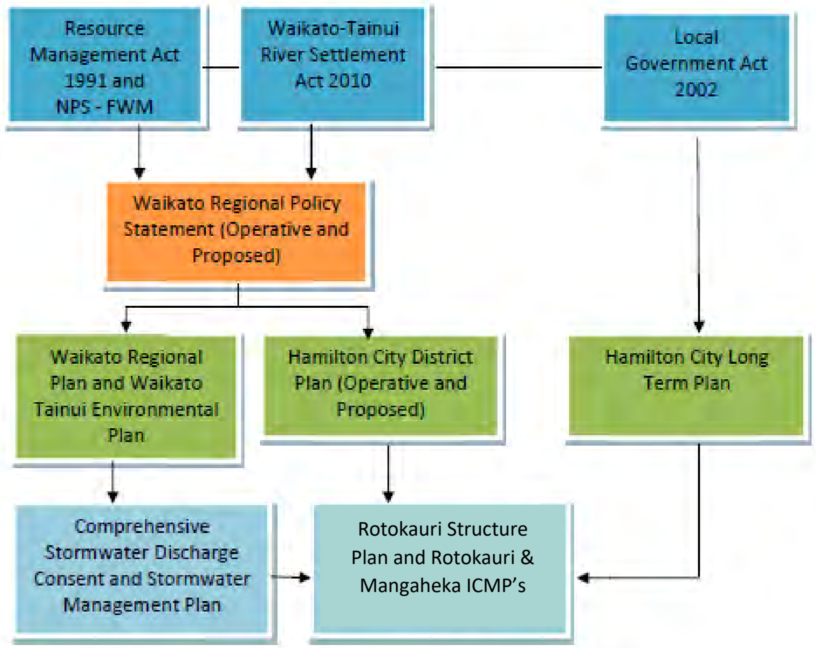

Figure 1-1: Key documents for planning

1.2.1 Legislation

The following legislation informs and guides the requirements for this ICMP.

National Legislation:

- Resource Management Act – specifically Section 15 of the Act includes controls on the discharge of contaminants into the environment, including from stormwater, and states that no person may discharge any water into water or onto land unless the discharge is expressly allowed for in a national environmental standard, regional plan or resource consent.
- Waikato-Tainui Raupatu claims (Waikato River) Settlement Act 2010. A co-management agreement was signed between Waikato Raupatu River Trust (Waikato-Tainui) and Waikato Regional Council. The agreement clarifies a range of factors and acknowledges Integrated Catchment Management requires coordination and collaboration between each Party's respective planning documents and implementation processes.
- Nga Wai o Maniapoto (Waipa River) Act 2012. The overarching purpose of the Act is to restore and maintain the quality and integrity of the waters that flow into and form part of the Waipa River for present and future generations and the care and protection of the mana tuku iho o Waiwaia.

Regional Policy:

- Waikato Regional Policy Statement (operative). This document provides an overview of the resource management issues of the region, and the ways in which integrated management of the region's natural and physical resources will be achieved.
- Waikato Regional Plan - The Waikato Regional Plan contains issues, objectives, policies and rules, relating to the discharge of stormwater into water and the discharge of stormwater onto or into land.
- The Healthy Rivers Wai Ora proposed Waikato Regional Plan Change 1 seeks to reduce the amount of contaminants entering into the Waikato and Waipā catchments to achieve the Vision and Strategy / Te Ture Whaimana o Te Awa o Waikato of making the river swimmable and viable for food collection along the entire length of the river. The proposed plan change is not currently in place, however the ICMP needs to include provisions which reflect its requirements and intent.

Local policy:

- Hamilton City District Plan - defines the way in which the city's natural and physical resources will be managed to achieve the purpose and principles of the RMA. The Provisions of the plan generally set maximum levels of building coverage, minimum permeable surface areas and water efficiency measures. The plan, together with the Council's Infrastructure Technical Specifications (ITS), are vital tools for managing development within the Mangaheka catchment.

- Waikato District Plan - Most of the Mangaheka catchment in the Waikato district area is subject to a Strategic Agreement (2005) that will see a boundary change transferring it into Hamilton City Council's jurisdiction in 2045 unless agreed differently. This land is included within an Urban Expansion Policy Area prohibiting urbanisation to prevent fragmentation that would hinder future urbanisation. It is expected that this would need to be informed by an updated ICMP. Waikato District Council have commenced a review of the district plan.

- Waikato River Authority Vision & Strategy. The Vision and Strategy for the Waikato River has been developed by the Waikato River Authority and lays out a set of thirteen objectives aimed to prevent further degradation of the Waikato River and improve water quality, associated environmental conditions and wellbeing of the river.

1.3 Waikato Regional Council - Resource Consent Compliance

The Comprehensive Stormwater Discharge Consent (CSDC) issued and administered by Waikato Regional Council for the urban catchments within Hamilton City authorises stormwater activities in new developments/growth areas, where these activities accord with an approved Construction Management Plan, where they have been transferred to Hamilton City Council and meet requirements of any approved ICMP. Hamilton City Council's water take consent has requirements for water demand management and Hamilton City Council's wastewater discharge consent requires network management to avoid events such as wastewater overflows.

1.4 Regional Council – Land Drainage

The strategic intent of land drainage activity is set out in Waikato Regional Council's Long Term Plan 2012 – 2022[4]. Effective land drainage is provided by maintaining a land drainage network that allows landowners the ability to manage water table on their properties, and that reduces surface flooding resulting from significant rainfall events.

1.5 Three Waters Master Planning and Integration

Three waters means the three key areas of strategic water management (including associated infrastructure) within the City – comprising water supply, wastewater and stormwater. The term 'Three waters integration' is recognition that there is a strong interaction between all three types of waters, natural water systems and land and that they need to be managed sustainably and in an integrated way to ensure the availability of services to growth areas and protection of the environment for future generations.

[4] This was the LTP which was reviewed at the time of document drafting

Application of BPOs must strongly consider Hamilton City Council's established hierarchy for the management of the three waters as follows:

Minimise Demand (water, wastewater) ➔ **Reuse** (stormwater) ➔ **Treat & Dispose to Ground** (stormwater) ➔ **Treatment & Detention** (stormwater) ➔ **Reticulation** (stormwater, wastewater)

Hamilton City Council has adopted this best practice hierarchy, based on sustainability, cost and efficiency principles. This is reflected within the Hamilton District Plan and Infrastructure Technical Specifications [5].

The ideal stormwater management system for a developed site is one that replicates the undeveloped scenario. A range of water sensitive techniques[6] are available to minimise the impact of development and enhance the environment.

Integration of the water supply and stormwater system is most easily achieved by rainwater tanks. 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 is noted that all new urban premises in the Waikato District are no longer required to have a rain tank under the Waikato District Council Water Supply Bylaw. Rural properties are still required to have a tank with a minimum size of 22,000 litres or equivalent to at least 48 hours storage, whichever is greater. This is relevant as the majority of the Mangaheka catchment is within the Rural Zone of the Waikato District Plan.

It is also noted that developers with sites located within the catchment, including Porter Properties Ltd (PPL) and Te Rapa Gateway Ltd (TGL), have provided input to the development of three waters planning via liaison with Hamilton City Council and WRC.

1.6 Additional Strategic Considerations

Development within the Mangaheka catchment is influenced by central and regional government policies, plans and resource consents, Hamilton City Council policies and plans and Waikato District Council policies and plans. The following table (**Table 1-2**) provides a list of some of the key source documents that have been reviewed / updated during the development of this ICMP. During the implementation of the ICMP, (and in future review for the ICMP) Hamilton City Council will need to consider and take cognisance of these changes.

[5] Previously referred to as Development Manual

[6] Refer to the definition in Hamilton District Plan Vol 2 Appendix 1.1.2, the Infrastructure Technical Specifications and the Three Waters Management Practice Notes for more details

Table 1-2: Key source documents

Document Title	Date / Version
Hamilton Urban Growth Strategy	April 2010
Waikato River Authority Vision & Strategy	July 2011
National Policy Statement for Freshwater Management	Sept 2017
WRC Waikato Regional Policy Statement	May 2016
WRC Waikato Regional Plan	April 2012
Proposed Waikato Regional Plan Change 1	Dec 2016
Sub Regional Three Waters Strategy	Sept 2012
Hamilton City Council Operative District Plan	Sept 2017
Waikato Tainui Environmental Plan	Sept 2013
Hamilton City Council Comprehensive Stormwater Discharge Consent (#105279)	June 2011
ICMP Consultation Feedback	June 2018
Future Proof Strategy, Planning for Growth	Nov 2017

1.7 Strategic Objectives

One of the purposes of ICMPs is for Hamilton City Council to define and set objectives for its catchments. Common strategic objectives have been set across all catchments within the Hamilton City Council jurisdiction (refer to **Table 1-3**). Strategic objectives for integrated catchment management planning have been developed referencing the Hamilton City Council Objectives and Targets for Integrated Catchment Management Plans.

Table 1-3: Strategic objectives for all Hamilton City Council ICMPs

Ref No.	Strategic Objectives
SO1	<u>Protect freshwater systems</u> Maintain, protect and enhance freshwater ecosystems and natural drainage systems by safe guarding the life-supporting capacity, improving water quality where degraded and protecting significant values of wetlands and outstanding freshwater bodies.
SO2	<u>Protect terrestrial systems</u> Maintain, protect and enhance indigenous biodiversity values and functions for terrestrial ecosystems and protect significant habitat of indigenous fauna.
SO3	<u>Kaitiakitanga</u> Give effect to the relationship of tangata whenua as kaitiaki of receiving water bodies and including the relationship of Waikato-Tainui with the Waikato River.
SO4	<u>Stormwater Management</u> Stormwater management related to land use and development shall encourage and enable low impact design, reduce impermeable surfaces where possible, utilise on-lot treatment devices to reduce reliance on downstream devices, and incorporate best practicable mitigation measures to minimise actual and potential adverse effects on: • Receiving water bodies in terms of quantity and quality of stormwater discharges, • Locations and communities subject to flood hazards, • Natural groundwater levels, • Baseflows for freshwater systems.

Ref No.	Strategic Objectives
SO5	Wastewater Management Wastewater management shall incorporate best practicable options and be managed so that: • Conveyed network volumes are minimised, (e.g. by demand management and management of stormwater infiltration) • Dry weather overflows are prevented and wet weather overflows are minimised.
SO6	Potable Water Management Water supply is planned and provided for in a way that meets existing and future requirements to: • Provide firefighting water supply (flow and pressure) by conforming to the Code of Practice for Fire Fighting Water Supplies. • Meet domestic, commercial and industrial water demand. • Ensure water consumption is managed to minimise peak and total demand.
SO7	Three Waters Management Three waters networks are planned, managed and operated in an integrated manner to: • Meet existing and future development requirements whilst maintaining human and ecosystem health. • Meet design standards, consent conditions and regulatory levels of service. • Ensure assets, technology and resources have capacity, redundancy (n+1), knowledge and plans to prevent or cope with unplanned events.

Ref No.	Strategic Objectives
	• Minimise the need for new infrastructure including by optimising the use of existing assets.
SO8	Catchment Specific Objectives for Mangaheka ICMP Tangirau wetland function and health is protected and enhanced via: • Increase in indigenous biodiversity. • Improvement of water quality. • Increased amenity values.

Specific Operational Objectives have been developed to give effect to the Strategic Objectives and these are provided in Section 3.5. The Means of Compliance table **(Table 6-3**) identifies the provisions of the ICMP which give effect to the Strategic Objectives. Ongoing liaison with key stakeholders and directly affected landowners will be conducted as specific programmes of works, investigations and/or projects are progressed

2 Catchment Description

In accordance with Condition 30 of the CSDC, this section provides a broad range of data and maps to describe the physical, cultural, environmental, infrastructure, economic and future development characteristics of the hydrological Mangaheka catchment. This section is supported by mapping which is included within the document.

This ICMP also considers water and wastewater network matters which extend beyond the hydrological Mangaheka catchment as shown in **Figure 2-9**.

2.1 Introduction

The overall Mangaheka catchment area encompasses approximately 2,080ha of flat to rolling Waikato lowlands in the area generally defined by Onion Road in north, the North Island Main Trunk Railway and Tasman Road in the east, Ngaruawahia Road in the west, and Te Kowhai Road to the south. The Mangaheka Stream is a small tributary of the Waipa River which flows southeast-northwest towards it. Refer to Figure 2-1. Approximately 86% of the catchment lies within Waikato District Council jurisdiction, with the upper catchment upstream of Koura Drive within Hamilton City Council jurisdiction.

Within Hamilton City Council boundaries, the catchment includes the 177ha Rotokauri Structure Plan industrial area between the Te Rapa bypass and the North Island Main Trunk railway and an employment zone between the bypass and Burbush Road/Koura Drive. More than 120ha of industrial land in this area has been developed since 2012. Farm drains have been replaced with stormwater treatment swales and detention basins with discharge points into the downstream drain network. The Te Rapa bypass and connecting roads was constructed with stormwater treatment swales discharging into modified watercourses within the upper Mangaheka catchment.

Downstream of Koura Drive within Waikato District, the Mangaheka Stream has a rural catchment (mainly dairy farming or grazing) consisting of modified watercourses and an extensive gully wetland (Morphum, 2018) which are discussed further in Section 2.3.2. The adjacent catchments are Te Rapa Stream to the east (discharging into the Waikato River), Lake Rotokauri to the south (discharging to the Waipa River), and Te Otamanui to the west (discharging into the Waipa River).

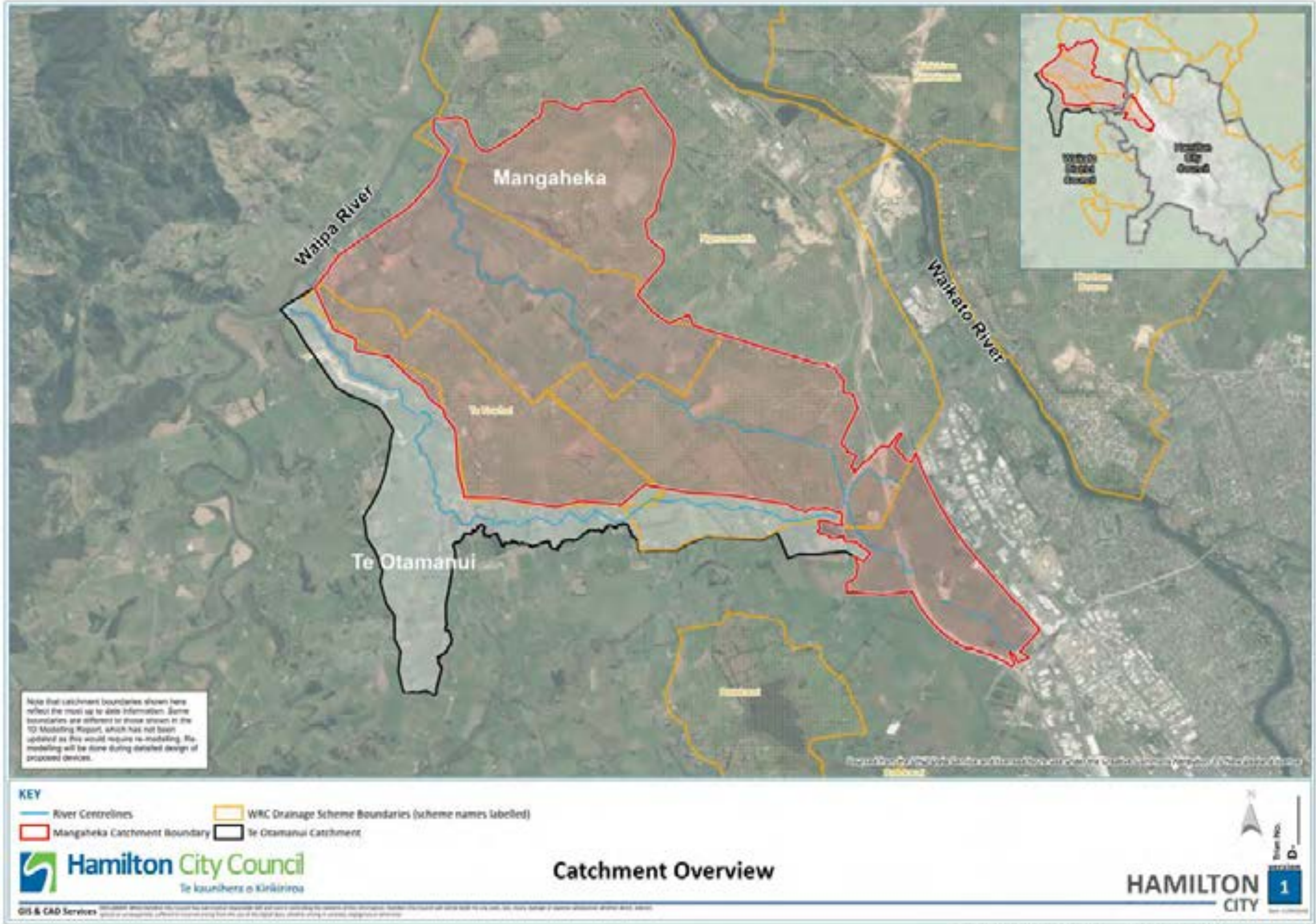

Figure 2-1: Mangaheka catchment map

2.2 Landuse

2.2.1 Historic and cultural landuse

Most of the Mangaheka Stream catchment is alluvial plains of the Waikato and Waipa Rivers which would originally have supported indigenous forest (Cornes *et al*. 2012). The topography and remnant vegetation indicates that the area would historically have included wetlands, particularly in low-lying flood plains and valley floors where groundwater emerges. Some of these wetlands would have included highly organic and/or peat soils, and peat swamps are known to have existed in the upper catchment. Similar to almost all rural land in this area, by the early to mid-1900s, most wetland areas would have been drained to create farmland, and the vegetative cover changed from predominantly alluvial secondary native vegetation to exotic pasture (Nicholls 2002). Vegetation throughout the catchment is now dominated by exotic pasture with shelterbelts and shade trees associated with rural-residential and rural properties.

2.2.2 Current land-use

The Upper Mangaheka sub-catchment is a peri-urban area that has mix of rural uses including dairy, dry stock, and crop farming; lifestyle blocks; and an increasing number of industrial activities. On the eastern flank of the Upper Mangaheka sub-catchment is the North Island Main Trunk Railway and on the western flank is the Te Rapa Bypass.

The land within the wider Mangaheka Stream catchment downstream is dominated by rural land uses, dominated by agriculture with some small lifestyle sized lots with dwellings and livestock. Tangirau/Waikeri Marae is located at the downstream end of the catchment in the lower part of the Tangirau Wetland area. Current land zoning is indicated in **Figure 2-2**.

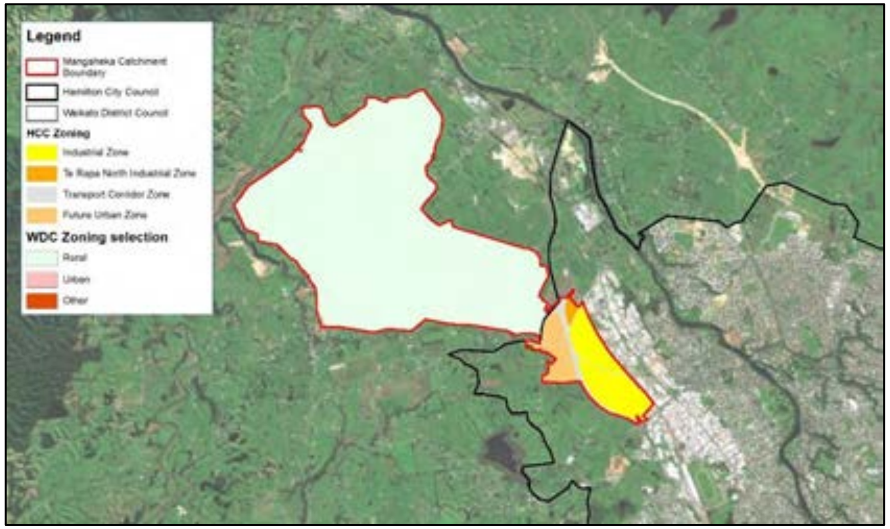

Figure 2-2: Current land zoning

2.2.3 Proposed land-use

Upper Mangaheka sub-catchment

The proposed long term land use change is to develop the entire Upper Mangaheka catchment as an industrial / commercial area. A general layout of proposed future land-use will be authorised through land use and subdivision consents.

Rotokauri is identified as a “strategic industrial node” in the Future Proof Strategy and Implementation Plan 2017 with an industrial land allocation of 85ha planned to occur by 2021, peaking at 90ha by 2041. The proposed land-use zoning is indicated in **Figure 2-3**.

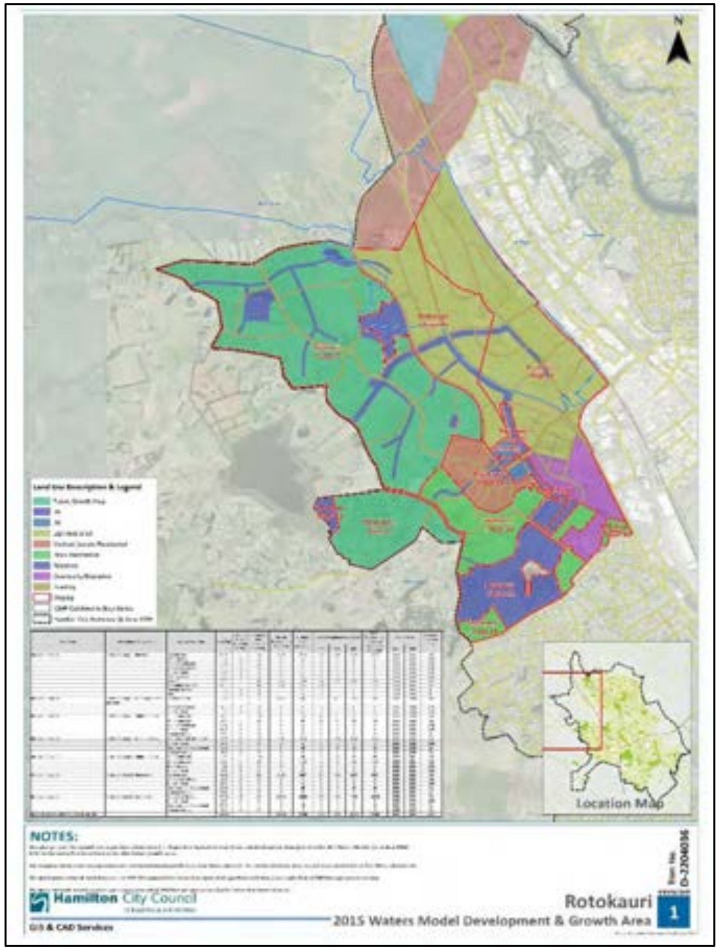

Figure 2-3: Proposed land-use[7]

Porter Properties Ltd Land Development Areas

There is approximately 64ha of industrial land in the Porter Properties Ltd (PPL) area. The land is zoned "Rotokauri Industrial".

The development of the PPL land is subject to the "Te Kowhai Road Comprehensive Development Plan". This Plan enables development of the land on a staged basis primarily to ensure that there are no adverse effects on the road network ahead of the Te Rapa Bypass opening.

The Te Kowhai Road Comprehensive Development Plan provisions require the preparation of a "stormwater catchment management plan" to facilitate the principles and proposals of the Rotokauri Structure Plan.

Land use and subdivision consents were granted in 2013 for full development of the area. A centralised stormwater treatment device was developed in this area, referred to as 'Porters Wetland'.

A stormwater discharge consent was granted by the Waikato Regional Council in February 2013.

Hamilton JV Investment Company Land Development Area

There is approximately 69ha of industrial land in the Hamilton JV parcels. The land is zoned "Rotokauri Industrial". This land may be developed under a "Comprehensive Development Plan" in terms of land use, staging and traffic.

[7] Source: HCC 2015: Rotokauri Structure Plan

Resource consent was granted in 2010 for a 22 lot industrial subdivision with 15 ha of developable land. This consent originally assumed that stormwater would be diverted out of the Mangaheka Catchment to Lake Rotokauri in accordance with the Rotokauri Structure Plan concepts. A revised design of stormwater infrastructure has since been approved which maintains the existing stormwater flow to the Mangaheka Catchment. A centralised stormwater treatment device was developed in this area, referred to as 'HJV Wetland'.

A stormwater discharge consent was granted by the Waikato Regional Council in March 2013.

4 Guys Land Development Area

There is approximately 3ha of industrial land in the 4 Guys area. The land is zoned "Rotokauri Industrial". The land is currently occupied by a 4 Guys car yard and a Z fuel station. A centralised stormwater management device has been constructed in this area and is referred to as '4 Guys Pond". This device provides stormwater detention only and is up stream of the HJV Wetland. Treatment is provided within the HJV wetland.

A stormwater discharge consent was granted by the Waikato Regional Council in February 2015.

The conditions of the discharge consents for all three areas largely mirror those in the CSDC.

Other industrial land within ICMP area

There is approximately 20ha of other (undeveloped) land within the upper sub-catchment which is identified for industrial use. Some of this land is zoned "Future Urban" lying on the on the western side of the Te Rapa Bypass. Plan Changes will be needed to bring this land into the urban land supply, at which time the extent of uses and development controls can be considered in detail. However, for the purposes of this ICMP, this area has been included in the anticipated industrial / commercial development area of the upper catchment and any future development in this area will be subject to the requirements of this document.

Industrial extension north of Ruffell Road

This land is zoned "North Te Rapa Industrial Zone" but with a "Deferred Industrial Zone" classification under the Operative District Plan.

The land is outside that identified for specific industrial development over the next 20-30 year period, but development will be provided for under future ICMP revisions.

Wider Mangaheka catchment

Waste and water servicing of this area is proposed via extension of existing networks through the Mangaheka and Rotokauri ICMP's. No significant development of the lower catchment land area is planned for the near-term at present.

2.2.4 Major transport links

The Rotokauri Structure Plan indicates an existing and planned road network in the upper catchment area as shown in **Figure 2-3**. The majority of the roads are classed as 'local' roads which serve the partly developed industrial area and its surrounds. The existing Te Rapa bypass section of State Highway 1 is a major arterial road passing through this area along the edge of the proposed industrial area. It should be noted that the alignment of future roads in **Figure 2-3** is indicative only and will be determined through a future designation process.

2.3 Physical Environment

2.3.1 Topography

The upper catchment area is generally flat-lying and represents one of the higher parts of the catchment. From this area the topography slopes generally to the northwest towards the Waikato River. The topography of the catchment is indicated in **Figure 2-4**.

The highest ground is located along much of the northern boundary of the catchment with associated steeper slopes trending south and south west. The highest point in the catchment is present in the northern-most area separating two south western-facing gullies. These gullies drain into the wetland area which extends from roughly the centre of the lower catchment and extends to the north western edge where the catchment drains to the Waipa River before it joins the Waikato River.

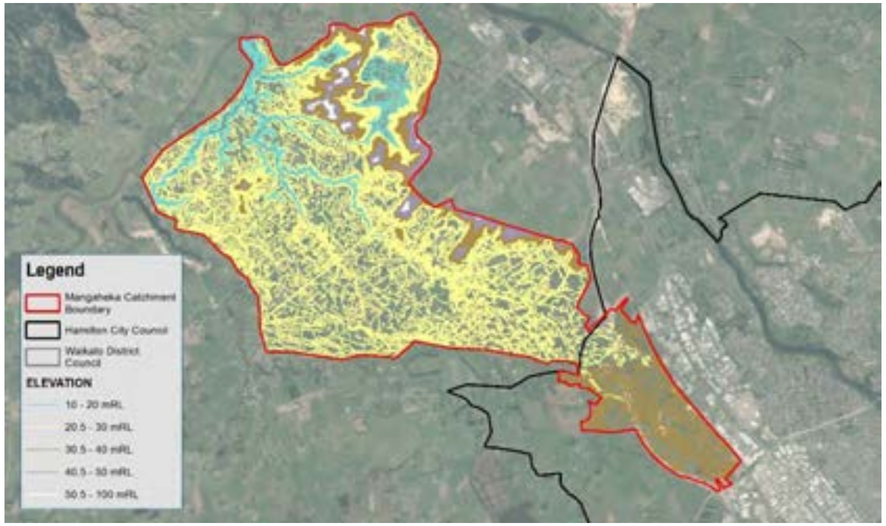

Figure 2-4: Mangaheka catchment topography

2.3.2 Watercourses

In the upper catchment, the two main branches of the stream meet immediately downstream of Koura Drive. Prior to development, the watercourses in the upper catchment comprised the stream headwater catchments located within the Rotokauri Structure Plan industrial/employment area, which was originally peat swamps. As a result of development of the industrial area and Te Rapa bypass designation, the original watercourses were replaced with planted swales and detention basins. The modified watercourses are recorded to have intermittent flow in the upper catchment and upper part of the lower catchment (as indicated in **Figure 2-5**) which approximately represents the upper 4km of the stream.

Downstream of the industrial area and Te Rapa bypass, the modified watercourses head north and northwest to Koura Drive, where they meet at the main stream stem. The stream then flows northwest through farmland before transitioning to a channel with perennial flow where natural topography forms a surface drainage channel. Outside the Hamilton City boundary, the catchment is almost entirely rural (dairy farming), comprising modified watercourses, with very little riparian vegetation.

Between Koura Drive and Horotiu Road, the waterway is comprised of a single main stem modified stream with other modified watercourses discharging into it from adjacent farmland. In this area the stream develops a more defined floodplain within an increasingly entrenched gully landform as it approaches Horotiu Road. At Horotiu Road, the road embankment and invert levels of the twin culverts dictate the groundwater levels, flood levels, and peak flows discharging downstream. Given that the culverts are perched at the downstream end, it appears that the road embankment and culverts are resulting in higher shallow groundwater levels and stream water depths than would be expected naturally. The modified stream catchment from Koura Drive to Horotiu Road is entirely rural with almost no riparian vegetation.

Between Horotiu and Ngaruawahia Roads (SH39), the stream transitions into a large willow-dominated wetland in an entrenched gully network and this extends for the remaining (approximately) 3.5km of the stream. The wetland is reported to have formed as a result of the Ngaruawahia road embankment impounding the stream upstream of its natural outlet to the Waipa River. Other branches of the stream form arms of the gully network at numerous confluences. The main stem flows northwest through an extensive rural (dairy farming) gully system that becomes increasingly deep and wide. The gully system is fully vegetated with a willow-dominated treeland and indigenous sedge understorey. The outlet to the Waipa River downstream of Ngaruawahia Road is via a short section (approximately 400m) of modified watercourse.

An ecological assessment has been completed[8] which identifies the range of waterway reach classification (Refer to **Figure 2-5**) within the catchment:

- often straightened modified watercourses in the upper third of the catchment (approximately 4km in overall stream length);
- modified watercourse with more natural form in the middle third of the catchment (approximately 3.5km in length); and
- Tangirau Wetland in the lower third of the catchment (approximately 3.5km in length).

The ecological assessment by Boffa Miskell included sampling of water, sediment and aquatic macroinvertebrates in 2012 and 2016 as indicated in **Figure 2-5**.

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[8] Boffa Miskell, June 2016: Mangaheka Stream Assessment of Ecological Values to inform Integrated Catchment Management Plan.

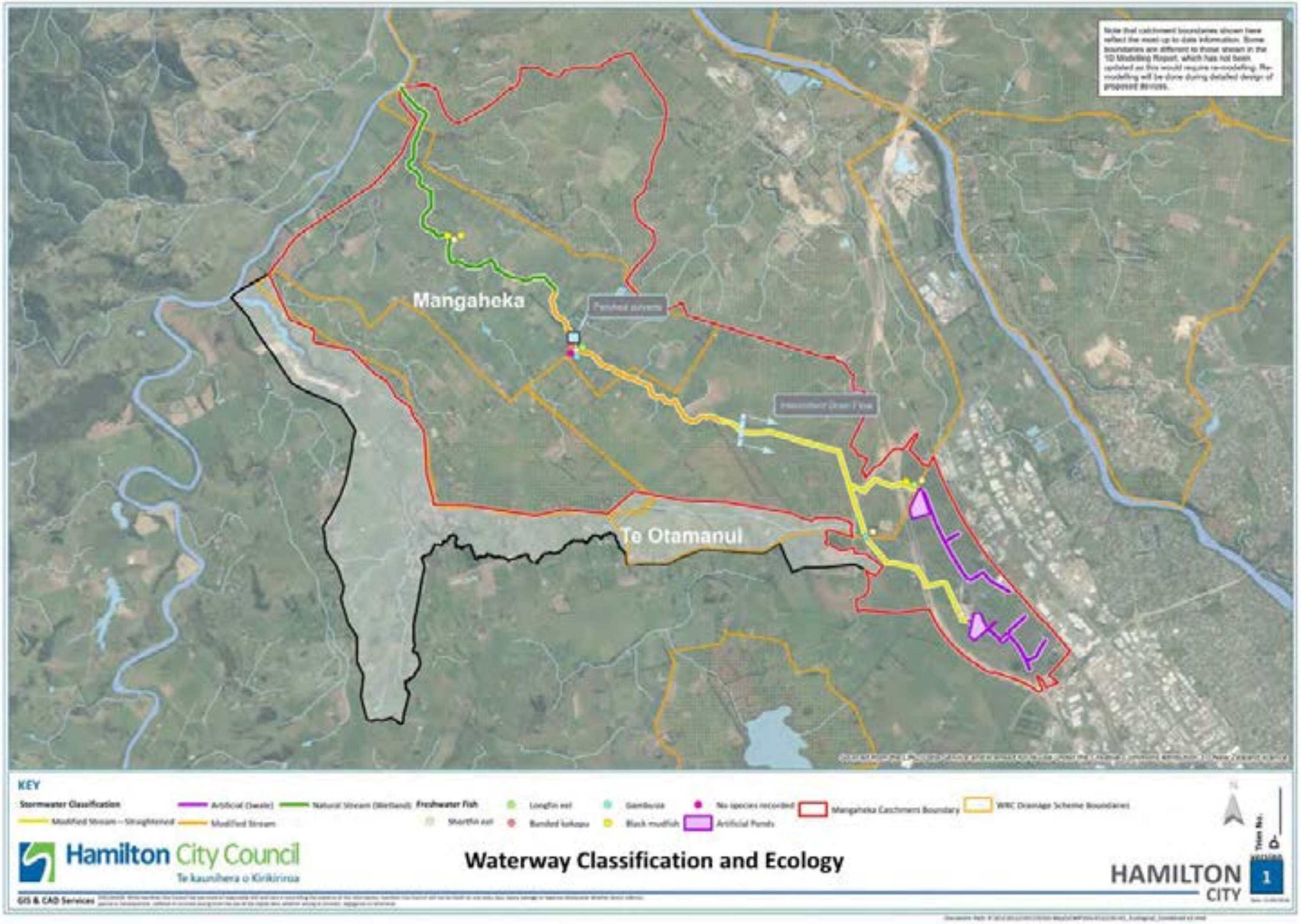

Figure 2-5: Mangaheka waterway classification

2.3.2.1 Erosion and Scour

A watercourse assessment[9] has been completed for the catchment, which included a walkover of the stream and assessment of erosion susceptibility of a 5km section of the stream in the lower catchment from the Hamilton City Council boundary at Koura Drive, where the stream is channelized to downstream of Horotiu Road at the upstream boundary of the Tangirau Wetland. The assessment informs concept projects and management options that are required to mitigate ongoing erosion within part of the Mangaheka Stream which is managed by Waikato Regional Council (WRC) drainage catchment board. Drainage catchments are divided into separate management zones. The uppermost part of the Mangaheka catchment (east of Ruffell Road) falls within the Central Waikato Management Zone, with the remainder of the catchment (west of Ruffell Road and extending down to the stream discharge into the Waipa River), falling within the Waipa Management Zone. This means that the industrial area in the upper Mangaheka Catchment is split across these two management zones.

The walkover survey identified 10 reaches defined by changes in bank morphology and landforms including roads. The assessment identified four sections of the stream (reaches 6, 8, 9 and 10) which were considered to have a low to moderate susceptibility to erosion and one section (reach 7), which was considered to have a moderate susceptibility to erosion (as indicated in **Figure 2-6)**.

These reaches are classed as low to moderate and moderate energy systems with localised erosion of the stream bed and undercutting of the stream banks in places. The location of fence posts in close proximity to the bank crest is considered to have destabilised banks in various locations leading to surface erosion and slumping, however over spraying of bank vegetation appears to have exacerbated the problem in many cases.

Reaches 1 – 5 are considered to represent low energy systems and have a low susceptibility to erosion, however it was noted that a lack of fencing in these areas could lead to erosion associated with stock access.

[9] Morphum Environmental Ltd, March 2017: Mangaheka Watercourse Assessment and Programme of Works

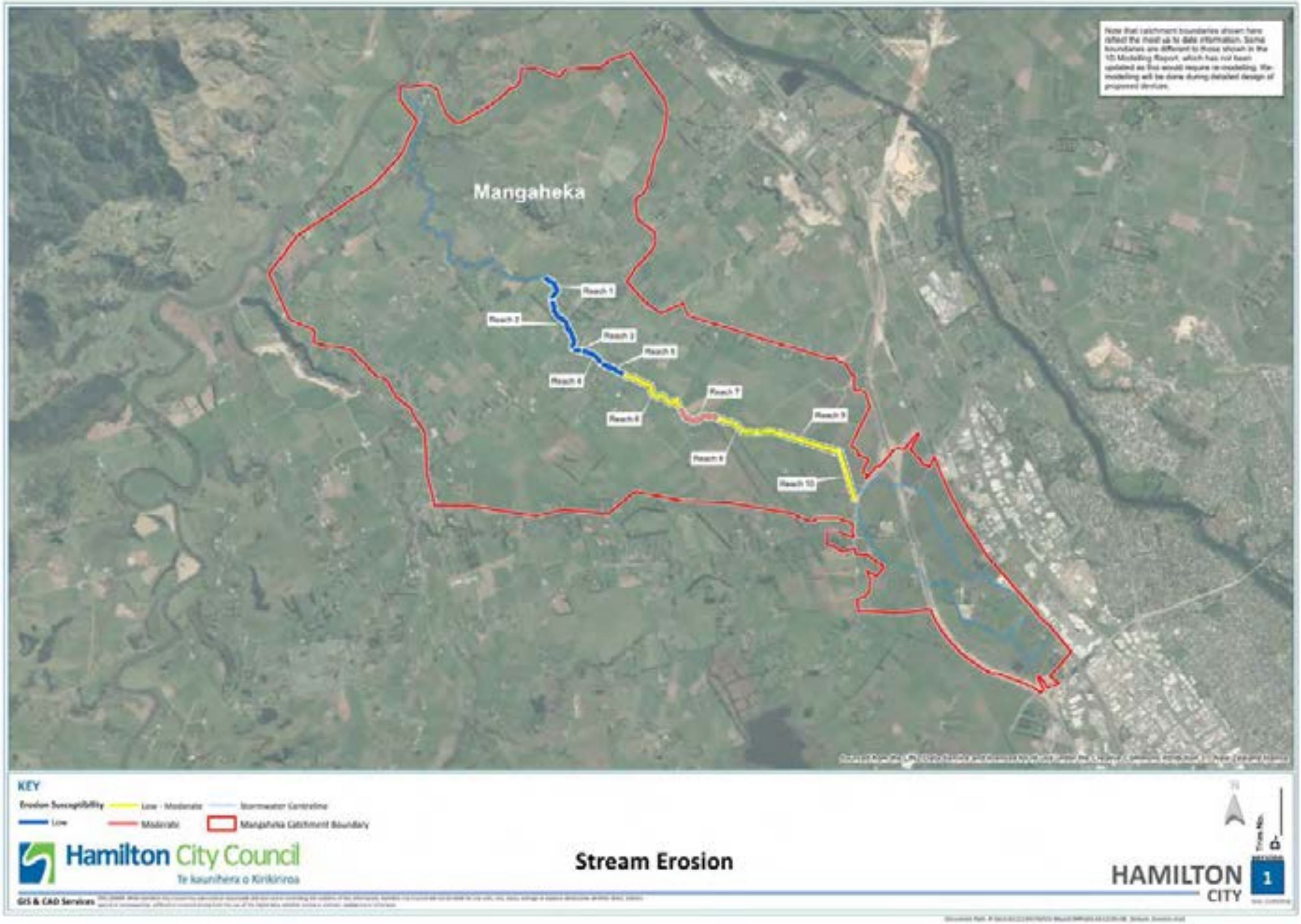

Figure 2-6: Mangaheka stream erosion susceptibility

2.3.3 Hydrogeology and groundwater resources

A desktop review of available information for the Mangaheka catchment (geological maps, Beca site investigation database, New Zealand Geotechnical Database (NZGD) and the WRC GIS Groundwater database) indicates that the geology for the Mangaheka catchment is broadly similar to the Rotokauri catchment although it is recognised that the inherent variability of the Hinuera Formation (due to the laterally migrating river system) can result in variability in profile and lateral extent of the geology over short distances. The soil profile is expected to be comprised of sands, silts, gravels and peats of the Piako (Hinuera Formation) and underlying Walton Sub-groups, with the latter outcropping and forming the low lying hills along much of the northern boundary of the catchment and some isolated low lying hills in the lower catchment.

Ground investigations have previously been carried out associated with proposed development within the industrial area in the upper catchment area. Reports for two of these[10] note the presence of peaty soils over layers of sands, silts and clays, however it is anticipated that the majority of the peaty soils within the industrial area prepared so far will have been removed or disturbed during platforming works to date.

Groundwater is recorded by these investigations to range from approximately 0.7-1m below ground level during winter months with summer groundwater levels roughly 1-1.5m below this. Groundwater level monitoring in Rotokauri catchment indicates a seasonal range typically in the order of 1.5 – 2 m but in places as much as 3 m or as little as 0.5 m.

No geotechnical investigation reports are available for the lower catchment area, however, based on available soils information (Section 2.3.4 below) the lower catchment is anticipated to comprise soils of similar limited poor-drainage capability with shallow groundwater and thus the potential for use of soakage for stormwater management is anticipated to be limited.

There are a number of groundwater takes recorded on the Waikato Regional Council website including for agricultural use and private water supply in the lower catchment area. One water take consent is recorded in the industrial area of the upper catchment for use in dust suppression. Other consents in the upper catchment relate to discharge of stormwater to the Mangaheka stream and one consent is recorded for discharge of treated domestic sewage to land for a rest home on Te Kowhai Road.

2.3.4 Soils

The ecological assessment did not assess the different soil types within the catchment, however, examination of the soils map on the WRC soil

[10] AECOM, August 2012: Preliminary Geotechnical Assessment for Proposed Industrial Subdivision – Ruffell Road/Te Kowhai Road for Porter Properties Ltd; and Coffey Geotechnical, August 2012: Factual Investigation Report for Proposed Industrial Subdivision at 103-129 Tasman Road, Rotokauri, Hamilton for Hamilton JV Investment Company

map viewer website[11] indicates six main soil types across the catchment. The upper catchment comprises mainly organic soils (peaty) as well as some allophanic soils which are a weak soil with low density structure. These allophanic soils together with grey soils are also present surrounding the lower section of the stream within the wetland area from the centre to the northwest edge of the catchment. These soils typically indicate wet conditions with limited drainage. More free-draining granular soils are present in the higher ground on the north eastern side of the catchment and brown soils are recorded on the western side.

The Land Environments of New Zealand (LENZ) database classifies most of the Mangaheka Stream catchment as Environment A5.3 which is comprised of poorly-drained peat soils of low to very low fertility or Environment A7.2 comprised of imperfectly drained soils of low fertility. There are very small patches of Environment F6.1 which is comprised of well drained soils of low fertility from rhyolitic tephra, outcropping mainly at Horotiu Road and around the Onion Road ridgeline.

2.3.5 Water quality and contaminants

2.3.5.1 Contaminated land

Analysis of soil contamination has been carried out as part of the resource consent process by land owners over approximately 80% of the land within the Upper Mangaheka sub-catchment (within the Hamilton City Council boundary). The testing undertaken to date[12] has not indicated any exceedances of National Environmental Standards for the parameters analysed. No soil analysis is recorded in the lower catchment and therefore no conclusions can be drawn as to soil quality within the lower catchment.

The presence of contamination within the catchment will be dependent on historical and current land use, in particular, agricultural and industrial activity. Sources of agricultural contamination can include storage and use of pesticides, herbicides and fertilizers; fuel storage; and waste pits. Industrial activity can generate a range of contaminative substances, however the industrial area in the upper catchment is zoned as 'light industrial' with the potential sources of contamination typically reasonably limited to storage and use of chemicals and waste disposal. In some areas surrounding Hamilton, former landfills are present, as well as localized filled areas formed to assist development. Such areas of fill are typically regulated by current standards, however, some former landfills and filled areas may have had limited regulation and so could potentially contain a wide range of contaminative substances. While no areas of such fill are recorded within this catchment there is a potential for these to be present locally.

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11 https://waikatomaps.waikatoregion.govt.nz/Viewer/?map=1aa9c952a38949a68cbe3ca7aed48270

12 As reported in Hamilton City Council, March 2015: Upper Mangaheka Draft Integrated Catchment Management Plan

It is expected that the change in land use from predominantly agricultural to a higher proportion of industrial/employment zone land and/or roading will change the stormwater contaminant profile. Pre-development stormwater contaminants from rural areas typically include nutrients, sediment, turbidity, bacterial pathogens, and metals associated with agricultural use and land drainage (e.g. aluminium, iron, manganese, nickel, copper and zinc). It is also noted that metals can be detected at elevated concentrations (often exceeding ANZECC guidelines) even in the absence of urban stormwater discharges or agricultural land uses, and these are assumed to be entering shallow groundwater due to mineralisation of organic matter in drained wetland/peat soils (Boffa Miskell, 2018).

Industrial stormwater contaminants typically include gross pollutants (including plastic and potentially micro plastics), sediment, petroleum hydrocarbons, and metals. Dependant on the activities taking place in the industrial area, there is also the potential for 'emerging contaminants', the effects of which on the environment and human health, may be poorly understood. Land drainage networks and industrial stormwater can both have elevated temperatures. The additional mass load of contaminants from new industrial development will be partly offset by reduced rural contaminant mass loads through land use conversion and loads removed by the wetland/swale devices.

2.3.5.2 Sediment quality

Sediment quality within the waterways was assessed by Boffa Miskell in their report issued in June 2016.

Four sediment samples taken in 2012 and one taken in 2016 were analysed for iron, arsenic, cadmium, chromium, copper, lead, nickel and zinc. The concentration of all metals in all samples but one was recorded to be below the ISQG-Low trigger concentrations. In one sample taken in 2012 at Te Kowhai Road, the arsenic concentration was equal to the ISQG-Low concentration. This in itself does not indicate an exceedance of the guideline value and therefore overall, based on the limited sampling conducted to, there is no evidence of metals concentrations in sediments within the Mangaheka stream representing a significant risk to biota.

2.3.5.3 Water quality

Water quality has had limited assessment by Boffa Miskell in their final report issued in July 2018 which has been used to inform this section. The Mangaheka Stream has water quality and water chemistry that is very similar to other Hamilton waterways. The stream receives ongoing inputs of suspended sediment, turbidity, nutrients, metals, and faecal pathogens.

Turbidity

Observations at Horotiu Road indicated suspended sediment increases rapidly after rainfall so suspended sediment spikes are likely to be common. As is typical for rural streams within this land type, low suspended solids concentrations do not always reflect turbidity, indicating that elevated turbidity is influenced by sources other than sediment. The observed orange staining and iron flocs are likely to be contributing (in part) to elevated turbidity, supported by elevated iron concentrations.

There is no guideline value for total iron. Although not analysed, it is expected that concentrations of manganese would be similarly elevated and contributing to turbidity. Although there is no guideline value for turbidity, the ANZECC Guidelines refer to research into banded kokopu avoidance behaviour at turbidity of 20NTU and WRC water quality scientists typically use turbidity of 10NTU or suspended sediment concentration of 10g/m^3 as the threshold above which recreational and ecological effects occur. Turbidity was above 10NTU at all sites in 2012 which is typical of rural streams around Hamilton draining peat/organic wetland soils.

Metals

Based on the available Mangaheka results and available results from all other Hamilton catchments, the Mangaheka metals concentrations are considered to mirror that of other Hamilton catchments as follows:

- Arsenic, cadmium, chromium, lead, and nickel generally below ANZECC guidelines.
- Aluminium, copper, and zinc exceeding ANZECC guidelines.
- Iron is elevated.

Based on the results in other catchments, phosphorus can be expected to combine with aluminium, iron, manganese, zinc, copper and other metals forming metal phosphates, increasing turbidity, reducing nutrient availability and limiting metal bioavailability and therefore toxicity in the water column. Concentrations of total copper and total zinc exceed ANZECC guidelines indicating potential for biological harm, but concentrations of the bioavailable dissolved fraction are likely to be below ANZECC thresholds.

Because there was little urban stormwater being discharged into these waterways prior to or at the time of sampling, metals are anticipated to be from agricultural or groundwater sources as a result of land drainage. This is supported by the average total copper, lead, and zinc concentrations being very similar to the median total concentrations of 28 samples taken at 20 rural waterways close to Hamilton, each with little or no urban stormwater discharges. It is considered likely that elevated metals are a normal water quality component resulting from land drainage, especially with the potential for mineralisation of organic matter in drained peat soils (Boffa Miskell. 2018). Metals complexes may have localised impacts on dissolved oxygen concentrations, especially where iron discharges occur.

Nutrients

Elevated concentrations of nitrogen and phosphorus are ubiquitous in waterways around Hamilton, and generally far exceed the Ministry for the Environment water quality guidelines required to limit algal growth. The very limited water sampling completed within Mangaheka catchment indicates lower phosphorus and nitrogen concentrations compared to other Hamilton catchments during a similar period, however nutrient levels are expected to fluctuate over time dependent on agricultural and industrial activities taking place as well as potential seasonal influences.

With respect to algal growth, the sequestration of phosphorus into metal phosphates and the predominance of particulate phosphorus may limit bioavailable phosphorus to concentrations below that required for algal growth to some extent. However, filamentous algal growth was observed frequently throughout the stream reaches during site assessment but was not observed in the modified stream reaches or wetlands.

Filamentous algal growth was most noticeable where aquatic macrophytes had recently been sprayed and in reaches downstream of this (Boffa Miskell, 2018).

Pathogens

Elevated faecal coliform levels are ubiquitous in waterways around Hamilton regardless of their catchment land uses, although rural streams tend to have lower levels than urban waterways. In the Mangaheka catchment, faecal coliforms exceed ANZECC guidelines for livestock watering and Ministry for the Environment guidelines for human contact at all sampling sites and the average for Mangaheka sites is close to the median for all Hamilton streams.

Water quality

Petroleum hydrocarbons and carbonaceous biochemical oxygen demand (CBOD) were not detected. However, given the agricultural land uses, it is likely that CBOD fluctuates in response to inputs of organic matter. A preliminary (2011) water sample taken in the stream at Ruffell Road, adjacent to maize cropland had concentrations of CBOD at almost 5 times the guideline so it is likely that CBOD fluctuates substantially in response to inputs of organic matter associated with crop harvesting.

Temperature and dissolved oxygen will experience diurnal and seasonal fluctuations. Water temperature was cool (10.6 – 15.7°C) at the time of sampling, but observations indicate that summer water temperatures will exceed thermal tolerances of aquatic fauna throughout the upper catchment modified watercourses where riparian cover is limited and water depth is shallow. The open water areas in swales and detention basins in the industrial area are likely to experience ongoing elevated turbidity and suspended sediment loads.

This may result in thermal storage causing rising temperatures during summer and low dissolved oxygen concentrations downstream of the discharge points.

In the modified stream channel where the stream has perennial groundwater-sourced baseflow and riparian vegetation cover, water temperature is likely to remain below the thermal tolerances of most fish and aquatic macroinvertebrate species.

On balance, the water quality and water chemistry of the Mangaheka Stream catchment is considered to be moderate to poor, but similar to most Hamilton waterways. It must be noted that the grab sampling conducted in 2012 and 2016 and offers a very limited picture of the Mangaheka Stream water quality due to the variable nature of stream water in a catchment at any given time with a range of variable inputs. The monitoring plan in Section 8 considers this and recommends establishing trends in water quality in order to help identify any significant changes.

2.3.5.4 Contaminant load

The following are the key stormwater contaminants that are likely to be generated within the Mangaheka Industrial Area.

- Suspended sediment
- Hydrocarbons
- Nutrients (nitrogen and phosphorus)
- Metals with the primary ones being zinc and copper but also lead, cadmium, aluminium, chromium, arsenic, iron
- Bacteria
- Biochemical oxygen demand (BOD)
- Litter

However, a range of other contaminants could be generated depending on the type of industry and activities taking place and the on-lot controls in place.

Predicting likely contaminant loadings in stormwater runoff and comparison against present conditions is useful to determine likely impacts on stream water quality and assess the potential need for particular stormwater devices to reduce specific contaminants. A contaminant load model (CLM) has not been developed for the Mangaheka stream due to the uncertainty around the types and numbers of industrial activities that will eventually occupy the planned industrial area in the upper catchment. In the absence of a CLM, an anticipated contaminant loading has been estimated using information sourced from TP10 and Auckland Regional Council CLM (V2.0 (2010) which is referred to by the Waikato Stormwater Management Guideline (2018). Contaminant load data for industrial landuse has also been taken from recent monitoring data collected for the Hamilton City Council Comprehensive Stormwater Discharge Consent (T+T, 2017). This provided up to date Hamilton specific data for an existing industrial area (Northway Street). A full table of source data is provided in the Addendum Water Quality Report (CH2M Beca, 2018).

This contaminant load assessment can be used to determine if the proposed treatment devices identified within this ICMP meet the required Means of Compliance requirements.

It should be noted that the Auckland Regional Council CLM only provides loadings in terms of sediment, zinc copper and hydrocarbons. Whilst these are likely to be some of the main contaminants, a range of others are also likely. For the Mangaheka industrial area the most applicable contaminant levels are provided in Table 2-1 which is from the CH2M Beca Water Quality Addendum Report (2018). This table compares a typical contaminant load in a rural setting against measured values from the Mangaheka Stream as reported in the Boffa Miskell 2018 report, and predicted values following development (with planned stormwater management provisions in place).

Table 2-1: Contaminant loads and concentrations

Contaminant	Contaminant Load Pre-treatment (kg/ha/year)	Contaminant Load Post-Treatment (kg/year)	Average Concentration (g/m3)	Guideline Value (g/m3)
TSS	320	4827.0	3.20	None
Total phosphorus	0.88	39.8	0.026	0.015-0.3a
Total nitrogen	4.66	304.6	0.20	0.04-0.1a
Zinc	4.90	98.6	0.065	0.02b
Copper	0.32	8.0	0.005	0.0024b

In Table 2-1, an examination of predicted contaminant loads with the proposed development loads is provided for both pre-treatment and post-treatment together with a comparison of the anticipated post-treatment contaminant concentrations against the guideline values.

The average concentration column in Table 2-2 shows that compared to existing water quality in the Mangaheka Stream, even after treatment, discharges of total phosphorus, total copper and total zinc will potentially be higher than existing levels. It is therefore possible that the ICMP targets of maintaining or enhancing the existing water quality (considering metals concentrations) may not be met without additional on-lot contaminant removal methods required.

Table 2-2 compares the predicted existing rural and post treatment contaminant concentrations with monitoring data collected by Boffa Miskell (BM, 2018)

Table 2-2: Comparison of rural, existing (monitored) and developed contaminant concentrations

Contaminant	Rural (g/m³) (calculated)	Existing Values (BM, 2018) (monitored) (g/m³)	Post Treatment (g/m³) (calculated)
TSS	116.7	13.9 (5 -31)	3.2
Total phosphorus	0.021	0.42 (0.035-2.6)	0.026
Total nitrogen	0.659	2.4 (0.44—4.6)	0.21
Zinc	0.013	0.0256 (0.0012— 0.069)	0.065
Copper	0.004	0.0023 (0.0018- 0.0028)	0.005

Details of the methodology for determining contaminant loading and the anticipated performance of existing devices are provided in the water quality report and water quality report addendum in Appendix C.

2.4 Values

2.4.1 Aquatic, terrestrial and riparian ecology

The ecological assessment for the catchment (Appendix E) concluded that the Mangaheka stream has poor to moderate habitat diversity, with diversity increasing with distance downstream. Water quality is generally poor but similar to other catchments in the Hamilton area.

There is a low abundance of sensitive macroinvertebrate taxa and limited fish species identified in the stream, however 'At Risk' native black mudfish and longfin eels were recorded in the watercourse and therefore has ecological significance under the provisions of the RPS.

The majority of the catchment vegetation has been widely modified over time with historic vegetation cover, including peat bog vegetation, replaced with exotic pasture grasses or crops and with exotic shrubs and trees established as shelterbelts. Indigenous plants are recorded as virtually non-existent throughout.

In the upper catchment the watercourse type is modified (typically straightened) with intermittent flow and which generally provide poor habitat for fish and aquatic macroinvertebrates. Low or no flow, high temperatures, low dissolved oxygen, and very poor water clarity are likely to present fish passage barriers in this section of the catchment.

From midway between Ruffell Road and Horotiu Road, the watercourse type becomes a modified stream with a relatively natural channel, however, there are some reaches where historic straightening has occurred.

In the upper and middle reaches, there is typically limited riparian vegetation adjacent to the waterways. Although most waterways have no canopy cover, some have cover from shelterbelt trees. Much of the waterway is fenced at the bank crest and periodically sprayed so riparian vegetation is very limited.

In the lower catchment, which is recorded as largely inaccessible, the riparian vegetation consists of wetland vegetation with a canopy and understorey vegetation providing extensive areas of shading from the sun.

Macroinvertebrate assessments conducted in 2012 and 2016 indicated a range of different macroinvertebrate communities, the stream is characterised by a low Macroinvertebrate Community Index which reflects the low abundance of sensitive taxa and indicates probable severe pollution.

A Fish survey conducted in 2016[13] identified a total of four native species: shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachii*), banded kokopu (*Galaxias fasciatus*), and black mudfish (*Neochanna diversus*); and one exotic species (mosquitofish) which correlates with the findings of surveys recorded by the NIWA Freshwater Fish Database for this stream. It is also noted that prior to development of the industrial land parcels in the upper catchment area in 2011/12, three native species (mudfish (12 individuals), longfin eel (2 individuals) and shortfin eel (16 individuals)) were caught and translocated under permit from the upper catchment to the wetland area near Crawford Road in the lower part of the Mangaheka catchment.

The diversity and abundance of fish species is likely to increase substantially with distance downstream, as flows become perennial, channel morphology is less modified, habitat diversity increases, and riparian vegetation cover increases.

Despite the presence of perched twin culverts at Horotiu Road and the culvert at Ngaruawahia Road, the presence of some non-climbing species found upstream indicate that the culverts are not considered as a significant fish passage barrier.

Riparian vegetation has been controlled by spraying over large sections of the upper and middle reaches of the watercourse causing widespread slumping in the low-cohesion soils. Erosion repair responses have included deposition of rock riprap into slumped areas which has led to further erosion. This has caused further bank collapse and diversion of flows to adjacent banks where toe undercutting and slumping subsequently occurs.

Anecdotal evidence from landowners indicates that there has been an increase in localised flooding events following the construction of the Te Rapa bypass and Koura Drive which indicates the potential sensitivity of the catchment to development. As noted in Section 2.3.5.1, proposed development of the Rotokauri Structure Plan industrial and employment areas are considered likely to increase some dissolved contaminants in the stream which has the potential to affect fish diversity. It is anticipated that additional on-lot contaminant removal will be required to reduce the potential for impacts to aquatic ecology.

[13] Boffa Miskell, June 2016: Mangaheka Stream Assessment of Ecological Values to inform Integrated Catchment Management Plan.

2.4.2 Cultural value to iwi and archaeological significance

Formal archaeological and cultural assessments of the Mangaheka catchment have not been conducted for this ICMP, however a range of publicly available information has been reviewed in order to identify any known sites of historic or cultural significance.

A marae recorded as both Waikeri and Tangirau marae, is located in the western part of the catchment in the vicinity of the Tangirau wetland. This marae is also identified on the WDC Map viewer as within a Pa Zone. The wetland is anticipated to be important for local fishing and cultural practices and the Tangirau Restoration Group has been formed by local iwi and local landowners with the objective to protect and enhance the wetland.

A review of information available on Archsite[14] identified the sites recorded in or immediately adjacent to the Mangaheka catchment. The sites listed are provided in Table 2-3 and are all located on the western boundary of the Mangaheka Catchment beside the Waipa River.

Table 2-3: Archaeological sites recorded in Archsite

Site ID	Type / Name	Description	Co-ordinates
S14/124	Wooden artefact	Indigenous pre-1769	E 1789738 N 5825156
S14/362	Borrow pit	A single borrow pit and Maori-made soils on the banks of the Waipa River	E 1789616 N 5825408
S14/361	Borrow pits	Eight borrow pits, and Maori-made soils	E 1789810 N 5825710
S14/122	Whakapuku Pa	The pa site is situated NW of the junction between Bedford Road and the Ngaruawahia Road, between the road and the river	E 1788141 N 5823748
S14/118	Pa	NW of Te Kowhai, on the east bank of Waipa River, bisected by Bedford Road	E 1787830 N 5823364

Refer to **Figure 2-7** for a map of the recorded archaeological and cultural sites within the catchment.

[14] https://archsite.eaglegis.co.nz

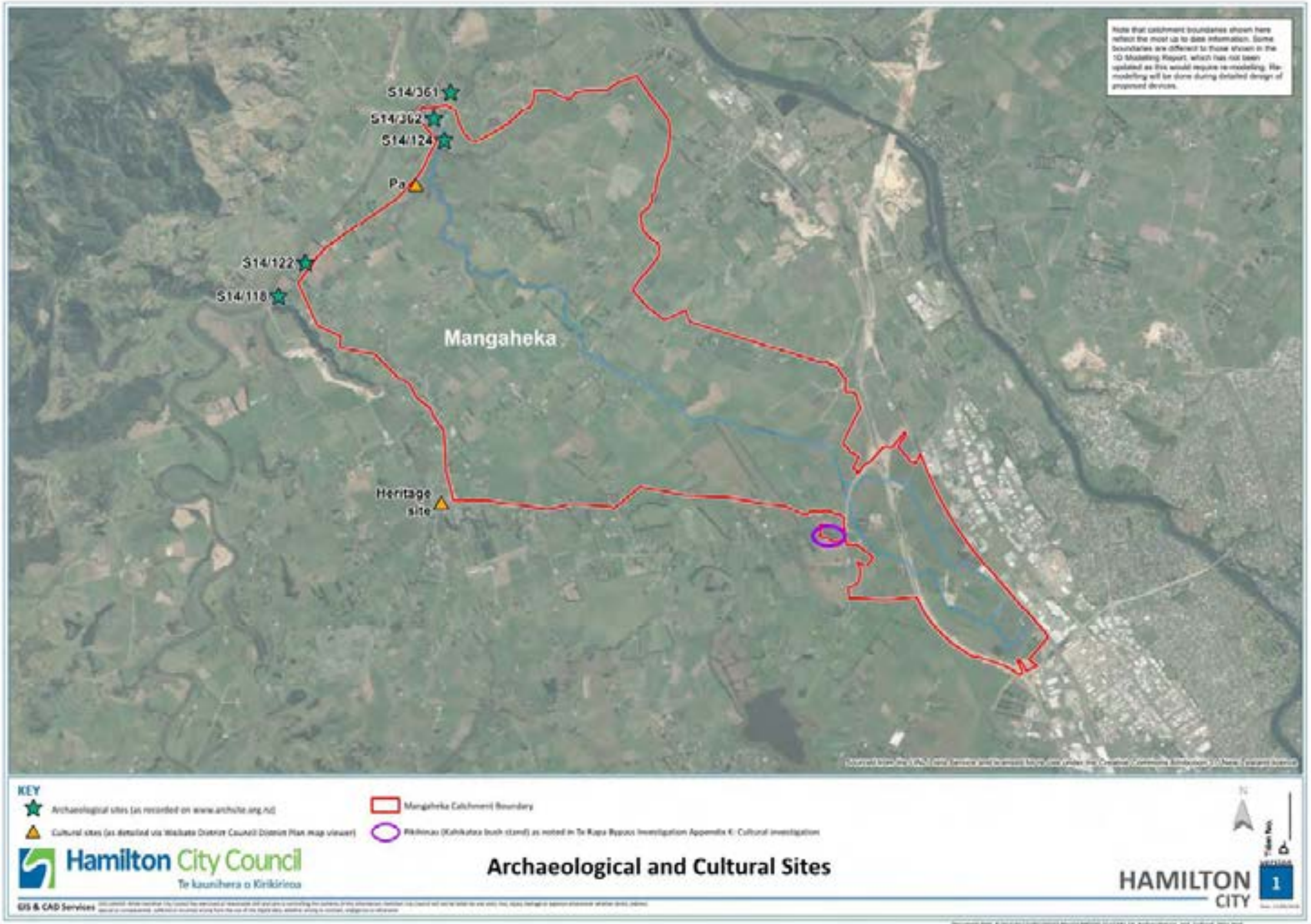

Figure 2-7: Archaeological and Cultural Sites

2.4.2.1 Mana whenua cultural values

The cultural impact assessments previously prepared by representatives of Nga Mana Toopu O Kirikiriroa for the Rotokauri Structure Plan (Phase 1) and the Te Rapa Bypass have been reviewed during the development of the ICMP. It is acknowledged that mana whenua (including representatives of Te Ha o Te Whenua o Kirikiriroa), particularly Ngati Maahanga, Tamainupoo and Ngati Hauaa have not concluded their final research in this area, which will be included in the broader Cultural Values Assessment being prepared by mana whenua currently. While this assessment was not available at the time of writing the ICMP, mana whenua agreed this ICMP should draw on the cultural values expressed in Tai Tumu Tai Pari Tai Ao (Waikato Tainui Environmental Plan) and the previous assessments in the interim, to be replaced by the updated cultural effects assessment when available. For the purpose of this ICMP, the following aspects of the previous assessments have been summarised as follows in Table 2-4.

Table 2-4: Summary of cultural assessments

Topic	Description	Source
Historic landform	In pre-european times the flora and fauna of this area was significantly different from today. The region was renowned and fabled in Maori legends and waiata for its large forests and abundance of birds and fish. The hills and ranges overlooking Rotokauri were densely forested with matai, miro, totara, rimu and tawa trees, by contrast the forests of the peat swamps were low lying plains of kahikatea, titoki, rewarewa and pukatea trees, with maire on swamp margins. The lakes held special spiritual and sustenance significance, supporting kaeo (freshwater mussel). The shells were manufactured into cutting implements to gather harakeke (flax) to make clothes, korowai (cloaks), whariki (mats), fishing line and other everyday items. The lakes were a great source of tuna (eels), koura (freshwater crayfish), and native trout. Kokowai (iron oxide/ochre) was present in swamp and creek margins, which was dug out of the swamps in large lumps and heated in wood fires. The orange/red pigment was used for personal adornment, painting houses, wooden carvings, palisades of the pa, and the scraped bones of the dead (to give a red colour). In addition people commonly painted themselves or children prior to going to sleep to ward off evil spirits, and Chiefs commonly smeared kokowai on the faces/bodies to indicate a state of tapu during ceremonies.	(RSP[15])
Cultural features and resources	The reports reference the significance of many natural features in the catchment, including the lakes (Rotokauri, Rotokaeo and Waiwhakareke), ripo (swamps), Te Tongahuanui walking track, and Te Uhi Pa (on the northern side of Lake Rotokauri within the Waikato District boundary).	

[15] Beca 2001: Rotokauri Structure Plan: Environmental Opportunities, Constraints and Urban Needs Assessment (Phase 1 Report).

Topic	Description	Source
	Harakeke (flax) was gathered from the swamp areas, kokowai (ochre) was gathered from creeks and swamps. Fire and burn-offs were a necessity of ancient Maori life. It created a clearing for viewing and protecting hinterland, and to encourage re-generation of food sources (rauruhe and kumara). Legends record many fresh water springs in the area for drinking, cooking, spiritual and ceremonial significance, some of which can still be seen today. The area was renowned for its large flocks of native birds which, depending on species was an important source of food, clothing and personal adornment, whereas others (kaahu, karearea, ruru, peho, koakoea) where considered deities. The area contained many papa huarakau (traditional forest hunting blocks), and was home to many native tree species.	
The Maori people of the area	The area around Lake Rotokauri was the scene of many battles between different Tainui hapu. The first people to occupy these lands were an ancient, pre-tainui Maori tribe called Nga Iwi, however they were driven from the Paraureroa Pa (near Mangatawhiri) by Hanui and Hotumauea, two Ngati Wairere war lords. The Nga Iwi people travelled south, eventually arriving in the Lake Rotokauri area, and established a number of Pa (one of which was on the northern lakeside).	

Topic	Description	Source
	Other people who subsequently settled in this area include Ngati Ngamurikaitaua, Ngati Koura, Ngati Ruru, Ngati Hourua, Ngati Wairere, and Ngati Iranui.	
Mitigation and protocols	Due to the enormous deforestation of the area, many of the surface features have been modified or destroyed. Hence mitigation for this area must be focused on commemorating the life and practices of the Maori people who lived here, rather than preservation of particular features. Mana whenua wish to see the planting of native berry bearing trees to attract native birds back to this area, and re-establishing pa harakeke (areas of flax) which would be available for harvesting and customary use. **Te Pikihinau reserve** The last remnants of a once famous stand of kahikatea trees still survives between Te Kowhai Road and Burbush Road. This stand of trees was a traditional bird hunting area and contained the famous landmark Hinau tree called Te Pikihinau. Because of its historic significance, tangata whenua wish to see this particular stand of trees protected and where possible enhanced with planting of more native trees. **Te Maire** Te Maire refers to the name of a swamp which makes up much of the flat dairy farmland north of Te Kowhai Road.	TRB[16]

[16] Nga Mana Toopu O Kirikiriroa (July 2004) Te Rapa Bypass Cultural Investigations Report, prepared for the Te Rapa Bypass Notice of Requirement for Transit New Zealand.

Hamilton City Council
Te kaunihera o Kirikiriroa

Topic	Description	Source
	Taonga tuku iho Whilst there are some legendary records of ancestral bodies being buried an ancient urupa (burial grounds) around the lake and Te Uhi Pa, the actual location of these urupa were never documented and hence are no now known. However it is clear that Maori traditionally buried koiwi (human remains) virtually anywhere, without any record of where the bodies were buried. In this contexts, the descendants of the dead knew where the bodies were so why should they document it. Often swampy area were favoured burial grounds and bodies were buried there as offerings to local deities, often accompanied by buried artefacts, talisman and Taonga. It is therefore highly probable that human remains, carved artefacts or other taonga will be uncovered, particularly in swamp area, spring and lake margins during any future earthworks to develop and subdivide this whole areas. Suitable protocols need to be investigated prior to significant development in these sensitive areas.	

Te Pikihinau reserve is indicated in **Figure 2-7**, however a record of the extent of Te Maire has not been found. An assessment of Tai Tumu Tai Pari Tai Ao – Waikato Tainui Environmental Plan and the various objectives and policies relevant to the development of the ICMP has been undertaken, and is included in Appendix H. Broadly speaking, engagement has been undertaken with mana whenua during the development of this ICMP, and as indicated in Section 7 (Consultation), their feedback has been incorporated in the context setting of the ICMP, and the means of compliance and future actions tables.

2.4.3 Amenity, recreational and aesthetic values

The ecological assessment identified that the faecal pathogen load within the stream is high and therefore the water is unsuitable for human contact or livestock consumption (Boffa Miskell 2018). Overall, the water quality is considered to be moderate to poor and generally similar to other waterways in the Hamilton area. Nonetheless the report suggests that access to the wetland area it likely to take place for local fishing and other recreational uses. No specific amenity, recreation or aesthetic values have been identified associated with this catchment which could be negatively impacted by development further upstream.

2.4.4 Economic values

The Mangaheka stream drains rural farmland with economic value to landowners. Management of stream bank stability is important for preservation of land and maintenance of land drainage capacity is vital for pastoral productivity and for delivering the Waikato Regional Council administered Ngaruawahia Drainage Area level of service for removing flood waters.

2.5 Existing Utilities and Network

2.5.1 Water network

Given that the majority of the Mangaheka catchment is greenfield, the existing water supply infrastructure in the WDC jurisdiction is minor and the focus of assessments has been provision for growth and mitigating issues related to growth in the upper catchment within the Hamilton City Council boundary. Accordingly, this section sets out a summary of assessments, issues and the proposed solution in terms of water supply infrastructure. Most of the information contained in this section is from the Hamilton City Water Master Plan (2016).

The existing water supply system in the Mangaheka upper catchment (within the Hamilton City Council boundary) is described as being serviced by Blue zone pressure (via the Water Treatment Plant).

Under the Water Master Plan Philosophy, this single Blue zone will eventually become 3 separate supply zones called the Pukete Zone (Brown), Newcastle Zone (Green) and the Dinsdale Zone (Orange). Refer to **Figure 2-8** below. The timing along with the physical capital works to create these zones has a bearing on the rate of water demand growth that can be serviced in the Upper Mangaheka catchment.

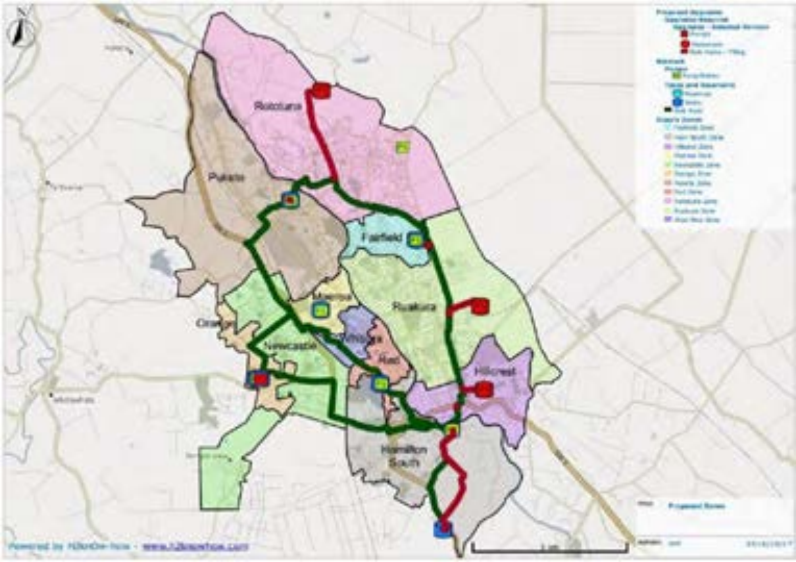

Figure 2-8: Proposed water network zoning

Future demand in green field areas where little or no existing demand is available uses the assumptions in the Hamilton City Council Infrastructure Technical Specifications for Water Supply: An average daily demand of 260 l/person/day (0.003 l/s/person average instantaneous) with a peak instantaneous flow rate of five times this amount (0.015 l/s/person).

In general, the current storage and zoning approach for Hamilton is to split the City into western and eastern areas, divided by the Waikato River, for water storage and use. The master plan approach keeps the storage within the zone it services without long pipe runs and more risky river crossings. There is currently no need in the Mangaheka catchment for a new reservoir or an additional treatment plant on the western side of the river within the 2061 design horizon.

Summary of assessment and observations

The current water infrastructure installed in the Mangaheka upper catchment allows for the development of the industrial area.

Future water supply performance in the Mangaheka area will ultimately be determined by the creation of 2 new zones called the Newcastle and Pukete Zones and the extension of the existing Dinsdale zone. The commissioning of the proposed Rototuna Reservoir and Zone in 2018 will remove the current reliance on the Pukete Reservoir to supply the Rototuna area at peak demand times. The Pukete reservoir will return to its intended use, servicing the western side of the river. A dedicated bulk main supply line is currently being developed to service the proposed Pukete Zone with the bulk main planned to be commissioned in 2019.

Once the Pukete supply line is completed the Pukete zone will be closed, resulting in significant system performance improvement.

Staged construction is proposed for extension of existing supply lines and trunk mains to service the new development of the Rotokauri area, lying to the south west of the Mangaheka upper catchment.

Stage 1 - relates to any proposed development prior to the future 520mm Bulkmain supply from Pukete Reservoir to the Rotokauri area. To facilitate growth this requires the installation of a 450mm main along Te Wetini Drive connected temporarily to the existing 250mm on Wairere Drive. This extends as a 250mm main from the end of the 450m and connecting to the existing 250mm on Rotokauri Road.

Stage 2 - construction of the 520mm link between Pukete Reservoir and the 450mm on Te Wetine Dr, disconnecting from the 250mm once in place.

Stage 3 - relates to remaining available development east of SH1 to Exelby Rd involving a 450mm bulk main across SH1 and 13km of 250mm trunk mains west of SH1.

Figure 2-9 below shows the existing and proposed water supply infrastructure, along with wastewater and reticulated stormwater, for the Mangaheka upper catchment and the northern part of the Rotokauri catchment.

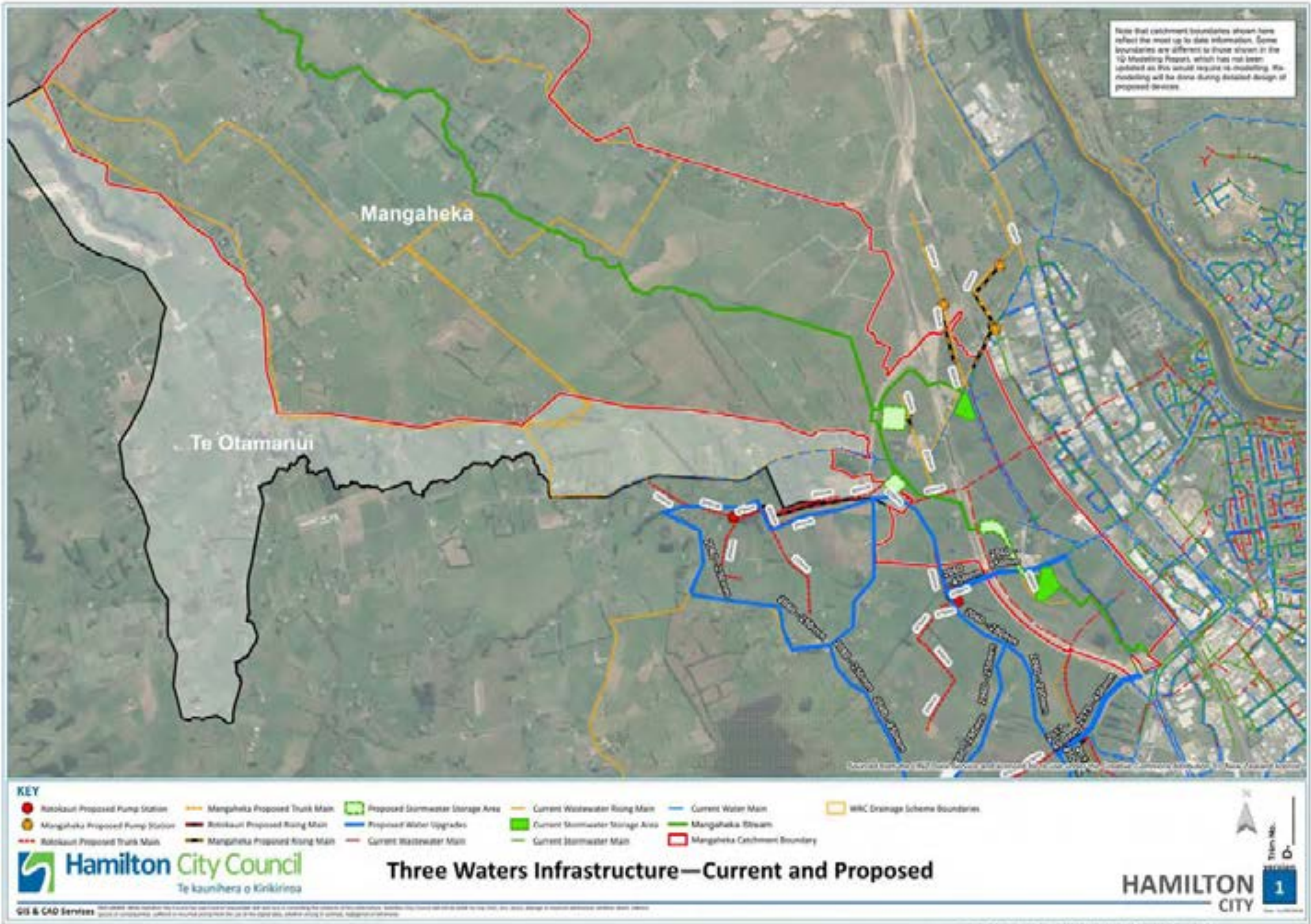

Figure 2-9: Three waters infrastructure – current and proposed

The Mangaheka catchment is currently serviced by the Bulk watermain network in Wairere Drive and sits within the Pukete Demand Zone (Water Master Plan 2015).

Historically, due to the rural nature of much of the catchment, existing dwellings have rainwater tanks and/or a trickle feed system to provide for their water needs. The City water reticulation will be progressively extended by both developers and Council to service growth in the upper catchment area.

A new 24 mega litre reservoir is now operational at Kay Road within the Otama-ngenge catchment. As indicated in **Figure 2-9** an existing 520mm dia trunk main along Wairere Drive will be extended along Te Wetini Drive on the western side of the Te Rapa bypass in 2018 with remaining trunk main extensions within the area between Te Kowhai Road in the north and Lee Road in the south planned to take place around 2060.

This water network will improve the security of supply and match the demand for all of the Rotokauri Structure Plan area. Based on the growth density predictions for the Hamilton City Council area, the Mangaheka catchment is not anticipated to have a significant increase in population, with most development anticipated to be light industrial, hence the water network expansion will largely service the future industrial land use within the upper catchment.

Both the water and wastewater trunk networks will be developed in a staged approach that is timed to meet growth needs by both the private sector and the Hamilton City Council network programmes.

The City Wide Strategic Master Plan identifies that estimated losses from leakages within the Hamilton City Council water supply network, are predicted to exceed recommended levels of service (i.e. leak-free supply) for the Rotokauri area (2014 Detailed Water Supply Modelling Report). There are no other issues attributed to poor LOS in the catchment.

2.5.2 Wastewater network

The network diagram for wastewater infrastructure in Mangaheka catchment and immediate surrounds is provided in Figure 2-9. Wastewater discharge from existing development and planned future industrial development in the Mangaheka Catchment and Te Rapa Northern Extension areas 1C (residential) and 1E will be serviced by the Far Western Interceptor (FWI). The existing FWI is 1050mm in diameter and extends southwest from the Wastewater Treatment Plant (in Pukete) under the North Island Main Trunk Railway to the Te Rapa Bypass where it tracks parallel to the road to within 400m of the Te Wetini Drive Interchange. There are several connection points at manholes along the alignment.

There is approximately 20ha of undeveloped land within the Mangaheka catchment. A new 150 mm pipeline flowing west to the FWI will be required in future to collect flows from this area.

Northern extension 1C

There is approximately 25ha of undeveloped land within the Northern Extension 1C (residential) Te Rapa area, which sits outside of the Mangaheka hydrological catchment but will be serviced by the Far Western Interceptor.

The area slopes to the north which makes the northern extremity too low to be collected directly by gravity (based on existing topography). The area is also too low and far away to gravitate to the east to be collected by a pump station in the northern extension 1E area. As a result, approximately half of this area will be serviceable by gravity network and the other half will require a lift pump station to raise flows up to the gravity network.

The proposed pump station may be able to be eliminated through detailed assessment based on future ground levels or flatter gradients than allowed by the ITS. An increase of approximately 1.5 m in ground level in the northern extent would be required to make gravity collection feasible. The portion serviceable by gravity will require an approximate 225 mm diameter pipeline flowing south to the 600 mm trunk pipeline proposed in the Rotokauri ICMP. The downstream elevation of this is constrained by the existing connection point to the FWI (manhole WWK09003) which has an invert level of 25.64 m. The 225 mm pipeline will also collect pumped flows from the northern half of the area and possibly some gravity flow from the Rotokauri catchment along the alignment.

Northern extension 1E

The northern extension 1E area is an area of land north of Ruffell Road with a total sub-catchment area of approximately 82 hectares.

The area is bisected by the North Island Main Trunk Railway (NIMT) so a pump station is proposed for either side of the railway. An area of approximately 5.7 hectares from the western half is anticipated be serviceable by gravity to the existing network on Ruffell Road. This area has been accounted for in the existing network (see Section 0 Key Operational Issues – Wastewater below).

Immediately south of Old Ruffell Road there is a 7ha wastewater catchment with an existing gravity sewer. The current proposal is to drain this sewer to an interim pump station located 50m east of the North Island Main Trunk Railway (NIMTR) in Ruffell Road. The pump station will discharge via 90mm diameter rising main which is proposed to run for 400m along Ruffell Road to join into the existing manhole WWJ09001 in Arthur Porter Drive. The capacity of downstream network receiving the pumped flows has been assessed (see Section 0 operational issues – wastewater below).

East of NIMT

Approximately 43.6 hectares of the northern extension 1E sub-catchment is located east of the NIMTs (including the 7 hectare area that will be temporarily pumped). This area yields a peak design flow of 18.6 L/s. The area has a central gully with a high bank level approximately 29 m and a base level of approximately 23 m. Based on existing topography the sub-catchment will require a pump station constructed in the low point of the gully with a rising main pumping back up to manhole WWJ09001. The topography is such that a local 150 mm diameter gravity collection network should be sufficient to convey flows to the pump station (subject to detailed design).

West of NIMT

Approximately 38.4 hectares of the northern extension 1E sub catchment, west of the NIMT is not serviceable by gravity. This area yields a design peak flow of 16.3 L/s. The area is generally flat with an elevation of approximately 30 m. The long and narrow sub catchment is suitable for a single central pump station. A central pump station will reduce pipe depths and allow the area to be serviced with one pump station. It may be feasible to locate the pump station at the ends of the area but pipe depths will need to be assessed.

It may be possible to eliminate the western pump station with a gravity network which collects all of the western flows in a central location then flows to the pump station located on the eastern side of the railway. Such a design would have the following implications:

- Eliminate the west pump station
- Increase the design flow for the east pump station. This may also impact the possible discharge connection points for the east pump station.
- A larger rising main and carrier pipe required to cross the NIMT.
- An additional gravity crossing under the railway with trunk main depths potentially in excess of 6m.

The feasibility of the alternative solution could be investigated further by Hamilton City Council or developers once the future network, topography and road layout is finalised.

2.5.3 Stormwater network

Two New Zealand Transport Authority (NZTA) culverts are present in the lower catchment area – one of these allowing passage of the stream under Horotiu Road and one providing a tributary passage under Ngaruawahia Road. One further culvert is present in the upper catchment on Te Kowhai Road as well as four Hamilton City Council culverts. Hamilton City Council culverts are also present on Burbush Road, Old Ruffell Road and Tasman Road. Stormwater channels are present locally in the south eastern corner of the upper catchment. Two NZTA culverts are present under Te Rapa bypass.

There are no known issues attributed to poor LOS in the catchment. Hamilton City Council recoded service requests up to March 2017 indicate routine maintenance only and no ongoing issues. See **Figure 2-10** for the existing and proposed stormwater network in the upper catchment.

Three existing stormwater management devices have been developed within the existing industrial area within the upper catchment. These devices have been constructed independently by developers of the Porter Properties Ltd, Hamilton JV Investment Company and 4 Guys areas. The ownership of the structures will be handed over to Hamilton City Council following completion. Outstanding remedial works have been identified and are captured in Future Actions.

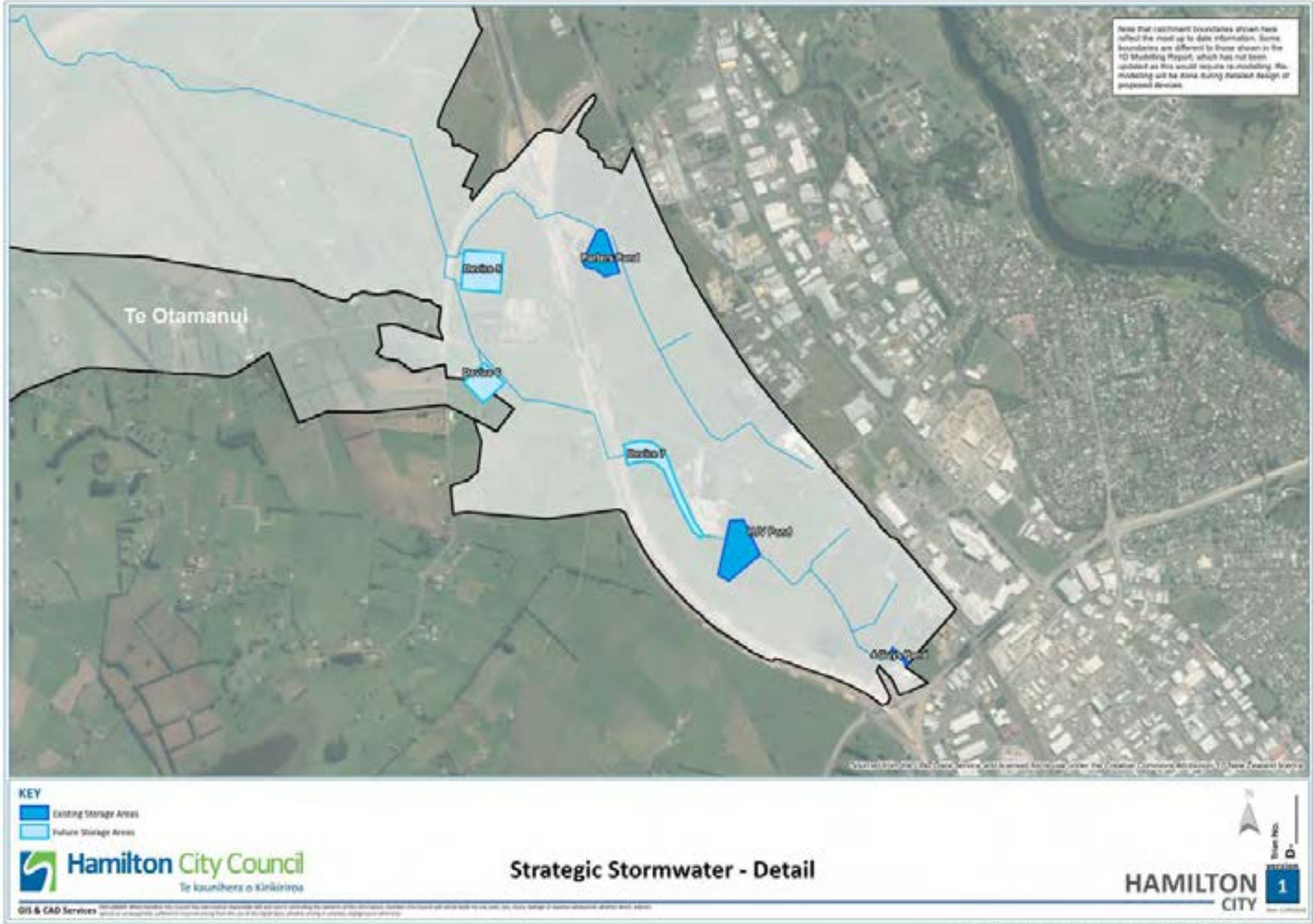

Figure 2-10: Stormwater network – upper catchment

The devices were inspected by CH2M Beca during site visits in June 2016 and a review of the specifications and current condition of each of the devices is provided in the Mangaheka Water Quality Assessment Report in Appendix D. At this time there were some concerns over whether they met the meet the full specification requirements of a TP10 wetland. However, subsequent site visits and device review was carried out during 2018 (refer Appendix N) which identified that the devices are likely to be operating as anticipated and hence are appropriate.

2.6 Surface Water Quantity and Flooding

The planned urban development within the Rotokauri Structure Plan will change the predevelopment runoff characteristics of the catchment. A greater volume of water will flow off the land in the upper catchment area rather than soaking into the catchment's soil as it has previously.

The estimated current impervious area of the full catchment is 9.7 % which includes farm tracks, hardstands, buildings and roads. Under the Operative District Plan light industrial urbanisation is expected to create levels of imperviousness of up to 90% within the portion of the catchment in the Rotokauri Structure Plan area. The total imperviousness of the total catchment will increase to around 14.9 %[17].

Detailed flood modelling has not been conducted for this ICMP, however a 1D stormwater model[18] has been developed with the primary objective of assessing the impacts of future developments (assuming Maximum Probable Development – MPD scenario) in the catchment on peak water levels and flows downstream, and to confirm what is required to mitigate these effects. The 1D model allows an assessment of flooding potential of a watercourse when there is limited detailed information available. The model has been based on a previous model of the Mangaheka Stream, developed by Lysaght[19]. The modelling has taken account of the existing and proposed attenuation devices in the upper catchment.

The modelling includes 10-year ARI scenarios however it focuses on the 100-year ARI event as this governs the overall size of attenuation devices and the design of the device outlet structures.

2.6.1 Flood risk

Hamilton City Council plans to undertake a LiDAR survey of parts of the catchment which could be used to develop a detailed 2D flood model in the future. Once undertaken, Hamilton City Council can programme an update to the current flood extent modelling.

No detailed information is currently available on existing flooding within the catchment. The modelling which includes the impacts of climate change indicates that flooding extents in the stream are anticipated to be very similar to those seen in the existing development 100-yr scenario (**Figure 2-11**), with the exception of increased ponding at the location of the proposed Device 7 and within Porters area.

[17] Values determined as part of the stormwater 1D model development

[18] CH2M BECA, June 2017, Mangaheka Integrated Catchment Management Plan - Stormwater 1D Modelling Report

[19] Lysaght Consultants Limited, November 2012: Proposed Te Rapa North Industrial Development, Stormwater modelling – discharge consent

This similarity between pre and post development is attributed to the design of the proposed stormwater devices, which have been sized to attenuate predicted increased stormwater peak flows. Flood extent maps are included in the 1-D modelling report in **Appendix B**.

2.6.1.1 Mitigation measures

The 1D model predicts that the effect on water levels resulting from MPD can be mitigated by using the existing and proposed attenuation basins such that there is limited additional downstream flooding effect. This mitigation also results in peak flows from the 100yr event which are at or below existing development peak flows (except where increases have been deemed appropriate and acceptable).

One of the overall objectives of this modelling is to confirm that flood levels are not raised by future development. A common method to do this is to reduce peak flows in order to mitigate water level increases.

However due to the flat nature of the catchment (the upper catchment in particular), peak flows do not directly correlate with water levels and therefore it is the water levels that have directly governed the device sizing. This has meant that attenuation requirements (in terms of peak flow reduction) are different for each of the devices due to the differing constraints on each (refer to **Table 6-2** Design Parameters).

2.6.2 Erosion risk

As noted in Section 2.3.2 (Watercourses), downstream erosion of the stream banks appears to be ongoing as a result of a combination of factors including stock access, over spraying and smaller flooding events rather than being the result of larger flooding events such as those investigated by the 1D flood model. The model does not address potential erosion in the Mangaheka stream such as the potential for destabilisation to stream banks and beds resulting from any increased flows and runoff volumes associated with the anticipated increased impervious areas of future light industrial / commercial development - the Hamilton City Council District Plan allows up to 90% impervious surfaces within a development area. The model has however been used to determine the required size of the centralised wetlands in order to minimise peak flows and hence reduce flood and erosion risk.

2.6.3 Land drainage effects

The lower Mangaheka catchment falls within the area administered by Waikato Regional Council.

Potential effects of urbanisation within the upper catchment that may impact on rural land drainage include capacity issues, ponding after rainfall for longer periods, bank instability in waterways, and increased operation and maintenance requirements. Flow volumes are predicted to increase due to urbanisation, therefore it is recommended that a funding mechanism is developed by Waikato regional Council and Hamilton City Council to ensure funding of the waterways maintenance and management is distributed equitably.

Operations and maintenance and minor Capex (capital expenditure) costs are likely to increase with urbanisation as a result of:

- Increased vegetation management
- Erosion protection works to repair existing areas of the stream affected by erosion
- Culvert enlargement of existing structures if required
- Channel widening and associated land take and compensation

Stream bank stability may be affected by increased flow velocity, frequency, and duration. However, the proposed wetland and swale devices are expected to attenuate peak flows.

Where it is identified that stormwater discharges will have an effect on aquatic habitat and water quality values habitat enhancement shall be included as a mitigation measure via riparian planting and/or stream works as appropriate. Flow conveyance beneath road corridors will be required to maintain land drainage.

Ongoing access to watercourses within the WRC administered drainage area is required and will be addressed at the detailed design stage for the capital works, to ensure operation and maintenance activities can be undertaken. This applies to ensuring proposed riparian planting and fencing enables ongoing access. Review and approval of the proposed works is required by the WRC Drainage Manager.

2.6.4 Hydraulic analysis

2.6.4.1 Culvert capacity

Detailed assessment of the culverts associated with Mangaheka Stream has not been conducted, however, an indication of each culverts capacity to convey predicted stream flows during storm events is provided by the 1D modelling assessment.

Major Mangaheka Stream culverts are identified beneath the following roads:

- Arthur Porter Drive
- Te Rapa bypass
- Te Kowhai Road
- Koura Drive
- Horotiu Road
- Ngaruawahia Road

The 1D modelling report indicates that culvert capacity restrictions beneath Te Rapa bypass (after the proposed Device 7); Te Kowhai Road, Koura Drive and Ngaruawahia Road could lead to localised flooding on their upstream side, however, it has not been assessed if any of these would lead to overtopping of the roads – except at the bypass which is confirmed to be at an adequate level to avoid overtopping in the 100 year event.

2.6.5 Flooding duration

When assessing network capacity the modelling indicated that the proposed mitigation devices do not result in overbank flooding with a duration of longer than 24 hours. This is a key requirement of Land Drainage Board managed by WRC to avoid areas of farmland from being affected by surface flooding for longer than 72 hours which can lead to grass die-off.

2.6.6 Overland flow

Stormwater runoff that exceeds the capacity of the reticulation system is required to be safely conveyed by overland flow paths (OLFP's).

To prevent localised flooding as an area is developed, both previously identified and newly identified OLFP's need to be incorporated into the design and layout of subdivisions. Some of these OLFP's have been identified and mapped while others may not have been identified to date. Overland flow paths shall be provided to convey flows in excess of the design storm, up to and including the 100 year ARI event. Roadways will form these secondary flow paths as far as possible. However, where necessary, overland flow paths required over private land will be formally recognized and protected as part of the consenting and construction processes.

Three potential overland flow paths, during large storms, have been identified associated with the upper catchment (refer **Figure 2-12**). It is considered that the Mangaheka Stream could potentially overflow into the Te Otamanui catchment as a result of flooding around the culvert exit beneath Koura Drive.

This periodic connection between the streams would likely have occurred more frequently in the past prior to Koura Drive being constructed. However, now, it is anticipated that floodwater would flow up the swale on the west side of Koura Drive and overflow westwards into the path of Te Otamanui Stream.

Another overland flow path from Rotokauri catchment is anticipated likely to occur should the culvert below Exelby Road become blocked during heavy rainfall. The blockage could lead to a backing up of the stormwater in the Rotokauri swale culminating in overflow approximately halfway between Burbush Road and the Te Rapa bypass. The predicted flow path is visible as an established feature on satellite imagery indicating that this has occurred in the past.

The OLFP from the Porters Wetland needs to be considered during the development of that land when it occurs, in particular the depth and extent the water would pond after overtopping the road.

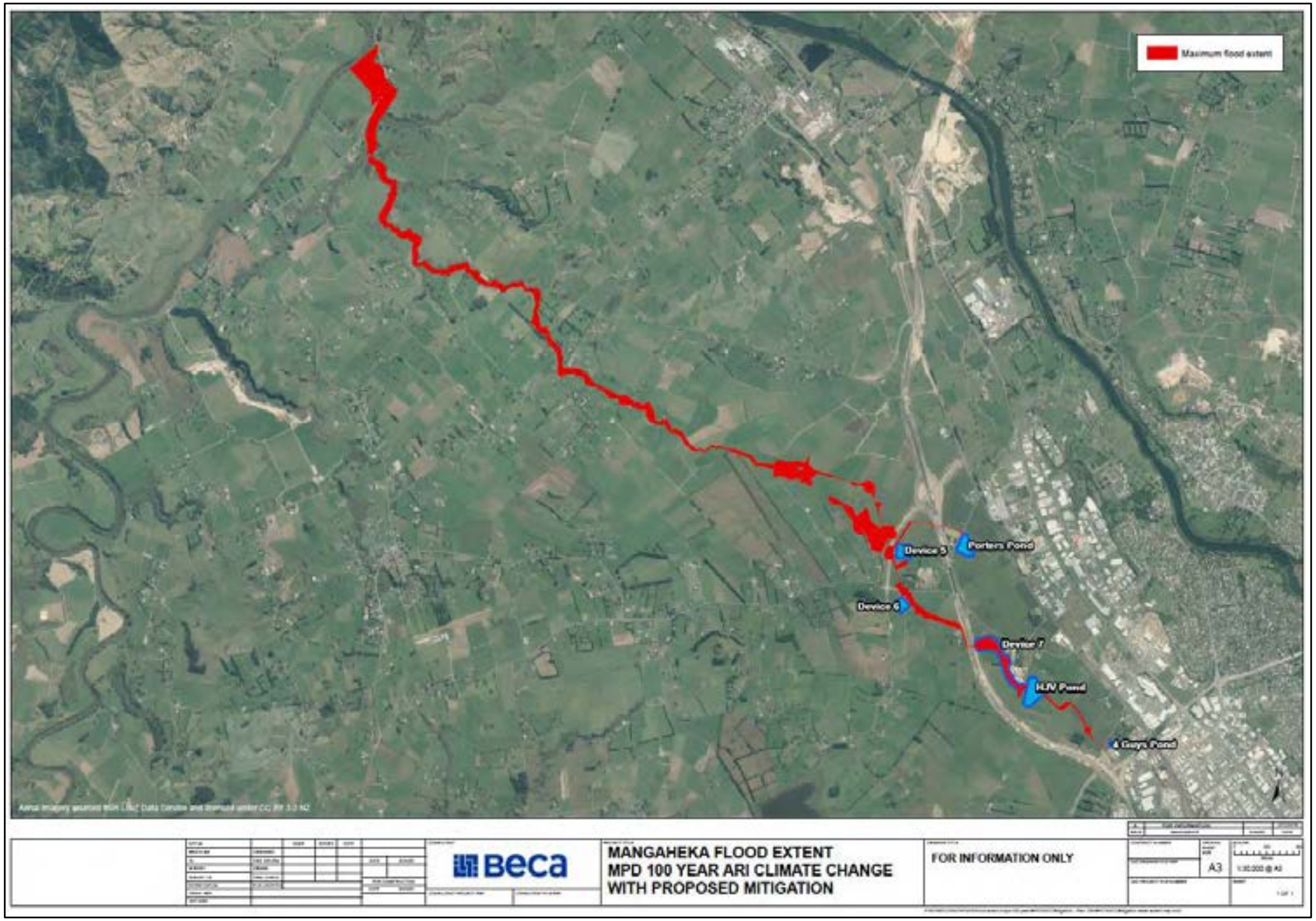

Figure 2-11: Predicted 100 year ARI event flooding extent within the Mangaheka catchment

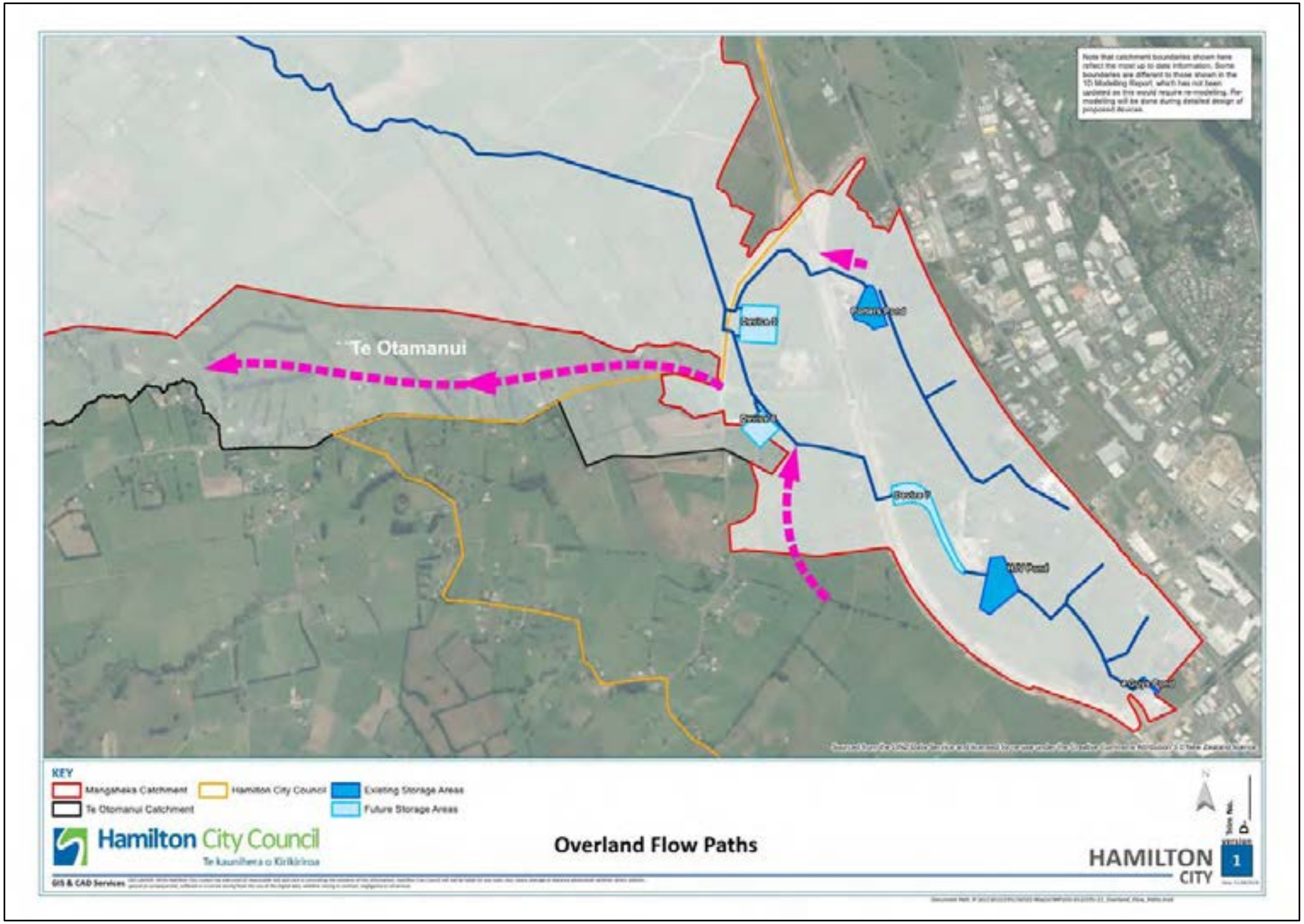

Figure 2-12: Overland flow paths into and out of Mangaheka catchment

3 Issues and Objectives

This section discusses outcomes and issues identified through the technical assessments undertaken for this ICMP, and compares existing and proposed infrastructure to the Strategic Catchment Objectives detailed in Section 1.7. Specific consideration of relevant requirements of the Hamilton District Plan (HDP) and the Rotokauri Structure Plan (RSP) which applies to part of the upper catchment.

The following represents a brief summary of the key findings of the technical assessments in terms of issues to be considered, for which the detailed reports are provided in the appendices to this ICMP.

To put the findings of the technical assessments in context, the key issues associated with the Mangaheka Catchment and its development are:

- **Flood Control -** Increases in flows, stormwater discharge volumes and stormwater drainage pathways could potentially lead to increased flooding

- **Stream Erosion/Watercourse Management -** Increases in stormwater volumes could potentially lead to erosion downstream

- **Water Quality and Contamination Removal –** Changes in landuse from rural to commercial / light industrial area is anticipated to lead to increased/changes in contaminant loads in stormwater with potential knock-on effects for aquatic habitats and species

3.1 Background Context

A number of studies have been completed previously within the Mangaheka catchment relating to proposed development together with periodic monitoring such as ecological and environmental indicators in the Mangaheka stream. Available reports and data have been reviewed to assist in building a picture of current environmental and developmental conditions in the catchment. In addition, the RSP provides information on part of the upper catchment; and details development zones and intended growth of the area and surrounds. The main documents used to inform this section are listed below:

- Morphum Environmental Ltd, May 2017: Mangaheka Watercourse Assessment and Programme of Works
- Boffa Miskell, July 2018: Mangaheka Stream Assessment of Ecological Values to inform an Integrated Catchment Management Plan
- Beca 2001: Rotokauri Structure Plan: Environmental Opportunities, Constraints and Urban Needs Assessment (Phase 1 Report).CH2M Beca, May 2017a: Te Otamanui Fatal Flaw Assessment
- CH2M Beca, June 2017b: Mangaheka Integrated Catchment Management Plan - Stormwater 1D Modelling Report
- CH2M Beca, February 2018a: Mangaheka Water Quality Assessment
- CH2M Beca, July 2018b: Mangaheka ICMP – Addendum to Water Quality Report
- Porters Group Limited and Hamilton Joint Venture Limited, March 2015: Upper Mangaheka Draft Integrated Catchment Management Plan

- Nga Mana Toopu O Kirikiriroa, July 2004: Te Rapa Bypass Investigation - Cultural Investigations Report
- Beca, April 2018, Desktop Hydrogeological Assessment

The subsequent focus of the ICMP has been on the requirements needed to limit impacts from changes in stormwater composition and flows associated with development in the upper catchment. This is considered further in the Assessment of Environmental Effects (Appendix F) which has also informed this section.

3.1.1 ICMP development

Based on information known about the catchment, issues have been identified that require management under this ICMP.

Operational Objectives will address the specified issues and align with Strategic Objectives of this plan. The strategic and operational objectives will be continually reviewed via ongoing consultation with key stakeholders and land owners to ensure they remain relevant.

In some cases there may be a conflict between developmental yield targets and environmental requirements. There is a clear expectation that in meeting development targets permitted by the District Plan, the receiving environment will not be further compromised. Further, given the ecological significance of the catchment as a habitat for threatened native aquatic species, preference must be given to those methods that enhance water quality and habitat values.

3.2 Key Operational Issues - Stormwater

Urban development within the Hamilton City Council portion of the catchment will increase the amount of impervious surfaces such as roofs and roadways and can lead to increased runoff, increased flow velocities in streams, extended duration of peak flows and potentially destabilisation of the stream banks. The following identified operational issues have the potential to impact on the way stormwater is managed and dealt with within this catchment. These are:

(a) Limited stormwater capacity of Mangaheka stream and erosion risk

In the upper catchment, and the upper part of the lower catchment, the modified stream channels are typically small and have steep banks which are already susceptible to erosion as identified in the watercourse assessment[20]. It is anticipated that any increases in stream flow volumes will lead to an increase in erosion of these banks. A lack of riparian vegetation on the stream banks in all parts of the catchment other than the wetland will also potentially exacerbate erosion of the banks via overland flow and soil saturation in these areas.

Mitigation works will be required along the stream to reduce the potential for erosion, particularly in consideration of the proposed development upstream and associated future stormwater flow volumes. Minimum mitigation works include a fenced 3m buffer with selective planting to improve bank stability and bank toe protection (see **Table 6-4**: Future actions). Need to ensure ongoing access to watercourses is

[20] Morphum Environmental Ltd, March 2017: Mangaheka Watercourse Assessment and Programme of Works

retained for operations and maintenance and approval of WRC Drainage Manager of any proposed works within WRC administered drainage area.

(b) Flood risk

Continued urbanization of the industrial area in the upper catchment is anticipated to significantly increase annual flow volume discharging from this area (due to impervious roofs, roads and pavement areas), as a result of the developable area being up to 90% impervious as per the Hamilton City Council District Plan. The 1D modelling indicates that with the stormwater management devices in place, peak flows will not be significantly different than the pre-development conditions, with drain down times within appropriate timeframes (CH2M Beca, 2017b). The effects of flooding following development is anticipated to be less than minor. The size of the proposed attenuation devices has been based on the 1D modelling results and this is key to minimizing changes to subsequent storm flows downstream. The effect on storm flows from the anticipated change in land use is considered to be mitigated by the combination of on lot water detention measures and attenuation devices. While the Hamilton City Council District Plan allows up to a maximum of 90% impermeable areas, developers will be encouraged to reduce impermeable areas, providing soakage opportunities, where possible, in order to further reduce peak flows and supplement baseflows during dry periods and particularly during times when the farm drainage channels typically dry up.

The 1D flood model indicates that a no more than minor change in flood risk is anticipated under MPD compared to existing development levels. Runoff, ponding, overland flow and infiltration in agricultural areas in the remainder of the catchment is unlikely to change significantly as long as there is no significant change in land use in this area.

(c) Soakage capacity

Peaty soils are recorded to be present over much of the upper catchment area, however, due to existing and planned development of the industrial area it is expected that much of the peat soils north of the Te Rapa bypass will have been, or are planned to be, removed prior to establishment of appropriate building platforms. Peat soils are anticipated to remain in the area of the upper catchment to the south of the bypass.

Overall, the soils in the catchment are recorded to be of poor drainage capacity hence soakage will generally be limited. However, where peat soils are still present these are anticipated to help provide some contribution to base flow in the modified watercourses and the Mangaheka Stream. Well drained soils from rhyolitic tephra are recorded to outcrop locally and so it is considered that some soakage opportunities are likely to be available in the upper catchment. Geotechnical investigation, including assessment of groundwater conditions will be required to assess soil drainage characteristics prior to development to confirm opportunities for soakage, as well as to inform wetland/attenuation pond design.

(d) Ecological values

The catchment has a predominantly rural land use with little or no native vegetation remaining therefore the ecological values of the catchment are moderate in line with the surrounding similar catchments in the Hamilton area. The Mangaheka stream catchment is considered to be on-par with other Hamilton waterways with a moderate to poor water quality, peat-influenced groundwater baseflows and a low macroinvertebrate community index. Nonetheless it is recorded to provide habitat for three native fish species: longfin eel, shortfin eel and banded kokopu and potential habitat within parts of the stream for threatened black mudfish. It is also noted that the giant kokopu is present within the adjacent Rotokauri Catchment.

The chemical composition of the stream waters are already recorded to contain nutrients, metals and faecal pathogens. The contaminant load used in the addendum water quality report (CH2M Beca, 2018b) included recent monitoring data collected for the Hamilton City Council Comprehensive Stormwater Discharge Consent (T+T, 2017) which provided up to date Hamilton specific data for an existing industrial area. An analysis of the water quality of Hamilton's rural, semi-urban, and urban waterways, shows that although total contaminant loads may increase following urbanisation, contaminant concentrations can be expected to remain similar to pre-development due to the release of metal loads from historic wetland areas into groundwater. This is supported by the average total copper, lead, and zinc concentrations being very similar to the median total concentrations of 28 samples taken at 20 rural waterways close to Hamilton, each with little or no urban stormwater discharges (Boffa Miskell, 2018).

The expected water quality of the industrial stormwater discharges is likely to be improved for nutrients and sediment, maintained for zinc, and slightly degraded for copper but within the tolerances of the aquatic species present (Boffa Miskell, 2018). This view on the contaminant load generally aligns with the findings of the water quality addendum report.

Maintaining the planned and existing wetlands within the catchment is considered appropriate to reduce the vulnerability of the catchment to detrimental effects. To avoid potential thermal pollution, stormwater treatment devices must avoid open water areas and achieve wetland/riparian plant cover >80% to maintain cool downstream temperatures (Boffa Miskell, 2018).

(e) Sediment

Sediment arising from earthworks and construction can have detrimental effects by smothering the stream's aquatic habitat. It is important that development provides appropriate local treatment to minimise any potential effects of sediment from earthworks activities and subsequent construction activities on stormwater runoff and discharges to the stream. All activities will need to ensure adequate on-lot sediment and erosion control measures are in place. Effective monitoring and enforcement of this is required by the relevant bodies.

As noted in Section 2.3.5.3, the species currently present in the stream are considered to be pollution tolerant. While the water quality for the stream is anticipated to improve overall, Boffa Miskell (2018) note that enhancement of habitat is an important factor in species protection and in the case of the Mangaheka Stream, is likely to have a greater influence than water quality alone.

(f) Risks to public health and safety

While waterways are viewed as both a stormwater asset as well as an amenity feature to the community, some stormwater assets are inherently risky to public safety. The public can access lined channels, deep ponds, inlets and outlets, and on occasions manhole lids can lift. It is important that the stormwater network, especially in urban/future urban environments, is provided in a manner that minimizes the risk to the public health and safety, and adequate consideration is given to the design of such features. Large areas of standing water associated with detention devices that are not shallow wetlands can also be a hazard.

The faecal pathogen load is recorded to be high in the stream (as per other catchments in the Hamilton area) and hence this currently poses a risk to both the public and livestock.

Considering the proposed wetlands and the transition of land use in the upper catchment from agricultural to light industrial / commercial, discharges from the upper catchment are anticipated to be improved for nutrients and sediment, and maintained or slightly degraded for metals (Boffa Miskell, 2018) compared to the existing conditions. The potential for bioaccumulation of metals within aquatic plants and fish within the stream which may then be used as a food source may remain a potential risk to human health. It is noted in the Boffa Miskell 2018 report, that metals concentrations recorded in the stream currently already exceed ANZECC thresholds for dissolved zinc and copper, however, the report also states that the toxicity of metals is likely to be limited by formation of mineral complexes with phosphorus and organic material, meaning the bioavailable dissolved form of metals in the water column is likely to be low.

(g) Maintenance of proposed devices

In order to maintain the flood capacity; Operations and Maintenance Plans for devices shall recognise the flat gradient of the upper catchment outlets and ensure downstream restrictions are identified and removed on an on-going basis. This will maintain hydraulic capacity and control water depth to allow plant growth in the upstream devices.

This issue was highlighted in an assessment which took place in May 2018, where the drain between Waikato expressway and Koura Drive had sections that were choked with weeds and had stream bed high points which required re-profiling.

The nature and frequency of routine maintenance needs to be factored into device selection in conjunction with access and traffic management requirements. An issue for on lot devices is the ownership and maintenance responsibility (including stormwater collection for re-use). The effect of maintenance, plant control, or lack thereof, on the receiving network, environment or public health must be considered where on lot devices are proposed.

Ongoing access to watercourses within the WRC administered drainage area is required and will be addressed at the detailed design stage for the capital works, to ensure operation and maintenance activities can be undertaken. This applies to ensuring proposed riparian planting and fencing enables ongoing access. Review and approval of the proposed works is required by the WRC Drainage Manager.

(h) Economic constraints

The stormwater disposal network needs to be provided in a cost effective manner to Council by making use of natural land features and existing disposal systems. Land developers must provide an efficient stormwater management asset. It is expected the future wetlands will have economies of scale. Collaboration with other developments should be investigated and implemented if feasible.

(i) Land drainage area requirements

The stormwater infrastructure proposed for development must take into account and mitigate potential impacts on downstream rural land and landowners. Potential impacts identified in the Waikato Regional Council Technical Report on Managing Landuse Change include:

1. Capacity issues.
2. Areas ponding for longer than 3 days
3. Bank and channel instability
4. Increased inspection and maintenance requirements.

The required Level of Service is to remove ponding from a storm with a 10% probability of occurring in any one year (the 10% Annual Exceedance Probability (AEP) event or ‘10 year storm’) within three days.” This level of service will need to be maintained post development using proposed mitigation measures and as shown within the network capacity model. The 1D modelling conducted to inform this ICMP determines that drain down times (following MPD and mitigation) will meet the required level of service. In the area of Horotiu Rd, for example, drain down times are reported as 11 hours and 5.5 hours for a 100 year and 10 year event respectively. This indicates that grass die back will be avoided.

3.3 Key Operational Issues - Water

(a) Water capacity

The main area for development will be in the upper catchment and predominantly in the industrial area. There are currently water mains installed in the industrial area ready for connection by developments. It is expected that water capacity will be sufficient for development of the upper catchment. The development of wet industries in the industrial area is not expected and has not been considered at this stage. The presence of wet industries would potentially have an impact on the water capacity. Water strategic infrastructure solutions have been identified and will be implemented by 2025.

(b) Water allocation and pressure

While achieving the Level of Service for the water network is not likely to be a problem, water conservation, non-revenue water and demand management measures will always need to be considered and implemented in order to be resilient and cost effective. Key Operational Issues – Wastewater Existing serviced areas have been assessed for their compliance with the ITS and suitability for conveying flows from other sub catchments (based on current Hamilton City Council GIS asset data). Collection and distribution networks should generally emulate the existing city network in order to maximise commonality and efficient maintenance (i.e. conventional gravity sewers).

3.4 Key Operational Issues – Wastewater

Existing serviced areas have been assessed for their compliance with the ITS and suitability for conveying flows from other sub catchments (based on current Hamilton City Council GIS asset data). Collection and distribution networks should generally emulate the existing city network in order to maximise commonality and efficient maintenance (i.e. conventional gravity sewers).

(a) Mangaheka existing network 1 (Arthur Porter Drive & Chalmers Road)

This area has three lengths of 150 mm diameter gravity pipeline flowing south to the FWI. The three branches were assessed based on the average grade and the as-built drawing for the sub-division. Overall, it is concluded the pipe capacity is sufficient for sub-catchment area, although the pipe grade is flatter than ITS standard of 0.55% for 150 mm diameter pipes, 0.33% for 225 mm diameter pipes (AECOM 2017).

(b) Mangaheka existing network 2 (south of the FWI)

This area has a central gravity pipeline 150 mm and 225 mm in diameter. The pipeline flows north to the FWI. This gravity pipeline has been assessed as two lengths based on the average grade and the GIS pipe diameter. Pipe capacity is sufficient however pipe grade is flatter than ITS standard of 0.55% for 150 mm diameter pipes (AECOM 2017). The network constructed in this area appears to have sufficient capacity and depth for future development. The upstream reaches of the trunk main are however flatter than the ITS standard.

(c) Mangaheka existing network 3 (north of FWI)

This area has a central gravity pipeline 300 mm and 375 mm in diameter. The pipeline flows south from Ruffell Road to the FWI. This gravity pipeline has been assessed as two lengths based on the average grade and the GIS pipe diameter. The upstream end of the 375mm pipeline is assumed to be the intended future connection point for pumped flows from the northern extension 1E sub-catchment. The upstream end of the 300 mm pipe could also be used as the connection point so has also been assessed for capacity to take pumped flows.

An additional 5.7 hectares of the southern end of the northern extension E1 zone may be able to be serviced by gravity network to this main based on existing topography. Pipes have sufficient capacity and grade to receive pumped flows from the Northern Extension 1E and the local gravity network.

The estimated catchment areas used for the assessment total 79.5 hectares from the following areas:

- 43.6 hectares pumped from the northern extension 1E east of the railway.
- 38.4 hectares pumped from the northern extension 1E west of the railway.
- 5.7 hectares of gravity network from the northern extension 1E west of the railway.
- 35.1 hectares of local gravity flows from Existing Area 3.

The network constructed in this area appears to have sufficient capacity and depth for future development. The upstream reaches of the trunk main are however flatter than the ITS standard.

(d) Pump stations

Due to the existing low lying terrain 3 indicative pump stations design parameters and locations have been assessed, together with emergency storage (AECOM 2017). These are provided in more detail in **Appendix K**.

(e) Wastewater conclusion

The majority of the Mangaheka catchment already has gravity trunk network installed or planned. Existing serviced areas have been assessed for their compliance with the ITS and suitability for conveying flows from other sub catchments. Preliminary pipe sizes and strategic network layouts have been identified for the areas where no existing network is installed or planned. The key findings of the assessment are as follows:

- Existing network generally has sufficient capacity for future flows with most pipes meeting or coming close to having capacity for ITS flows. There are however instances where there the ITS minimum gradients are not observed and may require operational cleaning.
- A pump station will be required for the low lying areas of the northern extension 1C subcatchment. The remainder of this area can be served by gravity connection to the 600 mm trunk identified in the Rotokauri ICMP.

- Two pump stations will be required for the northern extension 1E sub-catchment. It may be possible to remove the western of these two pump stations if a gravity connection can be achieved to the east with a new pipeline under the railway.
- A temporary pump station is proposed to for an existing 7 hectare area of development south of Old Ruffell Road. The rising main will need to be constructed under the railway with a carrier pipe to meet the Kiwirail standards. Design of the carrier pipe should consider the rising main sizing for a fully developed situation.

3.5 Operational Objectives

Operational catchment objectives are designed to more specifically address the issues described above in sections 3.2 (Key Operational Issues - Stormwater), 3.3 (Key Operational Issues - Water) and 0(Key Operational Issues – Wastewater) and align with strategic objectives of this plan (Section 1.7). These objectives form the rationale for the design parameters and means of compliance to ensure issues identified in the ICMP are addressed.

Table 3-1: Operational objectives for Mangaheka catchment

Operational Objective	Description
Operational Objective 1:	**Maintain or Enhance Mangaheka Stream Water Quality**
	a. Contaminants derived from urban or road stormwater are managed through appropriately designed treatment devices, so that any increase in mass contaminant loads and concentrations in the receiving environment following development, are minimised as much as practicable. For general guidance purposes the following guidelines (or updates thereof) are referred: i. For in-stream water quality and comparison with baseline contaminant concentrations: ANZECC, 2000 – 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality' ii. For in-stream sediment quality and comparison with baseline contaminant concentrations: ANZECC, 2000 – 'Australian and New Zealand Guidelines for Fresh and Marine Water Quality / Interim Sediment Quality Guidelines (ISQG)' iii. For treatment device design and performance efficiencies: Hamilton City Council ITS b. Primary stormwater treatment devices must achieve at least 75% sediment removal on an average long-term basis. Devices servicing roading should be suitable for the removal of hydrocarbons and heavy metals. c. To avoid increases in temperature in downstream receiving waterways, open water areas must be avoided in treatment devices and wetland vegetation cover must exceed 80% of the device surface area. d. Where it is shown that a single device will not address receiving environment sensitivities, that a treatment train approach should be adopted and to minimise temperature effects and maximise contaminant removal. e. Construction generated sediment (earthworks and building phase) shall be controlled to meet Waikato Regional Council standards and shall comply with relevant city bylaws and District Plan requirements. *This objective addresses issues d) ecological quality and e) sediment in Section 3.2, and aligns with strategic catchment objective 6 (refer to Section 1.7).*

Operational Objective	Description
Operational Objective 2:	**Minimise Alterations to the Natural Flow Regime**
	a. The erosion and scour of the bed and banks of the Mangaheka stream and other catchment waterways is not increased following proposed development within Hamilton City Council boundary. Where it is identified that stormwater discharges will have an effect on aquatic habitat and water quality values, then additional mitigation measures will be required (e.g. on-lot treatment / detention). b. Where stormwater discharge to the Mangaheka stream needs to occur, extended detention shall be provided by the proposed stormwater management structures in accordance with ITS to control flow velocities and erosion and that the volume control criteria is achieved (as a minimum that the initial abstraction volume is retained, refer to the Waikato Stormwater Management Guideline for further details). c. Energy dissipation and erosion protection measures are provided at all discharge locations, and preference is given to green engineering solutions over hard engineering solutions based on rock and concrete. d. Stream flooding in a land drainage area shall be managed to the extent that the ponding from a storm with a 10% probability of occurring in any one year (the 10% Annual Exceedance Probability (AEP) event or '10 year storm') shall be removed within three days and there is less than minor change from current level of service that is achieved in the drainage area. *This objective addresses issues a) stormwater capacity and erosion, and aligns with strategic catchment objectives 4 and 10 (refer to Section 1.7).*
Operational Objective 3:	**Utilise Water Sensitive Practices**
	a. Where on-lot and soil conditions allow, stormwater shall be discharged directly to ground via soakage. This will minimise increases in discharge volume, help to recharge groundwater, maintain stream base flows, and mimic the natural water cycle. b. The use of 'water sensitive practices' shall be incorporated into the stormwater management approach for the catchment. c. A treatment train approach shall be adopted to reduce contaminant loads as far as practical. *This objective addresses issue a) stormwater capacity and erosion, c) soakage capacity, h) economic constraints and i) land drainage requirements, and aligns with strategic catchment objectives 2, 7, and 10 (refer to Section 1.7).*
Operational Objective 4:	**Promote Riparian Margin Enhancement and Re-Vegetation**
	a. Riparian planting is recommended to be undertaken to mitigate effects of urbanisation in potentially affected areas.

Operational Objective	Description
	b. Stock fencing is recommended to be erected along stream banks to reduce bank erosion as well as help reduce suspended solids and pathogens in the water column. c. Works using natural solutions or green engineering which will enhance habitat and maintain natural stream processes in a soft sediment environment are preferred over hard engineering solutions using rock and concrete. d. Access to watercourses shall be maintained to enable future operation and maintenance activities to be undertaken. *This objective addresses issue d) ecological quality, and aligns with strategic catchment objectives 1, 2 and 5 (refer to Section 1.7).*
Operational Objective 5:	**Have Due Regard for Economic Affordability and Safety**
	a. Proposed stormwater management systems are cost-efficient during long term operation and maintenance. b. Stormwater and wastewater management systems are designed for public safety. c. Where it is shown that a single device will not address flood risk or receiving environment sensitivities, that a treatment train approach, incorporating an approved at source device upstream of a centralised public device, shall be adopted. WRC's preference is for the bulk of at-source devices to be in the public domain where possible, to ensure longevity of devices and appropriate operation and maintenance is undertaken into the future. *This objective addresses issue g) maintenance of devices and h) economic constraints, and aligns with strategic catchment objectives 1, 4, 8, 9 and 10 (refer to Section 1.7).*
Operational Objective 6:	**Protect Cultural Values**
	a. Riparian planting shall be encouraged by Hamilton City Council throughout the catchment in conjunction with developers, landowners, local iwi and other interested parties. Planting shall include an appropriate mix of native eco-sourced plant species. *This objective addresses issue d) ecological quality e) sediment and f) public health and safety, and aligns with strategic catchment objectives 1, 2, 3 and 5 (refer to Section 1.7).*
Operational Objective 7:	**Maintain or Improve Flood Protection Level of Service**
	a. Where existing flooding is known, or potential flooding is predicted, peak flow management is generally required with reduction to 70% of predevelopment flow for the 100 year ARI storm event.

Operational Objective	Description
	b. Overland flow paths shall be provided for all stormwater discharges in accordance with Hamilton City Council standards. Wherever possible, the use of private property for overland flow paths shall be avoided. c. Sufficient freeboard protection, in accordance with Hamilton City Council standards, shall be provided to building floor levels. *This objective addresses issues a) stormwater capacity and erosion b) flood risk, f) public health and safety i) land drainage requirements, and aligns with strategic catchment objectives 1 and 4, (refer to Section 1.7).*
Operational Objective 8:	**Minimise water consumption and wastewater discharge**
	a. That rainwater re-use tanks are installed and plumbed into non-potable water systems on-lot. b. That water efficient fittings are incorporated into businesses and promote sustainable water use practices. c. That the size of infrastructure is minimised by promoting sustainable water use. d. That future infrastructure upgrades are avoided or minimised by identifying and managing inefficiencies such as leakage, inflow & infiltration and unauthorised use. *This objective addresses issues h) economic constraints, j) water capacity, k) water allocation and pressure and l) wastewater network and aligns with strategic catchment objectives 7, 8, and 11 (refer to Section 1.7).*
Operational Objective 9:	**Integrated water management**
	a. Plan and implement three waters networks on a catchment wide basis to minimise the number of public stormwater treatment devices, wastewater pump stations and storage devices. b. Where it is shown that a single device will not address receiving environment sensitivities, that a treatment train approach, incorporating an approved at source device upstream of a centralised public device, shall be adopted and include minimisation of temperature effects, metals, metalloids and PAHs. Construction generated sediment (earthworks and building phase) shall be controlled via appropriate settlement ponds etc to Waikato Regional Council standards and relevant city bylaws. WRC's preference is for the bulk of at-source devices to be in the public domain where possible, to ensure longevity of devices and appropriate operation and maintenance is undertaken into the future. This objective addresses issues a) stormwater capacity and erosion, g) maintenance of devices and h) economic constraints quality and aligns with strategic catchment objectives 7, 8, 9 and 11 (refer to Section 1.7).

4 Stormwater Management

This section identifies options that will meet operational objectives and cover the nature of the discharges arising from development in the Hamilton City Council Mangaheka catchment. Consistency with Hamilton City Council's stormwater management hierarchy and Stormwater Management Plan (SWMP) is required. Options not considered to be viable are not included in the evaluation. Examples which make an option viable include the following:

- Technical feasibility
- Ability to meet relevant legislative requirements
- Consistent with the principles of the Waikato Tainui Environmental Plan
- Aligned with the catchment specific objectives outlined in this document
- Must have better environmental, social or cultural consequences than doing nothing
- Does not contravene any explicitly stated political objective
- Does not result in an increase in risk
- Does not increase health and safety risks compared with doing nothing.

Water sensitive 'principles' are required to be incorporated for all development proposals. Management principles that would apply under a water sensitive approach include:

- Minimise disturbance of soils
- Preserve and recreate natural landscape features
- Reduce effective impervious cover of developments below 90% where possible
- Stormwater disposal should mimic and follow, to the extent possible, the natural drainage processes and pathways that currently exist
- Modifications to existing natural drainage patterns should be kept to a minimum
- Riparian margins to be designated, planted and protected
- Effective impervious area increases should be kept to a minimum
- Disconnect impervious surfaces
- Utilise conveyance and stormwater treatment methods that also provide ecological and amenity benefits (no reticulated stormwater).

4.1 Option Identification- Stormwater

Table 4-1 provides a list of methods that could be used to potentially address stormwater management issues in the catchment, with commentary regarding how the option could be implemented.

Table 4-1: Stormwater management options

Management options	Description	Application in the Hamilton City Council Mangaheka catchment
On lot solutions		
Soakage	Soakage minimises the volume of stormwater to be managed by downstream stormwater management devices and provided for groundwater recharge. Soakage systems need pre-treatment to prevent sediment clogging of the system. Soakage is a useful part of the treatment train approach, and soakage is required to maintain base-flows in south branch waterways.	Intrusive investigation will be required in the upper catchment to confirm soil types and soakage capability. Provision of soakage is encouraged to correspond with associated reduction in impermeable areas on site
Sand Filters	Sand Filters are useful where space restrictions apply and they can be designed to take traffic loads. Sand filters often include a settling chamber for removal of coarse material followed by a tank containing the filter media. Finer materials are trapped or adhere to the filter media. Their limitation is that they can generally only service a small area.	Sand filters could be used for treating water from car park areas on-lot and high traffic use areas such as intersections as expected in industrial developments.
Rain Gardens	Rain gardens are another form of filtration device that use plants and layers of media (e.g. mulch, planting, soils, gravel under drain) for contaminant removal. There may also be detention through slowed infiltration of stormwater to the base of the rain garden, depending on the underlying soils. Rain gardens will be suitable for treating runoff from small areas.	Bioretention devices can be effective in treating water from industrial sites as well as providing some level of detention. These devices could be used on-lot to treat run off from car park and trafficked areas.
Vegetated Swales	Swales use a combination of slow, shallow flow and vegetation to remove contaminants from stormwater. Swales can be used in place of drainage pipes and to convey flood flows. Swales are most effective on gently sloping lots (1%-5%). In general a width of 3-7m is required to accommodate design requirements (maximum side slope 3H:1V). Swales can be used to filter a portion of hydrocarbons, sediments and metals from stormwater. Swales, if	Swales can be an effective on-lot device, however they can typically require more surface area, than say rain gardens, to provide effective treatment.

Management options	Description	Application in the Hamilton City Council Mangaheka catchment
	constructed well, can provide a low-maintenance solution for reducing contaminants in run-off from lots.	
Oil separation	Tanks and/or filters used to segregate oils from stormwater. Several products are available that specifically target oils and greases. Devices are most applicable to areas where this is the contaminant of concern e.g. garages.	Useful for industrial areas dependent on specific on-lot activities planned. This may be needed for High Risk activities (refer Stormwater Bylaw)
Rainwater reuse tanks	Rainwater reuse tanks are above or below ground tanks which are used to store rainfall collected from roof areas for non-potable use inside and outside the building. These tanks can be designed to have two functions. They can reduce the total volume of stormwater which runs off lots, especially from the frequent small rainfall events, and they can be used to reduce the demand for non-potable water use, including toilet flushing, laundry use and garden/landscape watering.	Suitable for residential homes as well as commercial and industrial developments in accordance with the Hamilton City Council Three Waters Practice Notes Hamilton City Council02 and Hamilton City Council05.
Detention	Detention tanks work by temporarily storing the rainwater runoff during a rainfall event and then slowly releasing the water through a controlled small diameter orifice. This storage and slow release of the rainwater reduces the peak stormwater flows during a rainfall event and which in turn reduces the impacts on downstream infrastructure and/or streams.	On-lot detention tanks (developed in accordance with the Hamilton City Council Three Waters Practice Notes Hamilton City Council 05 and Hamilton City Council 06), can aid reduction of peak stormwater flows in the downstream catchment including where on-lot soakage is not available. However, wetlands are also an opportunity for detention.
Permeable surfaces	Permeable surfaces are surfaces which absorb and detain stormwater reducing runoff to stormwater infrastructure. Natural permeable surfaces include grass and landscape and planted areas. Constructed permeable surfaces generally consist of a layered construction to enable rainwater filtration to either ground soakage or an underdrain connected to an approved stormwater outlet.	The first preference is to retain existing natural permeable surfaces, including grass and planted areas. Where hardstand areas are necessary for the development proposal, constructed permeable surfaces can be used that still achieve infiltration of the stormwater runoff to ground.
Building and landscape design	Set floor levels above flood levels and away from overland flow paths. Ensure landscaping (including driveways, walls and structures) does not block, divert or convey overland	Required either specifically under the District Plan or generally under the RMA and/or Building Act

Management options	Description	Application in the Hamilton City Council Mangaheka catchment
	flow in a way that causes ponding or potential flooding of buildings.	
Gross Pollutant Traps and Litter Traps	Devices in this category include floating booms, gratings and mesh inserts installed within ponds, culverts and catch pits. Proprietary products are available that use a combination of hydraulic motion and sedimentation to remove contaminants. Gross pollutant traps or 'catch pits' can provide effective collection of litter, coarse sediments and particulates.	Considered appropriate for on-lot stormwater treatment as the initial part of a treatment train approach, particularly due to litter being an issue in light industrial catchments.
Centralised Devices and Practices (Community based)		
Soakage	Refer to discussion under 'on lot'	Catchpits could incorporate soakage sumps for limited soakage but would still require reticulation.
Rain gardens/ Bioretention devices	Refer to discussion under 'on lot'	Rain gardens could also be used to target intersections for improved water quality should monitoring indicate the proposed wetland devices do not remove sufficient contaminant load.
Reticulation	Reticulation will manage the increased stormwater runoff from impervious areas in a controlled manner and control runoff and nuisance flooding to LOS.	Some form of servicing required as part of development proposal.
Subdivision design for secondary overflow	Secondary overland flow paths are necessary to manage runoff that exceeds reticulation LOS (e.g. 2 year ARI flows) residential Standard.	Required as part of development proposal.
Wetlands (off-line)	Constructed wetlands consist of shallow vegetated pond areas. Wetlands are only practicable where space is available for construction. Wetlands remove contaminants through physical and biological processes. Extended detention can be incorporated to moderate storm flows. Off-line wetlands are reported to typically allow more efficient contaminant removal than on-line wetlands. Constructed on-line wetlands are not supported by WRC.	Wetlands are an appropriate form of treatment within the Hamilton City Council Mangaheka Stream catchment for effective contaminant removal, maintaining low downstream temperatures, and attenuating stormwater flows. Wetlands may also provide or enhance indigenous biodiversity particularly where the historic environments were wetlands as is the case in the Mangaheka catchment. Three wetland devices have already been consented for the catchment, with the detailed engineering plans yet to be approved.
Water quality ponds	Where space is available, ponds can provide flood mitigation and improve water quality by settling suspended sediment. Potential for adverse temperature	Effective at removal of some contaminants but can contribute to reduced water quality for other parameters such as temperature (too high for fish and plants) and dissolved oxygen. Therefore, wetlands are preferred due to

Management options	Description	Application in the Hamilton City Council Mangaheka catchment
	effects. Ponds do not provide the potential contaminant removal capacity of wetlands.	enhanced contaminant removal, maintained water quality, and potential for biodiversity enhancement.
Swales	Refer to discussion under 'on lot'	In general, Hamilton City Council prefers that swales are used only on limited access roads due to public safety and maintenance requirements. However, in the following circumstances, swales may be considered for local roads and residential areas: • Flat land with high groundwater where the fall required for reticulated stormwater is impractical. • Sensitive receiving environments or sensitive indigenous aquatic species located downstream of discharge points requiring high standards of stormwater treatment. • Constrained space or distance within which to achieve stormwater treatment to a sufficient standard using conventional single device-methods.
Filter strips/riparian planting	Filter strips are used to intercept stormwater before it becomes concentrated. The effect of stormwater travelling through the vegetation is to slow down the stormwater allowing some infiltration and removal of contaminants. Riparian planting is a form of filter strip.	Suitable for treatment of diffuse sources of runoff along lengths of a waterway where there is overland flow or shallow sub-surface flow into the waterway, but only in specific circumstances. Riparian planting or filter strips can also contribute widespread habitat, water quality, and bank stability enhancements. Specific methods and plant selection are lot specific but applicable to the main rural Mangaheka waterway downstream of the upper catchment stormwater discharge where there is potential for effects.
Gross Pollutant Traps and Litter Traps	Refer to discussion under 'on lot'	The suitability of devices utilised off-lot needs to be reviewed on a case by case basis. Application for runoff from industrial/commercial areas with high risk activities may be appropriate but are generally considered unnecessary for the proposed residential areas and roading.
Permeable pavements for car parks and footpaths	Special concrete and aggregate mixes allow water to pass through reducing catchment imperviousness, promoting soakage. There may be a need pre-treatment so permeable matrix does not clog.	Application for treatment of runoff from high traffic or industrial/commercial areas may be appropriate but soils in the catchment are generally unsuitable for soakage from permeable paving.

4.2 Option Evaluation - Stormwater

Once the options are identified, they need to be evaluated for effectiveness in addressing the Mangaheka catchment risks and sensitivities and meeting the catchment objectives for stormwater management. To facilitate the option evaluation, assessment components are grouped under the framework of economic, environmental, and social and cultural effectiveness. Those options that rank highest in terms of environmental, economic and social/ cultural benefit will form the basis for the Best Practicable Option (BPO) for the catchment.

The qualitative assessment below shows which options are most likely to address catchment issues and meet objectives in accordance with the requirements of the CSDC Condition 30. Relative life cycle costs are considered for those options delivering similar outcomes. Multiple options may be suitable in each situation, and multiple options will be needed to provide full servicing and a treatment train for the developing areas of the catchment.

The effectiveness of a method with respect to each criterion is indicated by ticks (✓) 0-4; the more ticks listed, the more effective the method in addressing the criterion.

Table 4-2 – Stormwater management option evaluation

Management option	Environmental	Economic	Social, Cultural and Community	Overall assessment and applicability
On lot				
Soakage	Stream channel protection Ground water recharge	Low cost option if soils permit Minimises infrastructure	Very minor flood risk mitigation Reduce discharges at source	Cost effective and provides environmental benefits.
	✓✓	✓✓✓✓	✓	Good where soakage is viable. Contributes to meeting operational objectives 2, 3, 6 and 8.
Sand Filters	Contaminant management for car parks and high traffic	High cost and maintenance		Does not provide sufficient benefits to be widely implemented.
	✓	✓		
Rain Gardens	Contaminant management Reduced discharge if infiltration capability included	Moderate cost and maintenance	Amenity value if well planted	Can provide initial treatment of stormwater runoff together with some level of detention, particularly as part of a treatment train. Requires periodic maintenance to remain effective
	✓✓✓	✓✓	✓✓	Good as part of treatment train
Vegetated Swales	Contaminant management for car parks and high traffic	Low cost and maintenance Typically require more space than other bioretention devices to maximise effectiveness		Can provide initial treatment of stormwater runoff, particularly as part of a treatment train. Requires periodic maintenance to remain effective
	✓✓✓	✓✓✓	✓	Good as part of treatment train
Oil separation	Contaminant management for car parks and some industry	Moderate cost and maintenance		Provides benefit if implemented on-lot for relevant activities.
	✓✓	✓		

Management option	Environmental	Economic	Social, Cultural and Community	Overall assessment and applicability
Rainwater reuse tanks	Reduces impact of built environment on natural flow regime Capture first flush runoff Reduce peak flows for up to 10 year events	Moderate cost and maintenance. Reduces cost of water supply	Can be used for non-potable water supply including garden watering An option to support resiliency and security of water supply	Cost effective and provides environmental and economic benefits.
	✓✓✓	✓✓✓✓	✓	Good as part of treatment train. Contributes to meeting operational objectives 2, 3, 5, 8 and 9.
Detention	Capture first flush runoff Reduce peak flows for up to 10 year events	Relatively low cost		Cost effective and provides environmental benefits.
	✓✓	✓✓✓		Good as part of treatment train. Contributes to meeting operational objectives 2, 3, 5, 8 and 9.
Permeable Surfaces	Mimics natural flow regime	Moderate cost and maintenance	Can provide functional and aesthetic value	Provides some benefits in specific situations
	✓✓	✓✓	✓✓	Possible limited applicability
Building and landscape design		Relatively low cost as part of overall design	Mitigates flood risk associated with overland flow and ponding	High social and economic benefits.
		✓✓✓	✓✓✓✓	Essential to meet objectives. Contributes to meeting operational objectives 5 and 7.
Gross Pollutant Traps and Litter Traps	Contaminant management	Low to moderate cost, maintenance required	Improves visual appearance	On-lot applications can help prevent blockage/ clogging of centralised devices and swales.
	✓✓	✓✓✓	✓✓	Good as part of treatment train.

Management option	Environmental	Economic	Social, Cultural and Community	Overall assessment and applicability
Centralised Devices and Practices (community based)				
Soakage	Stream channel protection Ground water recharge	Low cost option if soils permit Minimises infrastructure	Minor flood risk mitigation Reduce discharges at source	Cost effective and provides limited environmental benefits. Good where soakage is viable.
	✓✓	✓✓✓	✓	Contributes to meeting operational objectives 2, 3, 6, 8 and 9.
Rain gardens	Stream channel protection Contaminant management Reduced discharge if infiltration capability included	Moderate cost and maintenance	Minor amenity provided	Provides some benefits, but other options have scored higher
	✓✓	✓✓	✓	Some applicability
Subdivision design for secondary overflow	Can incorporate bioretention features	Relatively low cost as part of overall design	Mitigates flood risk Minimises infrastructure	
	√	✓✓✓	✓✓✓✓	Essential to meet objectives. Contributes to meeting operational objectives 5, 7 and 9.
Wetlands (with extended detention)	Stream channel protection Contaminant and temperature management Habitat enhancement Some soakage provided	Economy of scale Less maintenance than pond	Mitigates Flood risk Provides amenity Wetland planting supports mauri Shallowness and planting bench make safer than deep pond	High benefits and already consented in catchment
	✓✓✓✓	✓✓✓	✓✓✓✓	Applicable
Ponds	Stream channel protection from flow attenuation Can elevate discharge temperature, reduce	Economy of scale	Mitigates flood risk Can provide amenity	Provides some benefits, but wetlands with detention score higher and alleviate temperature concerns in this catchment.

Management option	Environmental	Economic	Social, Cultural and Community	Overall assessment and applicability
	dissolved oxygen, affect fish passage, and replace stream habitat if online Contaminant management (principally sediment) Some soakage provided unless pond is lined			
	✓✓	✓✓	✓✓	
Swales	Stream channel protection from flow attenuation Contaminant management if densely planted Potential for enhanced indigenous biodiversity if planted	Can reduce reticulation Provide overland flow path	May mitigate flood risk	Cost effective and provides environmental benefits. Good as part of treatment train.
	✓✓✓	✓✓✓	✓✓	Only preferred by Hamilton City Council for limited access roads due to O&M considerations, access complications and conflicts with other services.
Filter strips/riparian planting	Contaminant management Stream protection Riparian planting enhances habitat	Very cost effective if space available	Can provide amenity Riparian planting supports mauri	Provides environmental benefits.
	✓✓✓✓	✓✓	✓✓	Applicable in suitable situations.

Management option	Environmental	Economic	Social, Cultural and Community	Overall assessment and applicability
In-stream channel or riparian modifications	Potential to enhance bank instability Potential to improve aquatic habitat Potential for increased capacity Potential for effects on aquatic life during construction	Can be cost effective if carefully managed	Can be effective in improving cultural and community values on degraded waterways if carefully managed	Must incorporate multidisciplinary approach to design and implementation not limited to a single outcome (e.g. capacity).
	✓✓✓✓	✓✓	✓✓✓	Applicable in suitable situations.
Gross Pollutant Traps and Litter Traps	Contaminant management	Low to moderate cost, maintenance required	Improves visual appearance	Potential for use on centralised devices to capture airborne litter etc.
	✓✓	✓✓	✓✓	Applicable
Permeable pavements for car parks and footpaths	Soakage	Minimise infrastructure	Reduce discharges at source	Does not provide sufficient benefits to be widely implemented.
	✓	✓	✓	

Based on this evaluation the following stormwater management methods are considered suitable to form the Best Practicable Option (BPO):

On lot devices and practices:

The preferred on lot stormwater management for this catchment includes:

1. Pollution Plan (for high risk activities) to inform on-lot requirements for contaminant management
2. Rainwater reuse tanks (mandatory on all industrial lots, it shall be plumbed back into the toilet and laundry with an option for garden use) as per HDP rule 25.13.4.5.
3. Maximisation of soakage opportunities (reduction of impervious surfaces as far as practicable)
4. Standard requirements for all industrial or commercial lots comprise:
   - No exposed zinc or copper building products
   - Gross pollutant traps
   - Carpark areas to drain to stormwater pre-treatment device (e.g swale/ rain garden etc) prior to leaving each lot

Other on lot practices that are encouraged:

1. Appropriate building and landscape design to reduce water demand, and capture and re-use non-potable water on-site.

Centralised devices and practices

1. Wetlands with extended detention and pollutant attenuation
2. Soakage (where feasible)
3. Bioretention/raingardens
4. Subdivision overland flow paths with erosion protection
5. Swales (if appropriate)
6. Riparian Planting

4.2.1 Ownership considerations

Assets that are required to meet a level of service for public good (e.g. centralised wetlands) are generally owned and operated by Hamilton City Council. However private on-lot devices will need to be owned and maintained by the on-lot owner such as on-lot swales, raingardens and gross pollutant traps.

Where assets are to be vested to Hamilton City Council, these must meet Hamilton City Council requirements of meeting levels of service, safety, access, flood risk protection, treatment performance, asset life cycle, operations and maintenance and renewals cost (and meet certification requirements of CSDC).

Where assets are to be privately owned, consideration shall be made for how the asset is to be operated and maintained and standard practice is to place a Consent Notice on the Certificate of Title informing the owner of the requirements. Any communal devices are normally vested, and whether public or private must be at the standard of Hamilton City Council Infrastructure Technical Specifications.

Developers must discuss with Hamilton City Council the intent and options of vestment and private ownership prior to approval of development proposals.

There are some watercourses located in the Mangaheka Stream catchment that are managed by WRC. These are located in the WRC administered drainage area. Within this area WRC manages drainage maintenance activities on behalf of the land owners using targeted rates applied across the drainage area (Refer to **Appendix D**). Collaboration is required between Hamilton City Council and the drainage board regarding watercourse performance and future maintenance see Section 6.6 - Future Actions.

4.3 Best Practicable Options (BPO) - Stormwater

This section presents the BPO for the catchment. It includes criteria for managing the discharges that are expected to occur with development in the Hamilton City Council Mangaheka catchment. The BPO organises and integrates the management options, existing standards and consented devices into a servicing approach that addresses issues and objectives in the catchment. This integrated approach to managing stormwater diversion and discharge activities is a key requirement of the CSDC Condition 30.

4.3.1 Flood management

Three existing consented stormwater treatment and attenuation devices are already consented within Hamilton City Council's jurisdiction to manage stormwater from development in the catchment (refer **to Figure 4-1**). As these are already consented and meet identified flood and network mitigation objectives, they will necessarily form part of the BPO and be reflected in the Means of Compliance table. Stormwater runoff associated with roading projects included in the structure plan is expected to discharge into the existing and proposed catchment devices via a swale network. BPO 1 is intended to provide the practical measures to give effect to Strategic Objective SO4 (Stormwater Management).

Stormwater BPO 1 – Maintain the existing flood protection Level of Service

a. Due to flood risk, topography and downstream capacity of the Mangaheka stream, flood control shall be installed so that the 100 year ARI post development peak flows are attenuated appropriately as described in the means of compliance table (Table **6-3**).

b. Each sub-catchment in the Mangaheka catchment shall be designed with suitable overland flow paths. Where feasible, overland flow should occur within the roading network or through designated paths in public reserve. If needed, suitable energy dissipation and/or erosion protection measures shall be provided.

c. Sufficient freeboard protection, in accordance with Hamilton City Council standards, shall be provided to building floor levels.

d. The stormwater system shall drain to the receiving environment firstly via soakage as far as possible and on-lot treatment (including gross pollutant traps and swales/rain gardens) prior to discharge into a centralised device. Refer to **Figure 2-9** for existing and indicative location of devices in the development areas.

e. Soakage and attenuation solutions must be designed to ensure no adverse effects to the WRC administered rural drainage areas and to ensure existing levels of service can be maintained. The level of service for flooding in the agricultural areas of the Mangaheka catchment is to be maintained, that is: remove ponding from a storm with a 10% probability of occurring in any one year (the 10% Annual Exceedance Probability (AEP) event or '10 year storm') within 72 hours.)

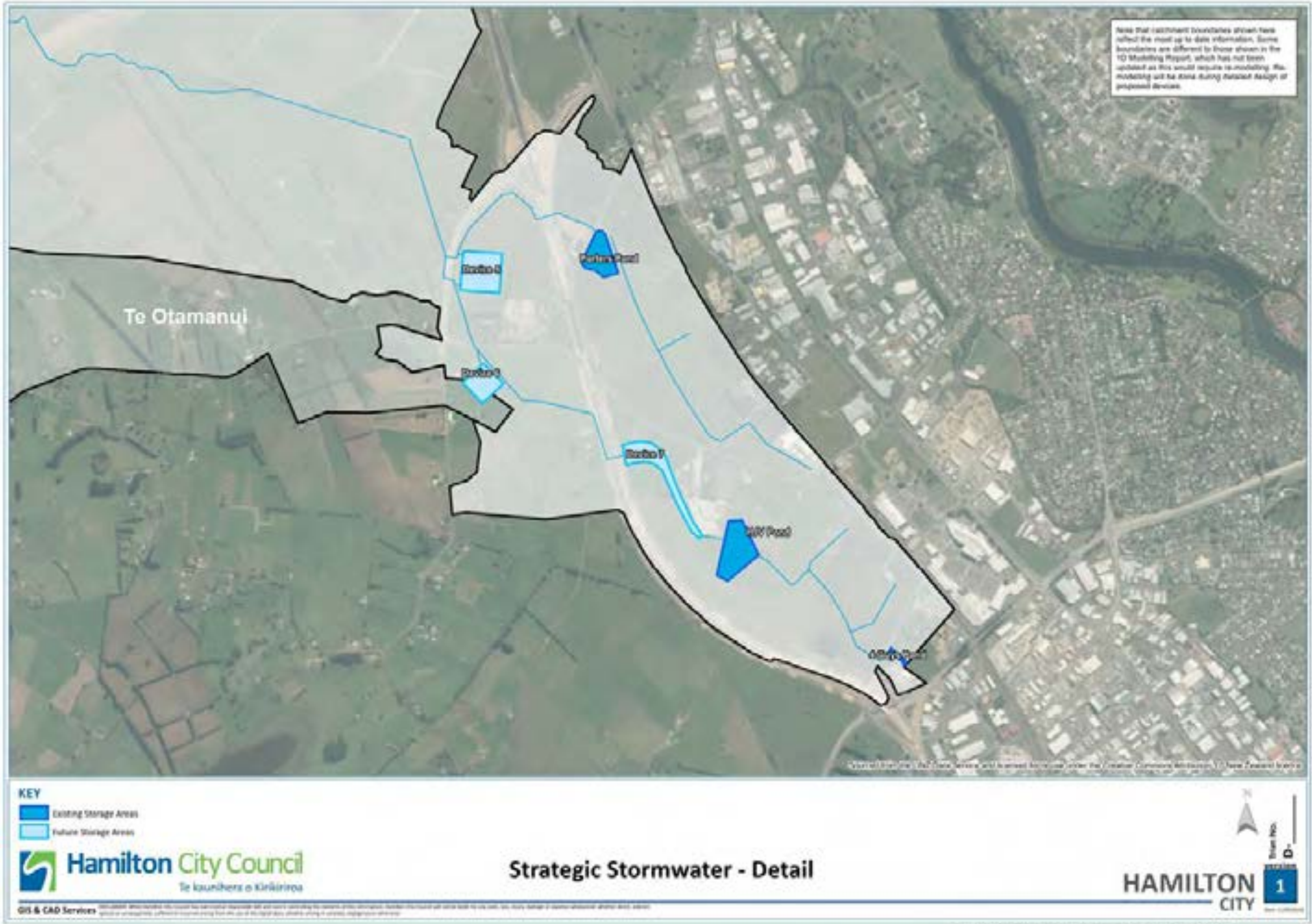

Figure 4-1: Stormwater devices in Mangaheka upper catchment

4.3.2 Water sensitive design

Water sensitive works include multiple site-specific stormwater controls that work with the natural landscape and are relatively cost effective. Water sensitive principles must be a part of the design philosophy in order to meet Strategic Objectives SO4 (Stormwater Management), SO6 (Potable Water Management), and contribute to meeting SO7 (Three Waters Management). Most water sensitive methods assist in controlling runoff at the source in order to replicate the predevelopment hydrology as much as possible. Controlling water at the source reduces the stormwater network requirements and may lower costs for developer and the Council. As shown in the option evaluation, options that meet a number of stormwater objectives, are cost effective and that can form part of a treatment train are ranked high and considered suitable for the Mangaheka catchment. Therefore the next two BPOs for the catchment are:

Stormwater BPO 2 – Water efficiency measures

a. Developers are to consider opportunities to implement water sensitive urban design approaches such as on-lot devices, permeable paving, minimising impervious areas and clustering development to retain larger natural spaces within the built form.

b. Water efficiency measures shall be incorporated as part of any new development within the Hamilton City Council boundary, in accordance with HDP 25.13.4.5a and 25.13.4.6. For developments that fall under rule 25.13.4.5a, all measures within the supporting practice notes are considered suitable for the developable area. In accordance with Hamilton City Council's drainage hierarchy, (ODP and ITS) the highest priority for stormwater management from domestic roofs is to capture and re-use rainwater for non-potable uses (e.g. toilets etc and watering landscaped areas) and it should be noted that this is mandatory for industrial lots, requiring resource consent, followed by soakage and then detention.

c. The opportunity to reconnect stormwater discharges to the Te Otamanui subcatchment is investigated.

Stormwater BPO 3 – Stormwater and soakage opportunities

a. Developers shall undertake sufficient testing to determine if suitable soakage characteristics are present before a piped network is approved. Where soakage is suitable, on-lot soakage shall be the water efficiency measure at the time of Building Consent. See Table 6-3 – Methods to achieve compliance. Pre-treatment will be required prior to soakage discharge to prevent sediment clogging of the system.

b. Where peat or peaty soils are present, these soils should be retained where possible and on-lot drainage designed to maintain these soils and associated soakage.

c. On-lot rainwater re-use tanks should be used to facilitate retaining the initial abstraction volume of the site during a storm event.

d. A development shall attenuate the 2 and 10 year, 24 hour post development events to pre-development levels and attenuate the 100 year, 24 hour post development event to appropriate requirements for specific devices. These calculations should be carried out during detailed design for individual developments.

e. Stormwater devices shall continue to discharge surface waters to the Mangaheka catchment waterways to maintain base flows in downstream ecologically significant habitats.

f. Suitable energy dissipation and erosion protection measures shall be provided at all discharge locations, with preference for natural solutions or green engineering appropriate to the soft sediment environment over hard engineering solutions (e.g. using rock and concrete).

g. All new development shall provide extended detention and volume control in accordance with the ITS and WRC's Waikato Stormwater Management Guideline.

4.3.3 Environmental protection

The environmental state of the Mangaheka catchment and downstream areas has already been modified through long term agricultural activities and land drainage. The nature of the stream channels are described in Section 2.3.2. With the change in land use from rural uses to industrial development, further environmental damage could occur but there is also the opportunity for environmental enhancement values. The following BPOs are intended to allow development to proceed while maintaining and enhancing environmental values where practicable, meeting Strategic Objectives SO1 (Protect Freshwater Systems), SO2 (Protect Terrestrial Systems), SO3 (Kaitiakitanga), and SO8 (Tangirau wetland function and health is protected and enhanced).

Stormwater BPO 4 – To Maintain or Enhance Mangaheka Stream Water Quality

a. Attenuation will be provided through the swale network and central device.
b. No exposed zinc or copper building materials
c. On-lot containment of gross pollutants / improvement of water quality will be achieved through an appropriate at-source device.
d. Swales and wetlands will be designed to remove 75% of suspended solids prior to discharge into the Mangaheka stream.
e. Wetlands will be designed as far as possible to limit the temperature of discharges at the point of discharge with a water temperature increase of no more than 3° Celsius.
f. Wetlands shall be designed to achieve appropriately lowered concentrations of copper and zinc commensurate with greenfield catchments prior to discharge into the Mangaheka stream.
g. Within wetlands, the management of gross pollutants can be achieved through the installation of inlet or outlet screening, such as floating litter traps or net technologies.
h. Swales and wetlands servicing high traffic roading and upgraded roads shall be suitable for the removal of hydrocarbons.
i. High risk activities (i.e. those with the potential for the discharge of unusual or high concentration contaminant runoff (as defined in Waikato Regional Plan and Hamilton City Council Stormwater Bylaw) shall have their own pollution plan and appropriate treatment system to meet the design parameters (**Table 6-2**) prior to discharge of stormwater from the lot.
j. Where it is identified that stormwater discharges will have an effect on aquatic habitat and water quality values, then habitat enhancement shall be included as a mitigation measure via riparian planting and/or stream works as appropriate.
k. Where it is identified that stormwater discharges will potentially contribute to erosion of channel beds and banks, then bed and bank stabilization works will be included as a mitigation measure.
l. All stormwater devices holding permanent static or flowing water shall have >80% wetland plant cover to provide habitat for indigenous fish where appropriate and reduce the effects of temperature increases and contaminant loads on receiving waters.

Note: For installation of such devices and any in-stream or riparian works in the stream it is highly recommended that a qualified river geomorphologist and aquatic ecologist participate in the design and implementation of engineering solutions to ensure long term performance and effectiveness. In-stream and riparian works on any waterway may require regional council resource consents.

Stormwater BPO 5 – Retention and enhancement of existing riparian areas and vegetation

a. Ecological assessments are required for all modified watercourses in the catchment (including farm drains).

b. Watercourses shall be identified by developers at the time of development planning and subject to the 'best practice ecological protection and mitigation measures' required. Hamilton City Council has made no provision for off-site mitigation in this ICMP

c. In the event of any discovery of threatened native aquatic species, the authorities shall be notified and an appropriate translocation programme shall be developed.

d. Provision for habitat restoration and protection where black mudfish species are identified

e. Review and remedy where necessary over-steepened/channelized stream reaches through options including battering back over steep banks, reinstating channel features, riparian planting for bank stability and armouring as far downstream as required. (Works on private property or within the Waikato District Council area will be subject to agreement of affected parties and may require regional council resource consent.)

f. Energy dissipation devices shall be provided at all discharge locations to prevent bed scour and bank instability.

g. The modified stream channel and its riparian margins shall not be used to locate stormwater treatment devices. The development of off-line facilities for devices 5 and 6 is required.

h. Hamilton City Council shall encourage landowners within the Mangaheka Stream catchment to retain existing riparian vegetation, and undertake riparian planting with indigenous eco-sourced vegetation selected from the Plant Selection Tool for Waikato Waterways, Waikato River Authority as well as the Mangaheka Restoration Vision, and the Local Indigenous Biodiversity Strategy (and/or using the advice of a suitably qualified ecologist). A minimum of 5m wide riparian planting either side of all watercourses shall be required.

i. Any restoration planting will require stock proof fencing and on-going weed control, through hand releasing rather than spraying or machinery to avoid bank instability and by-kill of desirable species.

j. Capital works for restoration planting and fencing projects within the WRC administered drainage area will require review and approval of the proposed works by the WRC Drainage Manager to ensure ongoing access to watercourses is maintained.

k. All new development shall provide extended detention and volume control in accordance with the ITS and WRC's Waikato Stormwater Management Guideline.

Stormwater BPO 6 – Construction Controls
a. Specific guidelines for erosion and sediment controls required for earthwork sites in the ICMP area are provided in WRC's Erosion and Sediment Control Guidelines.
b. Sediment discharges from building sites are to be managed appropriately. Specific guidelines for erosion and sediment controls required for building construction in the ICMP area will be provided by HCC.

5 Water and Wastewater Management

5.1 Wastewater

Wastewater shall be treated and disposed of in a way that minimises effects on public health, the environment, and cultural values.

The entire developable area in the upper Mangaheka catchment can be served by the proposed Hamilton City Council wastewater network **(Figure 2-9**). The network will be extended as development occurs in accordance with Hamilton City Council's ITS.

Water and wastewater management should be centralised and three waters networks planned on a catchment wide basis to minimise the number of stormwater treatment devices, wastewater pump stations and storage devices (except for private devices).

The size of infrastructure should be minimised by promoting sustainable water use and where possible, three waters networks are integrated within the catchment prior to discharge to the wider city networks. Future infrastructure upgrades shall be minimised by preventing, identifying and managing inefficiencies such as leakage, inflow and infiltration, and unauthorised use.

5.2 Best Practicable Options (BPO) - Wastewater

There are no Best Practicable Options for this catchment that are not standardised city wide measures as described in Hamilton City Council ITS and HDP. BPO1 for wastewater give provisions for the implementation of Strategic Objectives SO5 (Wastewater Management) and SO7 (Three Waters Management).

Wastewater BPO 1 – General requirements

a. The areas within the northern extension Stage 1C and 1E will be serviced via an appropriately sized trunk network into the Western Interceptor generally in accordance with the three waters infrastructure map (**Figure 2-9**).

b. The capacity of the wastewater system has been based on a landuse assumption (i.e. dry industry).

c. Sufficient wastewater networks and storage is provided to avoid or minimize wastewater overflows.

d. Wastewater systems shall utilize gravity flow and reduce the need for pumping stations.

5.3 Water Supply and Demand Management

Light industry premises will dominate the water demand within the Mangaheka catchment. Undeveloped areas of the catchment will be serviced by the existing water system. In future, as the area becomes urbanised, the remaining upper catchment area will be serviced by the new water supply network located from a connection at Arthur Porter Drive which will also be reticulated throughout the local roading network.

Existing rural residential dwellings however, will continue with their individual rain tank supply, until urban services are practically available for connection.

Notwithstanding the above, viable water sensitive options exist for a more sustainable and integrated approach and will need to be applied in accordance with provisions of the Hamilton Operative District Plan.

In addition, Hamilton City Council has the following initiatives planned to ensure that water demand is met in the Mangaheka catchment as well as other catchments within the city:

- New reservoir in Rototuna and associated bulk mains;
- City wide reticulation upgrades to support infill and intensification;
- Water demand and loss management programme to effectively manage water in the network and reduce loss;
- Continuation of the water model to forecast water demand out to 2061 and beyond;
- Enforcement of Water bylaw which requires water conservation in accordance with trigger levels;
- Education initiatives on water demand management;
- Reducing water demand through universal metering or meet increased growth demand through the construction of additional treatment capacity;
- Continue to work with Waipa and Waikato District Councils to provide a Sub-Regional solution to water as per the Sub-Regional 3 Waters Strategy; and
- Implementation of Public Health Risk Management Plan (Water Safety Plan).

5.4 Best Practicable Options (BPO) - Water

The following section provides details of the selected Water BPO measures and how they will achieve the objectives for the Mangaheka catchment.

Best practicable options are standardised city wide measures as described in Hamilton City Council ITS and HDP.

Water supply infrastructure shall be designed and constructed to meet consumption, hygiene, water-sensitive design and firefighting requirements. Undeveloped areas of the catchment will be serviced by the existing water system. New distribution networks shall be compatible with the existing system in accordance with the Hamilton City Council ITS.

A list of suitable BPOs for water supply and conservation for the catchment has been developed as discussed below. The BPOs listed below provide for specific requirements and will facilitate the practical implementation of Strategic Objectives SO6 (Potable Water Management) and SO7 (Three Waters Management). For items not discussed in this section, refer to the design requirements provided within the Hamilton City Council ITS.

Water BPO 1 – General requirements
a. The areas within Hamilton City including the northern extension Stage 1C and 1E will be serviced via the strategic bulk mains from the Pukete reservoir generally in accordance with the three waters infrastructure map (**Figure 2-9**).
b. The capacity of the wastewater system has been based on a landuse assumption (i.e. dry industry).
c. Water supply systems shall ensure that targets required for fire-fighting flow and LOS for water pressure are achieved.

Water BPO 2 – Water use reduction
a. To lower water supply demand and meet multiple three waters integration objectives, rainwater re-use as per BPO 2b in Section 4.3.2-Water sensitive design.

6 ICMP Implementation

6.1 Implementation Methods[21]

Most of the mitigation measures set out in this ICMP and selected in the planning and design process will be required to be implemented as subdivision proceeds and as individual lot development progresses. In some cases, Council may elect to install major infrastructure in advance of private development.

Funding decisions of Council are made via the Long Term Plan process in accordance with the LGA which is informed by Councils 30 Year Infrastructure Plan and planning documents (e.g. District Plan, Hamilton Urban Growth Strategy).

Developer led provision of key infrastructure is done in accordance with resource and/or building consents.

As required by the CSDC, key infrastructure is provided for in concept network plans with an implementation timeline indicated on the three waters infrastructure plan provided in **Figure 2-9.**

All BPOs identified in Sections 4 (Stormwater Management) and 5 (Water and Wastewater Management) have been translated into a range of actions, projects and compliance requirements that are given in:

- Hamilton City Council preferred options (**Table 6-1**)
- Discharge Parameters (**Table 6-2**)
- Means of Compliance (**Table 6-3**)
- Future Actions (**Table 6-4**)

4[21] CSDC / Condition 30(k)

6.2 Hamilton City Council Preferred Options

The following table shows the stormwater solutions acceptable to Hamilton City Council.

Table 6-1: Requirements for new development

Requirements	BPO's aligned with
On-lot	
The on-lot stormwater management measures for this catchment include standard requirements for all industrial or commercial lots comprise:	
• Rainwater reuse tanks (shall be plumbed back into the toilet and laundry with an option for garden use).	**Stormwater BPO 1 & 2 & Water BPO 2**
• Overflow and hardstand areas to be directed to soakage where soakage is suitable.	**Stormwater BPO 3**
• A pollution control plan is required for high risk activities	**Stormwater BPO 4**
• No exposed zinc or copper building products	**Stormwater BPO 4**
• Gross pollutant traps	**Stormwater BPO 4**
• Carpark areas to drain to stormwater pre-treatment device (e.g. swale, raingarden etc.) prior to leaving site	**Stormwater BPO 4**
• Reduced impervious cover considered (note 2 subcatchments have consented limits below the HCC District Plan).	**Stormwater BPO 4**
• Maintain the form of existing natural drainage paths on site	**Stormwater BPO 5**
Centralised Devices and Wider Development Activities	
The preferred centralised stormwater management options comprise:	
• Wetlands with at least 80% planted vegetation with submerged outlets	**Stormwater BPO 1, 3 & 4**
• Off-line management devices	**Stormwater BPO 1**
• Overflow and hardstand areas to be directed to soakage where soakage is suitable.	**Stormwater BPO 3**
• Gross pollutant traps & hydrocarbon traps on device outlets	**Stormwater BPO 4**
• Maintain existing watercourses and habitats	**Stormwater BPO 5**
• Maintain and enhance riparian planting	**Stormwater BPO 5**

6.3 Mangaheka Catchment Specific Requirements

The CSDC[22] requires an integrated catchment management approach based upon the Best Practicable Option. BPO requirements are to be implemented as part of development and ongoing management in the Mangaheka catchment. The BPO must be appropriate for site conditions such as contours, ecology and geotechnical characteristics. If a developer proposes an option not listed in the ICMP, then the developer must prove the option is the most appropriate and will meet the ICMP objectives. The development's design report should include, but not necessarily be limited to Information Requirements provided in **Appendix J**. (This may form the basis of a Water Impact Assessment as required under the District Plan.)

Key points are listed below:

- The BPO to be implemented must ensure management of stormwater quality and quantity;
- Stormwater management systems are to be designed in accordance with Hamilton City Council ITS, WRC's Waikato Stormwater Runoff Modelling Guideline and Waikato Stormwater Management Guideline.
- Development design must specifically consider cumulative environmental and infrastructure effects; and
- Development design must provide for long-term management of effects that encompasses the entire area over which potential effects may occur.

To ensure the catchment specific requirements, continue to be understood throughout the development of the catchment, ongoing consultation with key stakeholders and directly affected landowners will be conducted and the ICMP, including its objectives and provisions, will be revised as necessary.

[22] Condition 30(j)

6.4 Design Parameters

Table 6-2 outlines the parameters to be achieved for all discharges within the Mangaheka catchment. Refer to **Figure 6-1** for sub-catchment areas.

These parameters have been selected to address catchment risks and sensitivities set out in the ecological assessment, and to meet the operational objectives. Stormwater treatment and flow attenuation devices within sub catchments should be designed to achieve these parameters. For further information in regard to the design of specific solutions, refer to Hamilton City Council Infrastructure Technical Standards (ITS) and *Waikato Stormwater Management Guideline*.

Table 6-2: Mangaheka design parameters for stormwater management within Hamilton City Council Jurisdiction

Upper Catchment Area	
Environmental flow	
Extended detention	1.2x the water quality volume Water quality volume is assessed using 24mm, 24 as per HCC ITS
Stormwater quality	
Item / Parameter	Requirement
Either 1: At point of discharge from centralised treatment device or; 2: At point of discharge from on-lot treatment device (where no centralised device is downstream).	
Suspended solids	75% removal on a long term average basis (Waikato Stormwater Management Guideline definition) calculated at the discharge point
Hydrocarbons	No visible sheen. Installation of submerged outlets or shielded outlets required on devices (as required by ITS)
Temperature	<23°C* at the point of discharge to a waterway and existing water temperature change of no more than 3°C. Achieved via wetland planting over >80% of the device area or vegetated swale as per the ITS.
Gross pollutants	No gross pollutants
Other Contaminants	Removal designed in accordance with the ITS Note: Lots with High Risk activities require a Pollution Control Plan and on-lot source control and treatment.
Ammoniacal nitrogen	Less than $0.88gm/m^3$
Micro-organisms	No exceedance of relevant guideline values (*Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. MfE, 2003)*

Groundwater Depth Monitoring (for device design)	**Groundwater (depth) monitoring** at the location of each stormwater device is required from a groundwater monitoring well. For devices with an impermeable (lined) layer, a **minimum** of monthly readings over July- November is required. For devices with a permeable (unlined) layer, a **minimum** of monthly readings for a 12 month period is required. If the year is unseasonably wet or dry then the monitoring should be repeated for another complete cycle.	
In Receiving Watercourse (achieved after reasonable mixing)		
Turbidity	No greater than 25 NTU in the stormwater discharge in a water quality storm (1/3rd of a 2year 24 hour storm).	
Colour	No conspicuous changes in colour downstream of the discharge point (WRC Regional Plan)	
Dissolved oxygen	Greater than 80% of saturation concentration. If the concentration of dissolved oxygen in the receiving environment is below 80 percent saturation concentration, any discharge into the water shall not lower it further. (WRC Regional Plan)	
Stormwater Quantity		
No increase in water levels and peak flows downstream unless it can be demonstrated that there is no significant adverse cumulative effect. Location of compliance achievement is downstream from any subcatchment device and also the exit from Hamilton City Council jurisdiction (west side of Koura Drive).		
Attenuation of 2 and 10 year events may be required on-lot depending on the design of the downstream device. Peak flow management is required with reduction to generally 70% of predevelopment flow for the 100 year ARI storm event.		
Flood storage proportional to development* for 100 year event (To be confirmed at detailed design)	The below equivalent volume (m^3) per hectare of development shall be provided (gross including roads and reserves but excluding the area of the Te Rapa Bypass designation). Volumes are indicative and development specific design and/or modelling shall be carried out to meet requirements (a 1D model is available from Hamilton City Council, this assumes all devices are installed together). Refer to the Means of Compliance table for the catchment imperviousness that these are based on.	
	Catchment A (undeveloped area)	1080m^3
	Catchment C (Basin 7)	730m^3
	Catchment D (Basin 6)	680m^3
	Catchment E, G, H (Basin 5)	1320m^3
* Note that attenuation requirements differ depending on the development location in the catchment due to the flat nature of the Mangaheka catchment and issues related to coincidence of flows where the Porters and Mangaheka Streams join at Koura Drive.		
100 year peak flows after attenuation (to be confirmed by modelling at detailed design). Design to allow no more than minor increase to peak flows.	Peak flow downstream of device as % of Existing Development	
	Catchment E, G, H (Device 5)	100
	Catchment D (Device 6)	96
	Catchment C (Device 7)	73
	Catchment A (Un-named device)	96

Soakage	Soakage to the maximum extent possible
Stormwater Volume Control	Retain a minimum of the initial abstraction volume for new impervious areas if compacted soils are remediated. If compacted soils aren't remediated, then retain the initial abstraction volume for the entire site. Retaining more where soil conditions allow is supported. Match pre-development runoff volume through reduced runoff practices & sub catchment management including soakage and reuse. Where this cannot be achieved, mitigation within the receiving environment will be required such as channel stabilisation and/or a financial contribution for a third party to undertake downstream erosion prevention.

6.5 Means of Compliance

Table 6-3 outlines methods to achieve compliance with the discharge requirements and this ICMP.

This includes specific requirements for sub-catchments which may exist due existing resource consent conditions, topography or other reasons.

New Resource Consent applications should all comply with the requirements of the sub-catchment and general requirements. Furthermore, new developments will have additional information available such as site specific device monitoring and earthworks that can be taken into account when assessing requirements.

Where there is an approved Water Impact Assessment (WIA) that recommends specific on-lot water efficiency measures, the methods prescribed shall be used as the relevant methods to be implemented to achieve compliance with the Operative District Plan and CSDC.

Where the methods listed below are not practical for a given lot, reference should be made to the relevant authority, including Hamilton City Council Infrastructure Technical Specifications for alternative solutions which are acceptable to Hamilton City Council. It will be important for Developers to have joint pre-application meetings with Hamilton City Council and Waikato Regional Council and if required Waikato District Council to facilitate alignment with ICMP requirements and approval processes. A Means of Compliance Map is provided in **Figure 6-1**.

Table 6-3: Means of compliance with ICMP

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
Mana Whenua				
All sub-catchments	Mana whenua have indicated a cultural interest in the Mangaheka catchment. Evidence of mana whenua engagement and the outcome of such engagement is required to be submitted with any resource consent application. The latest cultural values documents should be referred to. During development works; in the event of any discovery of artefacts that may have potential cultural or historical significance, the appropriate iwi representatives and authorities shall be notified.	Prior to obtaining any resource consents	As required by development	Developer
Stormwater - General Requirements – On-Lot (unless they differ from specific sub-catchment requirements)				
All sub-catchments	**Standard requirements** for all Lots include • No exposed zinc or copper building products • Carpark areas to drain to stormwater pre-treatment device (e.g. swale etc.) prior to leaving site • Catchpits designed for capture of gross pollutants (as per ITS) • Retain a minimum of the initial abstraction volume for new impervious areas if compacted soils are remediated. If compacted soils aren't remediated then retain the initial abstraction volume for the entire site. Retaining more where soil conditions allow is supported. Match pre-development runoff volume through reduced runoff practices &	At time of building consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	sub catchment management including soakage and reuse. Where this cannot be achieved, mitigation within the receiving environment will be required such as channel stabilisation and/or a financial contribution for a third party to undertake downstream erosion prevention. • Reduced impervious area highly recommended, including volume control mitigation through reduced impervious area and/or re-use and/or downstream works The overall treatment train approach is Catchpit (or gross pollutant trap), swales and centralised devices for quality and quantity management (e.g. wetlands)			
All sub-catchments	Where the impervious percentage is higher than allowed for in the centralised device, **extended detention** as per the design parameters table shall be provided for the additional impervious area.	At the time of building consent and/or Hamilton City Council resource consent.	As required by development	Developer
All sub-catchments	Lots with **High Risk activities** require a **Pollution Control Plan** and site-specific on-lot source control and treatment design. (Refer to Figure 6-2: Mangaheka Top 15 Industrial Risks).	At the time of building consent and/or Hamilton City Council resource consent and/or as required by the Hamilton City Council Stormwater Bylaw.	As required by development	Developer
All sub-catchments	Lots with activities anticipated to generate **phosphorus** and/or **nitrogen** in stormwater runoff require to demonstrate stormwater nutrient removal/ management.	At time of building consent and/or Hamilton City Council resource consent and/or as required by the Hamilton City Council Stormwater Bylaw.	As required by development	Developer
All sub-catchments	**Rainwater tanks for non-potable re-use mandatory**	At time of building consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	Guidance provided in three waters practice management notes: Hamilton City Council 02 and Hamilton City Council 05.			
Stormwater - General Requirements – Treatment devices (unless they differ from specific sub-catchment requirements)				
All sub-catchments	**Centralised devices** (e.g. Wetlands) • To be located and sized to ensure all catchment flows (up to the 100 year event) are captured and managed and operation and maintenance costs are kept to a practicable minimum. • Attenuation of 2 and 10 year events may be required on lot depending on design of downstream device • Peak flow management is required with reduction to generally 70% of pre-development flow for the 100year ARI storm event. • Centralised devices located within the Hamilton City boundary to be in accordance with **Figure 2-9**. • **Water Quality** - Water quality treatment is required as per the design parameters table. • **Submerged Outlets** must comply with the ITS • **Groundwater (depth) monitoring** at the location of each stormwater device is required from a groundwater monitoring well. For devices with an impermeable (lined) layer, a **minimum** of monthly readings over July- November is required. For devices with a permeable (unlined) layer, a **minimum** of monthly readings for a 12 month period is required. If the year is unseasonably wet or dry then the monitoring should be repeated for another complete cycle.	At time of building consent and/or Hamilton City Council resource consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	• **Vesting.** Devices must be compliant with design parameters prior to vesting to Hamilton City Council and for the duration of the defects liability period. If the entire contributing catchment has not been developed at the time of vesting, alternative methods for demonstrating compliance will be required. Detailed operations and maintenance plans shall be provided to Hamilton City Council prior to vesting. • **Operation and Maintenance Plans** for devices shall recognise the flat gradient of the upper catchment outlets and ensure downstream restrictions are identified and removed on an on-going basis, to maintain hydraulic capacity and to control water depth to allow plant growth in the upstream devices. • **Details relating to level of water quality treatment provided by devices to be assessed at time of resource and building consent**			
All sub-catchments	Additional water quality treatment requirements for all devices (on-lot and centralised): • Off-line treatment (required) • Where flood storage is to be provided on-line, treatment is to be provided off-line up-catchment. On-line flood storage is to be provided by keeping a naturalised low flow channel, with storage provided in the adjacent flood plain. • High flow bypass of forebay for >10 year event • Device bypass for >100 year event	At time of building consent and resource consent	As required by development	Developer
All sub-catchments	**On-lot and centralised devices** Where it is identified that stormwater discharges will have an effect on aquatic habitat and water quality values, then specific habitat enhancement shall be included as a	At time of building consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	mitigation measure via riparian planting and/or stream works as appropriate.			
All sub-catchments	**New roads** within sub catchments are recommended to include stormwater collection/treatment systems following the hierarchy provided in the ITS to reduce or eliminate contaminants prior to stormwater entering the stream. Where possible this will be achieved in the centralized device.	To be confirmed	Prior to lot development	Developer
Stormwater - General Requirements				
All sub-catchments	**Peat in the development area:** It is encouraged that where peat is outside of the development footprint, it should be maintained. When in the development footprint the developer is required to: • Identify if peat is to be removed (and over what extent and depth); • Advise if being replaced (and if so, with what); and • Provide an assessment that this does not change shallow groundwater flows sufficient to cause any adverse effects (including but not limited to consolidation settlement, drawdown of surface water bodies etc.)	At time of resource consent	As required by development	Developer
All sub-catchments	**Developers and key stakeholders** shall work together and collaborate with Hamilton City Council to effectively implement the Mangaheka ICMP to implement the solutions and meet the requirements of the ICMP – actions BPO2.	At time of resource consent	As required by development	-

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
All sub-catchments	**Overland Flow Paths (OLFP's):** Developments to allow for existing overland flow paths discharging onto each lot and consideration of exacerbation associated with maximum probable development upstream. May require flood mapping for larger flowpaths. Detailed design required to accommodate up to the 100 year post-developed flows from neighbouring catchments.	At time of building consent and/or Hamilton City Council resource consent	As required by development	Developer
All sub-catchments	**All infrastructure sizing**, locations and alignments are preliminary and shall be confirmed by detailed design and integrated with other infrastructure (e.g. roads) to implement the solutions and meet the requirements of the ICMP	At time of resource consent	As required by development	-
All sub-catchments	**Networks shall be designed to ITS standards** (unless specified otherwise within this ICMP) and sized to service the fully developed catchment to the design parameters and requirements to achieve minimum levels of service	At time of resource consent	As required by development	-
All sub-catchments	**Development proposals** which are lodged with Hamilton City Council and/or WRC ahead of major infrastructure shall demonstrate how the solutions and requirements of the Mangaheka ICMP will be met. This includes showing that development proposals: • Are consistent with the solutions and requirements of the ICMP • Will not compromise future development or implementation of major infrastructure, and • Can establish flood storage and stormwater treatment solutions in the catchment which meet the design parameters in Table 6.2 of this ICMP • Any site/activity specific technical investigations and assessments have been undertaken as part of development planning (e.g. hydrological,	At time of resource consent	As required by development	-

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	hydrogeological, geotechnical and ecological investigations/assessments)			
All sub-catchments	**Resource consent applications for development activities** shall be lodged with Hamilton City Council and WRC contemporaneously, and both Councils shall work together to ensure that decision outcomes are consistent with the solutions and requirements of the Mangaheka ICMP Note 1: WRC has jurisdiction over earthworks sites and HCC has jurisdiction over building sites. Small scale development sites may not trigger WRC requirements for soil disturbance activities. In these instances Hamilton City Council will ensure that site specific erosion and sediment controls (including flocculation treatment systems) are required via Hamilton City Council land use and/or building consents. Hamilton City Council may also seek advice and specific input from WRC as required. Note 2: Ecological assessments are required for all modified watercourses in the catchment (including farm drains). These watercourses shall be identified by developers at the time of development planning and subject to the 'best practice ecological protection and mitigation measures' required.	At time of resource consent	As required by development	-
All sub-catchments	The **'Future Actions'** outlined in Section 6.6 of this ICMP shall be considered for implementation.	Detailed design and ICMP implementation planning	High priority Prior to development	-
Stormwater - Wider Catchment Requirements				
All sub-catchments	**Inside Waikato District Council Boundary** **Suitable energy dissipation and erosion protection measures** shall be provided at all required stream locations, as identified by this ICMP, in order to minimise erosion of stream beds and banks.	Actions for WRC and Hamilton City Council to be agreed	High priority Prior to development	WRC and Hamilton City Council funding split

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	Natural /green engineering solutions appropriate to the soft sediment environment are preferred over hard engineering solutions using rock and concrete to assist the retention and enhancement of natural features. Requirements for protection measures are detailed in Section 4.			
All sub-catchments	**Modified and natural stream channels** and their riparian margins shall not to be used as locations for stormwater treatment devices. This is to assist in the retention and enhancement of existing riparian areas and vegetation. Requirements for the downstream sections of the Mangaheka Stream are provided in Sections 4 (Stormwater Management) and 6 (ICMP Implementation).	At time of resource consent	As required by development	
All sub-catchments	**Ecological Requirements:** • Ecological assessments are required for all modified watercourses in the catchment (including farm drains). • Provision for habitat restoration and protection where black mudfish species are identified • Watercourses shall be identified by developers at the time of development planning and subject to the 'best practice ecological protection and mitigation measures' required. Hamilton City Council has made no provision for off-site mitigation in this ICMP. • Riparian vegetation, where present, should be retained and any new riparian planting done with indigenous eco-sourced vegetation selected from the Plant Selection Tool for Waikato Waterways, Waikato River Authority as well as the Mangaheka Restoration Vision, and the Local Indigenous Biodiversity Strategy. In particular, opportunities to introduce more harakeke (flax) into the natural environment in areas where it	At time of resource consent	As required by development	Developer/WRC and Hamilton City Council split of funding in WDC jurisdiction

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	can be accessed for harvest and cultural use should be considered. • In the event of any discovery of threatened native aquatic species, the authorities shall be notified and an appropriate translocation programme shall be developed.			
All sub-catchments	**Erosion and Sediment Control:** Erosion and sediment controls shall be in accordance with Hamilton City Council and WRC requirements, and shall be established on site and approved by Hamilton City Council and WRC (as required) prior to any soil disturbance activities taking place Note 1: This applies to all catchment development and physical works activities where soil disturbance activities are undertaken, e.g. bulk earthworks and development of major infrastructure/services where best practice guidelines, standards and relevant City bylaws shall be applied Note 2: Flocculation treatment systems shall be established on all development sites to treat sediment laden runoff prior to discharge from the site (e.g. to the stormwater network or directly to the receiving environment). In this regard flocculent bench testing to determine the reactivity of soils to treatment shall be undertaken, and the most efficient flocculent type applied via condition of resource consent or associated management plan	At time of resource consent and during construction	As required by development	Developer
Stormwater - Sub-Catchment Requirements				
A - 4 Guys catchment	**Catchment discharges to centralised device** (4 Guys Pond) which provides flood attenuation only.	On-lot treatment and flood attenuation to be assessed	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	Water quality treatment is provided by HJV wetland and associated swales. Additional on-lot treatment required ('Standard Requirements for all lots') to meet design parameters as per Resource Consent requirements.	at time of resource and building consent		
A1	**Subcatchment fully consented at time of ICMP approval (including on lot measures). This includes:** • **Catchment discharges to new centralised device** (4) which will provide flood attenuation up to 90% impervious lot area for up to the 100 year event. • Treatment is undertaken through subcatchment B devices • **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness. • High Risk activities (D-2736837) require a Pollution Control Plan **For future development requiring resource consent:** • All stormwater general requirements apply	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer
A2	**Subcatchment under development at time of ICMP approval (including on lot measures). This includes:** • Stormwater Centralised Device under construction • High Risk activities (D-2736837) require a Pollution Control Plan • Rainwater re-use tanks for non-potable use are highly recommended as a water efficiency measure **For future development requiring resource consent:** • All stormwater general requirements apply			

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
B	**Sub-catchment has an existing approved comprehensive development plan and is under development at time of ICMP preparation. This includes:** • Construction of stormwater centralised devices (wetland and swales) • Water quality treatment provided by HJV Pond and upstream swales. Additional on-lot treatment required ('Standard Requirements for all lots') to meet design parameters as per Resource Consent requirements. • Maximum of 75% impervious cover • For any development over 75% impervious cover, additional on-lot stormwater attenuation required (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 75% imperviousness. • No exposed zinc or copper building products **For future development requiring resource consent:** • All stormwater general requirements apply	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer
C	**Catchment discharges to new centralised device** (Device 7) which provides flood attenuation up to 90% impervious Lot area. **Centralised treatment device may not be possible** - on-lot/at source treatment required to meet design parameters at point of discharge **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
D1	**Catchment discharges to new centralised device** (Device 6) which provides flood attenuation up to 90% impervious Lot area. **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness. **Overland Flow Path present** – detailed design required to accommodate the 100 year post developed flows from neighbouring catchments. Flood mapping required to address associated flows.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent Overland Flow Paths to be considered at time of resource consent.	As required by development	Developer
D2	**Catchment discharges direct to stream.** Off-set flood mitigation provided by Device 6 up to 90% impervious Lot area. **Centralised treatment device may not be possible** - on-lot treatment required to meet design parameters at point of discharge **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer
E1	**Catchment discharges to new centralised device** (Device 5) which provides flood attenuation up to 90% impervious Lot area.	On-lot treatment and flood attenuation to be assessed	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	Lots with higher than 90% impervious area (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness.	at time of resource and building consent		
E2	**Catchment discharges direct to stream.** Off-set flood mitigation to be provided by Device 5 up to 90% impervious Lot area for all flood attenuation events. **Centralised treatment device may not be possible** - on-lot treatment required to meet design parameters at point of discharge **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness. **Overland Flow Path present** – detailed design required to accommodate the 100 year post developed flows from neighbouring catchments.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent Overland Flow Paths to be considered at time of resource consent.	As required by development	Developer
F	**Subcatchment has an approved comprehensive development plan and is under development at time of ICMP approval. This includes:** • **Catchment discharges to centralised device** (Porters Pond) which provides flood attenuation up to 75% impervious Lot area.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	• **Water quality treatment is provided** by Porters Pond and upstream swales. Additional on-lot treatment required ('Standard Requirements for all lots') to meet design parameters as per Resource Consent requirements. • **Maximum 75% impervious area** additional on-lot stormwater attenuation required for higher impervious area (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 75% imperviousness. • **No exposed zinc or copper building products** **For future development requiring resource consent:** • All stormwater general requirements apply			
G	**Catchment discharges direct to stream.** Off-set flood mitigation provided by Device 5 up to 90% impervious lot area. **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness. **Overland Flow Path present** – detailed design required to accommodate the 100 year post developed flows from neighbouring catchments.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer
H	**Catchment discharges to new centralised device** (Device 5) which provides flood attenuation up to 90% impervious Lot area.	On-lot treatment and flood attenuation to be assessed at time of resource and building consent	As required by development	Developer

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	Water quality treatment is provided by Device 5. Additional on-lot treatment required ('Standard Requirements for all Lots') to meet design parameters. **Lots with higher than 90% impervious area** (requiring resource consent) need to provide on-lot attenuation for storm water flows in the water quality device (1/3rd of a 2 year 24 hour storm), 5 year, 10 year and 100 year events, to reduce peak flows to that resulting from 90% imperviousness. **Overland Flow Path present** – detailed flood mapping required to address associated flows.	Overland Flow Paths to be considered at time of resource consent.		
Wastewater – General Requirements				
All sub-catchments	**Within Hamilton City Council Boundary** **Wastewater in all sub-catchments** shall be served by the existing and proposed wastewater network. Gravity mains to access the network shall be extended as development occurs and capacity shall be assessed during the engineering phase for suitability to serve the surrounding areas draining to the nearest pump. Levels of service to be achieved in accordance with Hamilton City Council's requirements. Best practice design, construction and inspection are required to ensure that inflow and infiltration is minimised. Temporary pump stations are proposed at Ruffell road and Tasman road with carrier pipes to be sized based on MPD and meet specific requirements associated with crossing infrastructure (e.g. such as the railway line near Ruffell Road). **Within Waikato District Council Boundary**	At time of resource consent		

Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
	No change to existing on-lot wastewater disposal requirements.			
Water – General Requirements				
All sub-catchments	**Low flow fixtures** and other water efficient fittings are to be installed into businesses in accordance with Rule 25.13.4.5a and c of the HDP. Low flow fixtures will promote water conservation, reduce costs associated with water consumption and ensure the size of infrastructure is minimised by promoting sustainable water use. Future infrastructure upgrades can be avoided or minimised by identifying and managing inefficiencies such as leakage, inflow & infiltration and unauthorised use.	At time of building consent	As required by development	
All sub-catchments	**Strategic 450mm water mains** shall be required in specified locations as per Water Master Plan and indicated in **Figure 2-9**. **250mm trunk mains** shall be extended along road corridors as the sub-catchments develop. Levels of service to be achieved in accordance with Hamilton City Council's requirements. Minimum pressure and flows to be achieved, including consideration of adverse effects on the existing built and consented environment.	At time of resource consent	In line with Hamilton City Council planned staging	

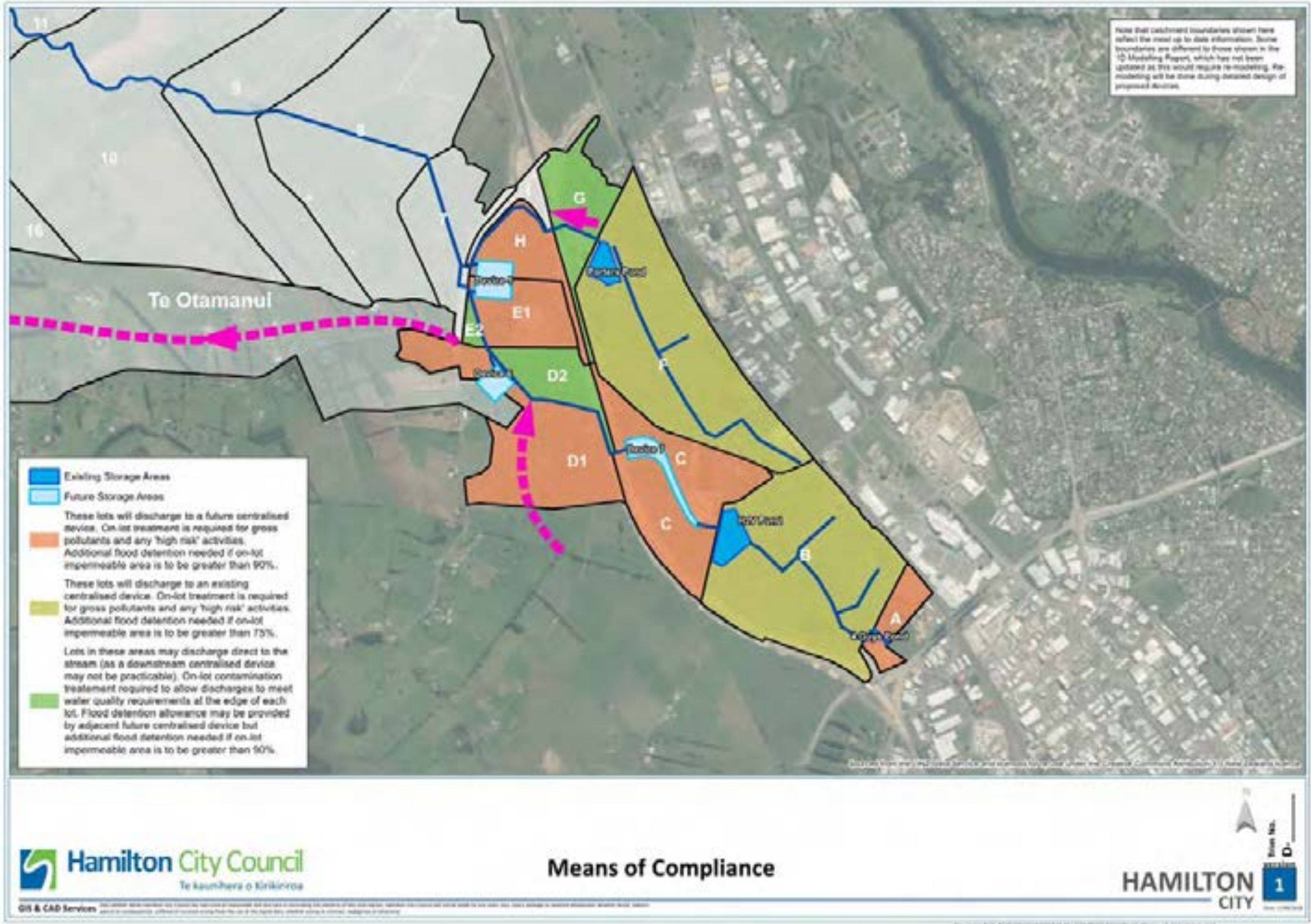

Figure 6-1: Means of Compliance Map

HCC "Top 15" High Risk Activities		Notes	Title on WSWMG/AC ITA List
1	Car Wreckers	Not on HRFR list	"Automotive Dismantling"
2	Hazardous Waste treatment sites	Not on HRFR list	"Hazardous materials storage or treatment"
3	Waste management sites (transfer stations, compost sites, landfills etc)		" Waste transfer stations", " Non-metal recycling (composting, glass paper or paper board." and "Landfills" on WSWMG and AC ITA
4	Manufacture or processing of chemicals, and of petroleum, coal, rubber and plastic products.		Various Activities "Petroleum or coal product manufacturing" and Various " Rubber Industry" and Various :"Other Chemical Products"
5	Bitumen Plants	Medium risk on Waikato SW Mgmt Guide list.	"Bitumen/asphalt premix or hot mix"
6	Electroplaters, foundries,galvanisers and metal surfacing.		" Processing of metals (smelting, casting)", "Metal plating, anodising or polishing"
7	Timber preservation, treatment and storage sites where chemically treated timber is stored		"Treated Timber Storage" and "Timber Treatment"
8	Stockpiled tyres		"Tyre manufacturing or retreading", "Recycling, recovery, reuse or disposal
9	Manufacture of fabricated metal products, machinery and equipment		Various: " Machinery or equipment manufacturing"
10	Concrete batching plants and asphalt manufacturing plants.		"Concrete batching plants (ready mixed concrete)"," Bitumen/asphalt premix or hot mix"
11	Crushing, grinding or separation works (other than sand, gravel, rock or mineral - e.g slag, road base, demolition material)		"Metals (crushing, grinding, sorting or storage)"
12	Road freight transport depot (non-chemical) with mechanical servicing		Same
13	Log storage yards (outside of forested areas)		Same
14	Truck wash facilities		Not on other lists
15	Car wash and valet services.		Not on other lists

Figure 6-2: Mangaheka Top 15 Industrial Risks

6.6 Future Actions

Table 6-4 details future actions considered important to meet the ongoing outcomes of the Mangaheka ICMP. These will need to be addressed by developers at the time of their proposals or by Hamilton City Council and reflected in future revisions of the ICMP. Opportunities that should be sought by parties in the hydrological catchment are also listed.

Table 6-4: Future actions

Ref	Future action	Anticipated timeline (responsibility)
	General	
1	ICMP is implemented once the ICMP is finalised and approved by the Hamilton City Council: • Place the ICMP (and appendices) on the Hamilton City Council website • Inform key stakeholders (internal and external) • Pass to the Hamilton City Council Compliance Team for education purposes in accordance with Hamilton City Council CSDS requirements Meet with Hamilton City Council Development Engineers, City Planning, Planning Guidance Unit and Building Unit to ensure requirements within the ICMP (specifically BPSOs, Design Parameters and Means of Compliance are sufficiently understood and implemented through Resource Consents and Building Consents (as required)	2019 (Hamilton City Council)
2	Integrate with the Hamilton City Council CSDC Monitoring Programme – this includes the proposed catchment monitoring, as per Section 8 of this document, in the Hamilton City Council CSDS Monitoring Programme when it is reviewed / updated (as per Condition 37 of the Hamilton City Council CSDC). This should include consideration of detailed monitoring methods to ensure consistency with baseline methods and any broad scale updates to the Hamilton City Council CSDC Monitoring Programme, if/ when required	2018/2019 (Hamilton City Council) Integrated with Draft CSDC Monitoring programme (2018)
3	Proposed Waikato Regional Plan Change 1 – Waikato and Waipa River Catchments (Healthy Rivers): Seek guidance from WRC on the short term and long term numerical water quality targets for the Waikato and Waipa River Catchments, in particular determine how these targets relate to urban stormwater discharges.	Following WRC Plan Change 1 (Hamilton City Council)
4	Wider catchment management and monitoring initiatives – Explore opportunities to collaborate with other agencies on wider catchment management and monitoring initiatives. These may include, but are not limited to: • Ground and surface water monitoring throughout the catchment • Water quality treatment and monitoring throughout the catchment	Ongoing (Hamilton City Council and other agencies - e.g. Waikato Regional Council, Waikato District Council, Iwi, Tangirau Restoration Group etc.)

Ref	Future action	Anticipated timeline (responsibility)
	• Ecological restoration and monitoring throughout the catchment • Further stream channel erosion and stabilisation projects if/ where required throughout the catchment	
5	ICMP to be reviewed and updated as required (refer to Section 8.5)	Ongoing (Hamilton City Council)
	Flood Hazard Assessment	
6	LiDAR survey extent update	Dependent on LTP funding and programme requirements (Hamilton City Council)
7	Detailed flood hazard modelling in accordance with extent assessment using MIKE 11 (or similar). To be in accordance with Hamilton City Council's Stormwater Modelling Methodology	To be undertaken after new LiDAR is flown of the city, and in line with funding prioritisation. (Hamilton City Council)
	Water	
8	Bulk water mains - 550/700mm bulk pipelines (e.g. the Pukete supply main) for water service level	2015-2018 (Hamilton City Council)
	Habitat Restoration	
9	Update and Implement the Mangaheka Restoration Vision	To WRC timeline
	Erosion Prevention	
10	Review and implement programme of works for erosion protection as per Appendix D. Remedial works may include battering back over steep banks, reinstating channel features, riparian planting for bank stability and armouring and stock proof fencing.	Ongoing in collaboration with WRC, Hamilton City Council, the consent holder and landowners
11	HCC to investigate potential re-connection of Te Otamanui Stream to upper catchment when planning Device 6.	2018 currently underway
	Water Quality	
12	Hamilton City Council officers to review pollution control plans for catchment high risk activities through the building consent process for new development	2018 (Hamilton City Council) ongoing
13	Hamilton City Council officers to review and audit existing developments with a focus on the prioritised activities identified in the Water Quality report in (**Appendix C**) and as listed in **Appendix M**	2018 (Hamilton City Council)

Ref	Future action	Anticipated timeline (responsibility)
14	Hamilton City Council officers to discuss recommended improvements to Porters and HJV centralised devices with consent holder prior to vesting	2018 (Hamilton City Council)
15	Hamilton City Council officers to require completion of the Porters and HJV centralised devices under urgency	2019 (Hamilton City Council)
16	Review of ITS requirements for contaminant removal and device parameters following adoption of Waikato Regional Council Proposed Plan Change 1 – Healthy Rivers.	Following WRC Plan Change 1
17	Erosion and sediment controls shall be in accordance with Hamilton City Council and WRC requirements, and shall be established on site and approved by Hamilton City Council and WRC (as required) prior to any soil disturbance activities taking place	As required by development
	Operation and Maintenance	
18	Review Hamilton City Council Stormwater Device Operations & Maintenance template and ITS checklist. Ensure the template refers to ICMP parameters, and consider stormwater device performance at the time asset is vested. Compare to city wide monitoring plan.	2018/19 (Hamilton City Council)
19	Operations and Maintenance Plans for devices shall recognise the flat gradient of the upper catchment outlets and ensure downstream restrictions are identified and removed on an on-going basis, to maintain hydraulic capacity and to control water depth to allow plant growth in the upstream devices. Site visits in August 2018 showed excessive weed/vegetation growth in the stream between Porters Wetland device outlet and Koura Drive, and stream bed high points up to 35m downstream of the Koura Drive culvert, which need to be re-profiled prior to vesting of device.	Ongoing (consent holder)
20	Changes/upgrades to existing stormwater devices to consider litter screens and hydrocarbons (submerged outlets). Consider these changes for standard design in ITS.	2018/19 (Hamilton City Council)
21	Waikato Regional Council may want to consider reducing the drainage board area within the urban area and manage this with Hamilton City Council.	Ongoing (Waikato Regional Council and Hamilton City Council)
22	The capital works and ongoing operation and maintenance programmes outside of Hamilton City Council's jurisdiction shall be agreed by WRC (land drainage manager) and Hamilton City Council (City Waters). The first project is recommended to be within the first 35m of the watercourse outside Hamilton City Council's jurisdiction to provide for ongoing ease of operations and maintenance to allow for urbanised flows.	2019/2020 (Waikato Regional Council and Hamilton City Council)

Ref	Future action	Anticipated timeline (responsibility)
23	Hamilton City Council will work with Waikato Regional Council regarding the future maintenance of the watercourse to the east of Koura Drive within Hamilton City Council's jurisdiction to ensure adequate capacity for the upper urban area to drain efficiently	Ongoing (Waikato Regional Council and Hamilton City Council)
	Mana Whenua Cultural Impact Assessment	
24	Maahanga, Tamainupoo and Ngati Hauaa have not concluded their final research in this area. Mana whenua are currently preparing a broader cultural values assessment for the wider Rotokauri area and this will supersede historical cultural impact assessments relied on for this ICMP. Please refer to the new cultural values assessment when it is available.	2018/2019 and ongoing (Waikato District Council and Hamilton City Council)
	Opportunities	
25	Hamilton City Council to recommend to WRC a review/update the High Risk Facilities register to bring in line with that of Auckland Council's register and the stormwater guidelines under development. High risk facilities register should include activities and associated pollutant management solutions.	2018/19 (Waikato Regional Council and Hamilton City Council)
26	Hamilton City Council to consider updating the Stormwater Bylaw to reflect additional high risk activities recommended in the Water Quality report in **Appendix C**.	2019/2020 (Hamilton City Council)
27	Hamilton City Council will continue to have conversations with WRC during the period of transition in the strategic legislative context and will update the Contaminant Module and continue working with WRC during this stormwater treatment evolution phase	2019/2020 (Waikato Regional Council and Hamilton City Council)
28	A city wide change to the District Plan will be considered to achieve a lower impervious cover for industrial sites (currently 90%) to assist in reducing volume of stormwater runoff	2019/2020 (Hamilton City Council)
	Education	
29	Once the ICMP is finalised and approved, key stakeholders will be informed. The ICMP will be placed on the Hamilton City Council website and implementation meetings with Hamilton City Council Development Engineers, City Planning, Planning Guidance Unit and Building Unit to ensure requirements within the ICMP (specifically Parameters and Methods to Achieve Compliance Table) are implemented through Resource Consents and Building Consents as required	2018/19 (Hamilton City Council)

6.7 Mechanisms for Implementing Measures

Mechanisms for implementing measures include:

- **Development applications**: Developments will be assessed against the Design Parameters and Means of Compliance tables at the time of resource consent and/or building consent application. A Geographical Information Systems (GIS) layer has been developed to aid Hamilton City Councils consent processing officers in identifying the requirements for each sub catchment. Resource consent conditions will be written and enforced accordingly.

  See **Figure 2-9** for network service plans to assist in development proposals. Developers will need to check with Hamilton City Council on the status of the plans in this ICMP, catchment performance and where a resource consent is required, should participate in pre-application meetings to understand requirements prior to development of proposals.

- **Enforcement –proposed district plan and bylaws:** Council has adopted a stormwater bylaw[23] which sets out Councils powers under the Local Government Act to manage, regulate and protect, and to prevent the misuse of Council's land, structures or infrastructure associated with stormwater drainage. This will be supported by an Education Strategy.

- **Waikato regional council drainage networks:** Waikato Regional Council has powers relating to the maintenance of land drainage networks to maintain groundwater levels, manage surface ponding after rainfall, and prevent flooding. Hamilton City Council's Education Strategy will include information relevant to ensuring Waikato Regional Council's land drainage requirements are met.

- **Council's long term plan:** The LTP is used as a funding mechanism for infrastructure required for the Mangaheka catchment. ICMP's will contribute to funding decisions on infrastructure projects in the LTP.

- **Existing programmes** such as:
  - Planned maintenance[24] and operational improvements
  - Asset renewal programmes
  - Design and development in accordance with ITS
  - Customer service level (satisfaction surveys, complaints, monitoring)

- **Education strategy:** this requires effective internal and external communication

[23] Hamilton City Council Stormwater Bylaw 2015.

[24] For example road catchpits and sumps are currently cleaned out on an annual cyclic basis. However, streets with known leaf fall problems which are swept up to three times a week to forestall blockages.

Incorporate into City Waters education strategy and assess appropriate communications plan within 1 month ICMP approval. The strategy needs to ensure that affected Units understand and apply ICMP content and implement though mechanisms such as consent approval processes and conditions. The external communication strategy needs to ensure that the ICMP is understood, referenced in consent application documents and by key stakeholders, BPOs are adopted and there are no buildings exposed to unacceptable levels of risk from flood hazards. Measures will include: Roadshow, Intranet, Website – ICMP, Website – FAQ, Territorial authority websites where appropriate.

- **Collaboration with other agencies:** Collaboration with other agencies on ICMP's, District Plan changes and resource consent approvals and bylaw reviews to ensure appropriate quality and quantity requirements are met.

7 Consultation

Consultation has been undertaken with all key stakeholders (internal and external), directly affected landowners (developers and non-developers) and the wider community as an integral part of the ICMP development process. This has helped to generate a greater understanding of the Mangaheka Catchment and the issues and opportunities arising. It has also assisted with gathering baseline information and testing proposed management options.

Key actions have included:

- Development and execution of the Mangaheka ICMP Communication Plan (Hamilton City Council, December 2017)
- The provision of information and meetings with key stakeholders, including regular project updates, facilitation of discussions and related follow—up actions
- Internal and external key stakeholder workshops (presenting on issues, options and proposed BPOs / management solutions)
- Targeted consultation on the Draft ICMP (Version 1), including public notification and a 'drop in' session to enable the participation of all interested parties
- Follow up communications and/or meetings with all parties who lodged submissions via the targeted consultation process.

Further details regarding this consultation are provided in the 'Mangaheka ICMP Communication Plan' (Hamilton City Council, December 2017).

7.1 Key Stakeholders

A list of the parties consulted is provided in **Table 7-1** (for more detailed records refer to the 'Mangaheka ICMP Communication Plan' (Hamilton City Council, December 2017)).

Table 7-1: Key Stakeholders

Name
Internal Stakeholders
• Elected Members • City Planning • City Waters • City Development • City Transportation • Parks & Open Spaces • Asset owners • Operations and Maintenance • Regulators
External Stakeholders
• Waikato Regional Council: The Regional authority for the Mangaheka catchment area, Technical assessor for CSDC alignment and Drainage area administrators • Waikato District Council: Territorial authority for large part of catchment • Waikato-Tainui Raupatu River Trust: In accordance with the Waikato River Settlement Act • Tangirau Wetland Restoration Group • Mana Whenua (Te Ha o Te Whenua O Kirikiriroa) • Developers (as landowners) in headwater of catchment and within city boundary and Landowners outside city boundary adjacent to Mangaheka Stream • Land drainage scheme parties • NZ Transport Agency

Consultation on the ICMP included the following:

- Presentation and drop-in session for Developers
- Stakeholder Open Day - for members of the public and targeted stakeholders
- ‘Drop in’ sessions for Hamilton City Council internal staff where the ICMP could be further explained and feedback provided
- Series of workshops with WDC/WRC staff regarding emerging issues and findings of technical reports.
- Follow up letter on outcome and ICMP outcomes and implementation presentation (invite to PCG reps, Unit Managers, Building Unit, PG Unit, DE’s, City Waters reps and Compliance team)
- Follow up letter to external parties, developers and submitters (with invitation to meet) on finalised ICMP

7.2 Issues Raised

A total of 197 issues or queries were raised in submissions received from internal and external stakeholders. The external stakeholders included Waikato District Council, Waikato Regional Council, Porter Properties Limited, Te Rapa Gateway Limited, Tangirau Restoration Group, developers, mana whenua and the community.

The majority of the submission points (127) were from Waikato Regional Council, requesting minor clarifications and/or amendments, however, there were 70 points or queries raised by other submitters. All submissions have been considered and acknowledged, and the issues which directly relate to the ICMP have been addressed and are reflected in this ‘Final Draft’ document where appropriate.

Many of the submission points /issues overlapped, and common themes were identified. A high level summary of the points raised and how they have been addressed is provided in **Table 7-2**.

Table 7-2: Consultation – High level summary of key issues

Issue category	Issues Raised	Addressed	Refer Section
Water Volumes	Reduction in ground soakage leading to greater stormwater volumes Flooding of roadways (already taking place in some locations)	The ICMP identifies the proposed maximising of on-lot soakage opportunities and stormwater detention tanks. Centralised man-made wetlands aimed to help mitigate against an increase in peak flows during flooding events.	4.3.1 (Flood Management) and 4.3.2 (Water Sensitive Design)
	Potential for ongoing development to alter stormwater flow directions which may alter the catchment boundaries	The potential for this has been reviewed and the catchment boundary within the ICMP has been revised based on information provided to date. Hamilton City Council expect to provide better definition around the upper reaches of the Mangaheka Stream and the Te Otamanui sub-catchment. This will be an on-going future action for the catchment boundary to be updated as development occurs and potentially modifies the current boundaries.	6.6 (Future Actions)
Te Otamanui Re-connection	Need to consider potential development of Te Kowhai Village and cultural/ecological/ erosion etc effects of the reconnection.	Hamilton City Council are preparing a scope of works to undertake further modelling and survey of the Te Otamanui sub-catchment and will discuss with Waikato District Council and other stakeholders. It is expected this will model a few development scenarios in order to reach a conclusion on whether re-connection is possible.	6.6 (Future Actions)
	Potential for flooding to some landowner properties	There are a number of investigations noted in the Te Otamanui Fatal Flow Assessment which would need to be conducted, including assessment of potential flooding and impacts to existing infrastructure and properties, prior to any further decision being made on the reconnection of this catchment.	2.6.1 (Flood Risk)
Water Quality	Post-development water quality should be improvement on current conditions	The programmed stream works for erosion protection, riparian planting and stock protection will assist in the enhancement of the stream environment and improvement of water quality in terms of nutrients and suspended sediment.	2.3.5 (Water Quality and Contaminants)
	Alignment with Healthy Rivers (Plan Change 1) targets	The use of a treatment train approach in the upper catchment, meeting best practice standards, will also help reduce contaminants in stormwater. This aligns with the intent of Plan Change 1.	3.2 (Stormwater and Receiving Environment Assessments)
	Concern for increased contamination	Projected changes in the contaminant load following MPD and anticipated contaminant removal via the proposed treatment train approach has been re-assessed and is included in the Water Quality Addendum Report.	6.4 (Design Parameters)
	Definition of expected levels of contaminants and what levels of contaminant removal need to be attained	The Design Parameters table identifies contaminant removal requirements as per the best practice standards as detailed in the ITS.	6.5 (Means of Compliance)

Issue category	Issues Raised	Addressed	Refer Section
Water Quality	Monitoring of high risk sites and stream water quality	Monitoring of high risk sites will be addressed through the consenting process associated with each high risk development. A monitoring regime is included in the ICMP to monitor downstream water quality a part of the city wide monitoring programme.	6.5 (Means of Compliance) 8.2 (Proposal for Catchment Monitoring)
	Potential impacts on downstream users, native fish and the wetland	The ICMP discussion on effects on downstream users, native fish and the wetland has been expanded and clarified. It is anticipated that the combination of the programmed stream works and the treatment train contaminant removal approach in the upper catchment will overall improve both water quality and ecological conditions.	2.3.5 (Water Quality and Contaminants) 3.2 (Stormwater and Receiving Environment Assessments)
	Implications for developers for on-lot treatment devices - further assessment of risk and options should be undertaken before imposing this requirement.	On-lot contaminant control and a ‘treatment train’ of swales/rain gardens and wetlands will be required to achieve a stormwater discharge ‘betterment’.	6.2 (Hamilton City Preferred Options) 6.5 (Means of Compliance)
Centralised Devices	Potential effect of proposed development on groundwater and its interaction with centralised devices	The ITS specifies that constructed wetlands should include an impermeable layer. Such a layer will isolate the wetlands from groundwater, hence the operation of existing and future wetlands is/will not be impacted by any variances in groundwater level. There is, however, a need to understand localised conditions in the area of a proposed device to help inform design. For this reason advice has been sought and the Design Parameters Table has been updated to include requirements for groundwater monitoring prior to design.	4 (Stormwater Management) 6.4 (Design Parameters) 6.5 (Means of Compliance)
	Issues with the performance of existing centralised devices Future device performance monitoring	A study has been undertaken by Beca to understand these issues. Landowners are being consulted on what is required to address this. Regulation and monitoring of device performance is controlled via the device consent. The compliance of the existing devices is being addressed by WRC who issued the consents. The ICMP refers to the need for devices to be designed and constructed in line with the ITS and details the sizings required to meet the stormwater volume projected to be generated as a result of proposed development.	
Erosion	Potential for increased erosion	An erosion assessment has informed a planned programme for works to address this and detailed design for works will be scoped up with landowners.	6.5 (Means of Compliance)

Issue category	Issues Raised	Addressed	Refer Section
			6.6 (Future Actions)
Objectives	No clear detail on how all points of objectives are to be achieved	The ICMP has been revised to clearly define how the objectives will be met.	3 (Issues and Objectives)
	Not clear how the ICMP aligns with the Vision and Strategy for the Waikato River and the Waipa Catchment Management Plan	The ICMP has been revised to more clearly communicate the alignment with the Vision and Strategy for the Waikato River and the Waipa Catchment Management Plan	4.3 (Best Practicable Options - Stormwater
Stormwater Management	ICMPs should give developers very clear guidance as to what is expected of them	Guidance is provided in the Design parameters and Means of Compliance Tables	6.4 (Design Parameters) 6.5 (Means of Compliance)
	The water conservation measures proposed for the ICMP (including the mandatory provision of rainwater tanks) are not credible.	Water metering is not due to be implemented by Hamilton City Council at the present time therefore an emphasis will remain on water detention and reuse.	4.3.2 (Water Sensitive Design)
	Potential impacts associated with failure of centralised devices	Hamilton City Council prefer to use larger devices to streamline the maintenance process. The treatment train options together with the development of a programme of inspections and maintenance will address the risks associated with associated with device failure.	4 (Stormwater Management)

7.3 Cultural Values

7.3.1 Consultation

Due to the large number of ICMP's under development by Council, engagement with mana whenua for the Mangaheka ICMP only occurred towards the end of the ICMP drafting. It is acknowledged that this was not ideal, and earlier engagement with mana whenua may have been more beneficial to enable an updated cultural values assessment to be prepared to better inform this ICMP.

Notwithstanding this however, Council staff met with mana whenua representatives of Te Ha o Te Whenua O Kirikiriroa over three hui to discuss the outcomes sought in this ICMP. This culminated in a highly engaged site visit to look at the wetlands under construction (Porter and Te Rapa gateway) and the severed Te Otamanui sub-catchment. Following the discussions at various hui and the site visit, Council committed to providing the mana whenua group with a copy of the ICMP prior to lodgement with WRC for certification, so they could see how their feedback had been incorporated into the document.

Those outcomes of specific interest to mana whenua have been incorporated into the ICMP document and tables as described below:

7.3.2 Means of Compliance Table

The following requirements have been included in the means of compliance table for all sub-catchments:

- Mana whenua have indicated a cultural interest in the Mangaheka catchment. Prior to obtaining any resource consents for development of land in the ICMP boundary within Hamilton City Council's jurisdiction, the developer shall consult with mana whenua and provide evidence of such consultation as part of any resource consent application.
- Rain-water re-use tanks for non-potable use will be required for all new development (requiring a resource consent). It is important to note that a number of the Porter Group and Te Rapa Gateway properties have historic resource consents that don't require this, so it will only apply to new developments that aren't covered by the existing resource consent.
- Additional on-lot contaminant removal and control (no exposed copper or zinc, catch pits for capture of gross pollutants and carpark areas draining to pre-treatment devices before entering the swale and wetland treatment device).
- Encouragement of reduced impervious area (for volume control).

7.3.3 Future Action Table

Reconnection of the Te Otamanui Stream is highly desirable to recharge the Te Otamanui lagoon, and to also reduce flow and potential erosion in the Mangaheka Stream. The following action has been included in the Future Action table (and investigation is currently underway as part of the Rotokauri North housing development which requires Device 6):

- Investigate the potential re-connection of Te Otamanui stream to the upper catchment when planning for Device 6.

Preparation of a wider cultural values assessment is proposed to be a condition of the Rotokauri Greenway Notice of Requirement. It will take a wider perspective than the earlier CIA's prepared for Te Rapa Bypass and Rotokauri Structure Plan, and include the Mangaheka catchment. However as this could be six months away, and rather than have no cultural context in the ICMP, it was agreed this ICMP should reference the Rotokauri Structure Plan and Te Rapa Bypass Cultural Impact Assessments prepared by NAMTOK, together with Waikato Tainui Environmental Plan Te Tai Ao to inform the cultural context for the Mangaheka ICMP, with the following notes in the Future Action Table:

- Maahanga, Tamainupoo and Ngati Hauaa have not concluded their final research in this area, which will be included in the broader Cultural Values Assessment being prepared by mana whenua. That assessment will be the primary cultural values reference document for development in the Mangaheka catchment once it is completed.

Another action for Council to pursue in the future is to seek to reduce the amount of impermeable surface permitted in the Industrial Zone across the city. Currently development can cover up to 90% of their site in concrete/hard-stand surfaces. This is one way to reduce the amount of run-off and potentially manage the volume of stormwater entering the system. The following future action has been included:

- Reduce the permitted impervious cover for industrial zones across the City (currently 90%) through a city wide plan change.

7.4 Future Stakeholder Liaison

Ongoing liaison with key stakeholders and directly affected landowners will be critical to the effective implementation of the ICMP. This is recognised throughout the ICMP, in particular Section 1.7 (Strategic Objectives), Section 3 (Issues and Objectives), Section 6.3 (Mangaheka Catchment Specific Requirements) and Section 8.2 (Proposal for catchment Monitoring). Consultation may also be carried out as part of further investigations and assessment work, major infrastructure and development design, land designation and resource consent processes and general implementation where appropriate. The specifics of these initiatives fall outside the scope of this document.

8 Monitoring

8.1 Catchment Monitoring

Development in the Mangaheka catchment will be monitored as per the requirements of individual land, water and discharge consents as well as the Hamilton City Council city wide monitoring plan. Stormwater discharges will be monitored under the requirements of:

a) Subdivision discharge consent monitoring conditions prior to being transferred to Hamilton City Council under the City wide consent number 105279.

b) Extended CSDC monitoring plan required under consent number 105279.

8.1.1 Hamilton city council responsibility

Hamilton City Council holds Waikato Regional Council resource consents for stormwater discharges, water take, and wastewater discharges. Hamilton City Council's citywide stormwater discharge consent 105279 covers existing urban development. Hamilton City Council was required to prepare a monitoring plan to assess the adverse effects of municipal stormwater diversion and discharge activities on the environment. The monitoring plan has been revised in 2018 and is hereafter referred to as the Tonkin and Taylor Stormwater Monitoring Plan (SMP), (2018).

Hamilton City Council will carry out monitoring in the catchment guided by the methods outlined in the monitoring plan. In addition, where the monitoring plan does not provide fit for purpose method the Auckland Council Watercourse Assessment Methodology: Infrastructure and Ecology (Version 2.0), Lowe and Young 2015 (referred to as the WAM) and Environment Waikato Environmental Monitoring Methods will be utilised.

The monitoring plan for Mangaheka catchment has been developed in consultation with the authors of the Tonkin and Taylor SMP, to ensure that the two plans align and catchment specific monitoring requirements so that representative data can be collected to support future planning and management.

The effects from upstream discharges could potentially occur in the Waipa River, outside of the ICMP area and Hamilton City boundaries in to Waikato District.

8.1.2 Development community responsibility

Developers require stormwater consents to allow discharge to the receiving environment in accordance with the requirements of the Regional Plan. The ICMP will help developers in the preparation of these consents and assist the Waikato Regional Council in determining what monitoring of discharge quality and quantity is required. In particular the ICMP will help ensure consents are issued which address cumulative effects. In general, discharge consent conditions need to be consistent with the Hamilton City Council CSDC to provide certainty that the consents can be transferred to Hamilton City Council.

A fuller description of the administrative process for incorporating new diversion and discharge activities in to the CSDC is contained within the most up to date version of the Hamilton City Council Stormwater Management Plan.

Any stormwater discharge consent held by a developer must have its specific consent monitoring requirements carried out by the developer until the consent is transferred to Hamilton City Council. Performance assessment of stormwater treatment systems that are in private ownership are to be carried out by the owner/operator.

8.2 Proposal for Catchment Monitoring

A catchment specific monitoring plan is provided in **Figure 8-1**: Monitoring Plan - Sampling and Monitoring Locations and **Table 8-1**: Monitoring Plan. This plan has been developed based on technical assessment recommendations. The proposal is designed to take into account the Ecological Report recommendations (as per **Appendix E**); to tie in with the citywide stormwater monitoring plan previously developed by Tonkin &Taylor and which has been revised in 2018; and for Hamilton City Council to satisfy the monitoring requirements of Consent 105279, Condition 37.

Where a method has not been predetermined or is not considered fit for purpose, suitable methods will be agreed with Waikato Regional Council.

At agreed points on the Mangaheka stream, and at pre-determined intervals, the following monitoring program is proposed and will be used for baseline data, monitoring for change over time, to determine any trends and for identifying required remedial actions. The monitoring plan will be reviewed and revised periodically based on findings of the monitoring as well as any relevant input from ongoing stakeholder consultation.

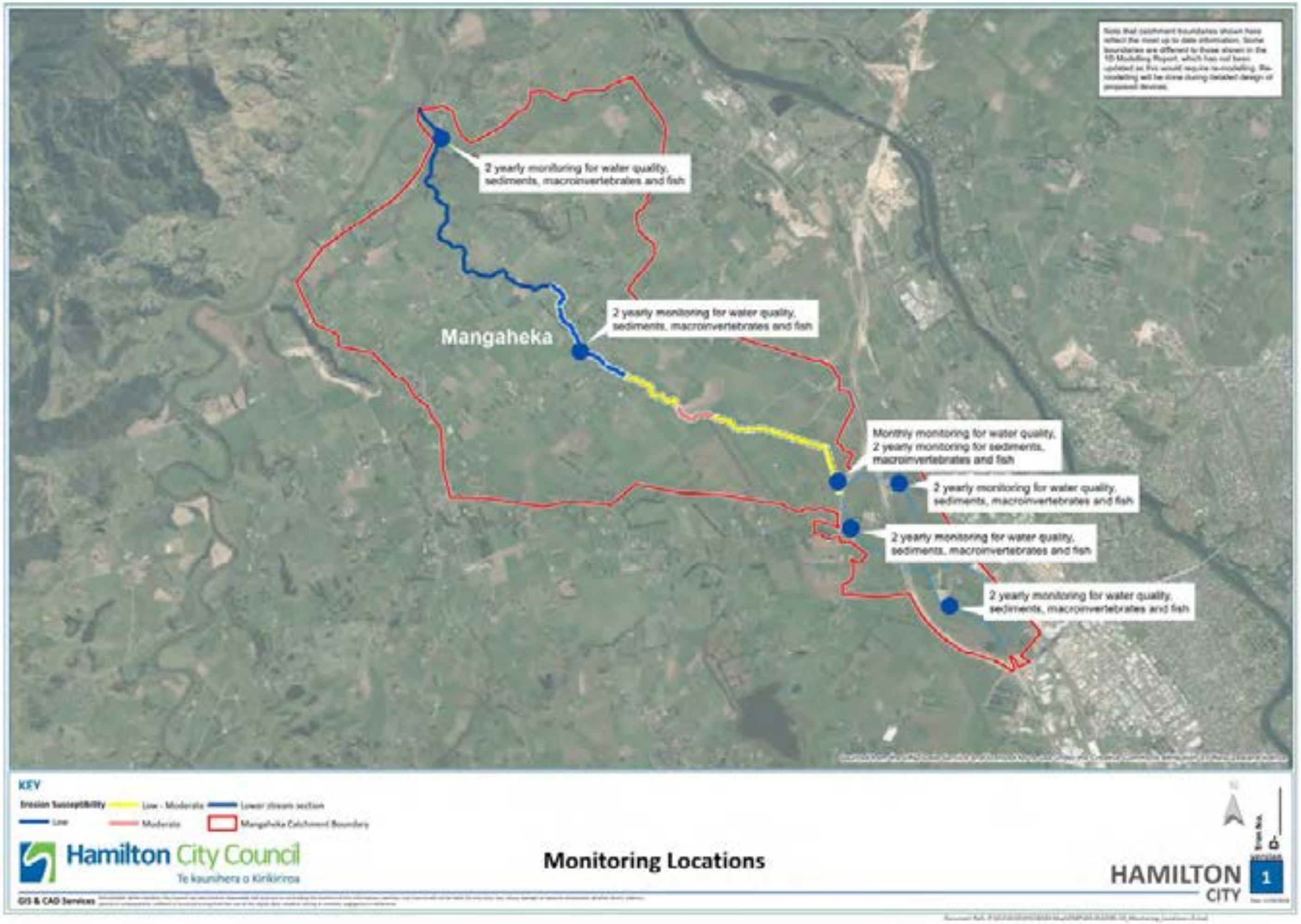

Figure 8-1: Monitoring Plan - Sampling and Monitoring Locations

Table 8-1: Monitoring Plan

ID	Parameter	Criteria	Program/Method	Performance measure	Frequency
1	**Receiving Environment**				
1a	Visual semi-quantitative, assessment of bank and bed stability	Riparian margins, vegetation type and density, any adverse scour, erosion and sediment deposition on land, property and the stream bed, channel width and depth	Baseline conditions have been established through the watercourse Assessment (Morphum, 2017) including GIS mapping and photo points along all stream reaches (1 – 10) located between Koura Drive and Ngaruawahia Road. Ongoing monitoring will focus on erosion hot spots and reaches identified as being of high susceptibility to erosion (an overall stability score of "poor"). The monitoring and inspection should follow the approved Hamilton City Council Rapid Geomorphic Erosion Assessment Methodology and the erosion hot spot assessment from Hamilton City Council's Receiving Environment Module.	Riparian margins improve in stability, channel width and depth remain stable. Change in the extent and severity of scour and erosion at identified locations as well as downstream of discharge points compared with baseline erosion information as detailed in the Watercourse assessment (Morphum, 2017).	Monitoring of identified erosion hot spots and reaches identified as being of high susceptibility to erosion (an overall stability score of "poor") on an annual basis during low base flows following implementation of the ICMP, and then following any significant (> 10yr) storm events. The monitoring of Mangaheka Stream shall align with and be coordinated into the approved CSDC Monitoring Plan and be allocated to a "Round" to facilitate the monitoring programme as per Table 3.6 of the approved CSDC Monitoring Plan. Where erosion is identified, more frequent targeted inspection or remedial actions may be required. Likewise if sites are stable the monitoring frequency may reduce.
1b	Semi-quantitative assessment of aquatic fauna presence and/or diversity	Aquatic and riparian habitat quality	Habitat quality will be assessed in accordance with Waikato Regional Council's Regional Guidelines for Ecological Assessment of Freshwater Environments and/or the approved CSDC Monitoring Plan methods. Results can be compared with results from similar Hamilton City Council Stream catchments in addition to providing year-on-year comparison to assess changes in habitat values.	Results from the visual semi-quantitative assessment provide context in the event of unexpected fish diversity, MCI or sediment quality results.	Monitoring will be repeated annually at the reference site on the Hamilton City Council boundary with sampling at upstream and downstream monitoring locations conducted as necessary based on findings of this monitoring and in alignment with the approved CDSC Monitoring Plan.

ID	Parameter	Criteria	Program/Method	Performance measure	Frequency
					Monitoring will be conducted alongside macroinvertebrate and sediment sampling.
		Biological sampling and analysis of aquatic macroinvertebrate community composition and diversity	Aquatic habitat quality will be assessed in accordance with relevant Waikato Regional Council's Regional Guidelines for Ecological Assessment of Freshwater Environments relating to aquatic macroinvertebrates and/or the approved CSDC Monitoring Plan methods. Sample recovery will include one replicate sample and will prioritise the city boundary monitoring location as a reference site.	Macro invertebrate metric values (e.g. unchanged or improved) compared with baseline information and compared with results from similar Hamilton City Council Stream catchments, in addition to a year-on-year comparison of metrics to assess changes in aquatic habitat values.	Macroinvertebrate sampling will be repeated annually at the reference site on the Hamilton City Council boundary with sampling at upstream and downstream monitoring locations conducted as necessary based on findings of this monitoring (e.g. if a downward trend in macroinvertebrate communities is identified at the reference site) and development progress. The monitoring will commence following implementation of the ICMP until development is complete and, if considered required to be continued, thereafter at a frequency based on monitoring findings and in alignment with the approved CDSC Monitoring Plan.
		Native fish presence and diversity	Aquatic habitat quality will be assessed in accordance with relevant Waikato Regional Council Regional Guidelines for Ecological Assessment of Freshwater Environments relating to native fish and/or the approved CSDC Monitoring Plan methods. The fish survey will be in accordance with the National Protocol.	Native fish diversity in the catchment is similar or better than baseline results when assessed in the context of the catchment values.	A baseline for fish species in Mangaheka Stream has been compiled from recent and ongoing monitoring observations. Monitoring surveys will be repeated 2 yearly following implementation of the ICMP. Ongoing frequencies of these surveys will respond to findings and will align with the approved CDSC Monitoring Plan.
		Sediment Quality Sample	Composite sediment samples will be collected from surface sediments at habitat quality monitoring sites	Sediment quality data presented in NIWAs 2012 report will be used as	Sediment sampling will be repeated annually at the reference site on the

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ID	Parameter	Criteria	Program/Method	Performance measure	Frequency
			identified in the Monitoring Location Plan (**Figure 8-1**). Each sample will be tested for total organic carbon, polynuclear aromatic hydrocarbons and total recoverable copper and zinc. Laboratory analysis of samples would follow the same protocol as used in NIWAs 2012 study of contaminants in Hamilton's urban stream sediments and as per the approved CSDC Monitoring Plan methods.	a baseline for the CSDS consent monitoring. Sediment quality data should be unchanged or improved compared to the baseline information and other CSDC monitoring sites in the Hamilton area.	Hamilton City Council boundary with sampling at upstream and downstream monitoring locations conducted as necessary based on findings of this monitoring (as per for macroinvertebrate sampling). Monitoring will be conducted alongside macroinvertebrate sampling and habitat assessment.
1c	Quantitative assessment of stream water quality	In-stream water quality variables to be assessed.	Water samples to be taken at the main monitoring site at the discharge from the Hamilton City Council jurisdiction with sampling following the Waikato Regional Council Water Quality Monitoring Protocol to assess: in-field measurements: - pH - Temperature - Dissolved Oxygen Laboratory analysis: - pH - Hardness - Conductivity - Total suspended sediment22 - Chemical oxygen demand - Total and dissolved copper lead and zinc - Total and ammoniacal nitrogen - Turbidity - Total and dissolved reactive phosphorus - Nitrate & Nitrite - E. coli - Faecal Coliforms.	Results to be compared to trends in water quality within the stream and other watercourses in the Hamilton area as per intent of the approved CDSC Monitoring Plan. Comparison of results at Hamilton City Council monitoring point at base of Hamilton City Council catchment area and base of WDC catchment area (via WRC monitoring results).	Baseline water quality established by assessment in 2012 and 2016. Monthly monitoring to be undertaken as per the approved CDSC Monitoring Plan at the reference site on the Hamilton City Council boundary with water quality sampling at up-stream and down-stream monitoring locations conducted as necessary based on findings of this monitoring (e.g. if a downward trend in water quality is identified at the reference site or a monitoring plan trigger value is exceeded).

ID	Parameter	Criteria	Program/Method	Performance measure	Frequency
			For analysis of samples, refer to CDSC Monitoring Plan.		
	Device performance and discharge quality				
1d	Stormwater treatment device performance (by consent owner/operator via consent conditions)	Criteria per Mangaheka ICMP discharge parameters set out in **Table 6-2**, using methods specified in developer consent conditions or, if not specified, methods specified in CSDC.	To test performance of large treatment devices in situ is both technically challenging and cost prohibitive. If the treatment devices being wetlands in the majority are monitored to ensure they are built and maintained as per design, the efficiency can be considered to be achieved. This will require monitoring of wetland vegetation cover which must be above 80% of the total wet area of any wetland and hydraulic function to ensure short circuiting is not occurring the device functions as per design as per inspection sheets in GD05. Water temperature discharge to be monitored using in-situ monitor at discharge point with 5 minute time stamp. This should be done in the summer months from 1 December to March 30. If upstream input flows, particularly from open channels, can be monitored then they should be included in sample design.	Assets meet design of over 80% vegetated and functions as per design to meet criteria being 75% TSS removal and passes inspection checks as per GD05. Have discharge temperatures no more than 3 degrees above ambient stream temperature levels at end of mixing zone.	Operational Monitoring to be undertaken annually following implementation of the ICMP until development is complete, including defects liability. Waikato Regional Council consent conditions remain the responsibility of the consent holder until it is transferred to the local Regulatory authority. Temperature monitoring to be conducted as specified and if Hamilton City Council considers adverse temperature effects are likely.
1e	Visual contaminants	Oil, grease, scum, foam, colour, and litter.	Site inspections of devices and associated discharge areas, and inspections at key road crossings as indicated on the monitoring location plan (**Figure 8-1**).	Absence of oil, grease, scum and foam. Less than minor litter. No conspicuous changes in colour downstream of discharge points.	Monitoring at devices and Hamilton City Council jurisdiction discharge point to be undertaken monthly along with water quality monitoring and/or visual assessments undertaken in accordance with the approved CSDC Monitoring Plan and following any significant (> 10yr) storm events. Monitoring at remaining locations (upstream and downstream) to be conducted when

ID	Parameter	Criteria	Program/Method	Performance measure	Frequency
					necessary based on findings of ongoing monitoring.
1f	Sediment control of building construction and earthworks	Audit by both Hamilton City Council and Waikato Regional Council	Earthworks, building and construction sites inspected for appropriate use of on-site management controls, including correct design, installation, operation and maintenance. Water samples may be taken downstream of the site to determine overall management performance and to ensure compliance with relevant regulatory provisions, including building permits and/or resource consents where applicable.	Onsite management controls are correctly designed, installed, operated and maintained. All relevant regulatory provisions are met[25]	During construction.
1g	Riparian mitigation works	Bank stability and condition of riparian planting	Visual walkover assessment of condition of completed capital works. Plant maintenance including weed removal.	Bank stability and stock fencing maintained/ improved and establishment of planted vegetation	Assessment walkover within 6 months of completion of capital works, annual walkover assessment. Plant maintenance visits to be conducted 4 times per year for first two years, reducing to 3 visits per year in third and fourth years, subsequently reducing to 2 visits per year thereafter if ongoing monitoring is confirmed to be required.

[25] Waikato Regional Plan Permitted Activity standard = 100 gm per m3 after reasonable mixing. CSDC turbidity criteria = 25 NTU

At the time when applicable assets and discharge consents are transferred to Hamilton City Council, responsibility for maintaining and monitoring those assets and discharges also transfer Hamilton City Council. It is important to note that Hamilton City Council will only allow transfer of assets and discharge consents if:

a) Assets have been designed to meet required performance standards
b) Assets have been appropriately maintained and are fit for purpose at the time of transfer
c) Compliance with resource consent conditions has been achieved
d) Monitoring of device performance and discharge effects has been carried out in accordance with the conditions of the consent
e) Appropriate legal protections have been established (e.g. easements)

For detailed monitoring methodologies and scheduling see the most up to date version of the Hamilton City Council Stormwater Monitoring Plan and protocols 1, 2, 7, 8, 9 and 10 from the Auckland Council Watercourse Assessment Methodology: Infrastructure and Ecology (Version 2.0), Lowe and Young 2015.

8.3 Reporting and Review Process

Monitoring of individual discharge consents will be reported to Waikato Regional Council in accordance with consent conditions, and copies of the reports and monitoring results will also be provided to Hamilton City Council.

Monitoring of discharges required under the CSDC (including where this has been extended to include the Mangaheka catchment) will be presented as part of the Municipal Stormwater Network Operation Annual Report (as required by Condition 38 and 39 of the CSDC).

The report will contain recommendations on any changes that may be needed to the monitoring plan.

Waikato Regional Council and Hamilton City Council will liaise in order to review and, where necessary, alter the CSDC monitoring plan in scale and/or method and/or location after having regard to the consistency and significance of the monitoring data collected, or any other information relating to the stormwater diversion and discharge activities authorised by this consent.

Hamilton City Council will be responsible, on an ongoing basis, for the review of guidelines and procedures for the implementation, performance evaluation, operation and maintenance of Mangaheka Stream catchment and on-lot practices consistent with the approved ICMP.

Hamilton City Council will also be responsible for reviewing the level of subdivision and development occurring in the Mangaheka catchment relative to the land use assumptions underlying the ICMP, with particular emphasis on:

- Monitoring on-lot stormwater management;
- Restoration and management of riparian and aquatic habitat downstream of discharge points; and
- Compliance with (and performance of) erosion and sediment controls implemented in the Mangaheka catchment for building sites.

Hamilton City Council may direct immediate intervention where significant effects are identified.
This may include, but is not limited to:

a) Building site management enforcement
b) Remedial stream and riparian works for scour and erosion

c) Additional auditing
d) Riparian vegetation management
e) Maintenance or retrofitting of stormwater devices.

8.4 Asset Monitoring

Asset monitoring is carried out on all three networks including condition assessment and capacity reviews. A list of this type of monitoring is provided in respective Activity Management Plans.

8.5 ICMP Review

This document will be reviewed approximately every eight years[26]. However, should there be demonstrable adverse effects identified through monitoring, or significant changes in policies and structure plans, the ICMP will be reviewed earlier. For demonstrable adverse effects, the Waikato Regional Council report procedure (as required by condition 10 of the CSDC) shall be carried out. Developers should be aware that changes to ICMP objectives may mean that different BPOs will be required. Such changes will be subject to consultation processes.

Hamilton City Council will monitor designs and construction as development progresses. Where approved designs or as built construction changes the outcome, the application of BPOs or the nature of the BPOs in the ICMP may need to be changed. These could differ from those already implemented by earlier developments in the catchment. Changes will only generally be made if a more practicable option is identified. The exception to this is where implementation results in the identification of an environmental shortcoming (e.g. water quality) which requires a more effective BPO.

A reduction in requirements will not be made for minor improvements against the objectives. For a fundamental change to the ICMP objectives to be made, the positive impact of actual development will need to be significant and measurable. The same approach will generally apply to the application of more stringent requirements, but it is acknowledged that adverse effects and degradation can be a slow and cumulative process.

A more proactive approach to managing the effects of stormwater discharges will be undertaken where a minor but consistently measurable reduction in water and/or habitat quality and/or bank stability is observed

Significant ICMP changes will require an internal Hamilton City Council Group review process, stakeholder consultation and approval by Waikato Regional Council. Minor changes will be discussed and agreed with Waikato Regional Council where this is relevant to the Hamilton City Council CSDC.

Potential amendments may also be required to any of the following:

a) Associated Structure Plan/District Plan
b) Hamilton City Council Stormwater Management Plan
c) Relevant bylaw or policy
d) The relevant activity management plan.
e) CSDC Monitoring Programme

[26] This term is considered appropriate on the basis of development. Sufficient monitoring data, flood hazard assessment, ability to review critical requirements through other mechanisms such as Stormwater Master Plan reviews and the ability to amend the ICMP at any time if adverse effects are identified.

9 References

- AECOM, August 2012: Preliminary Geotechnical Assessment for Proposed Industrial Subdivision – Ruffell Road/Te Kowhai Road for Porter Properties Ltd
- AECOM, March 2016: Porters and HJV Model Review
- AECOM, March 2017: Draft Mangaheka Wastewater Servicing Concept
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- Rotokauri, Hamilton for Hamilton JV Investment Company
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- http://districtplan.waidc.govt.nz/pages/plan/book.aspx?exhibit=WS
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- Morphum Environmental Ltd, May 2017: Mangaheka Watercourse Assessment and Programme of Works
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- TRIM D-928128 Integrated Catchment Management Principles
- TRIM D-1049842 Hamilton City Council – Streams and lakes in and near Hamilton and the issues for stormwater disposal, NIWA, March 2001
- TRIM D-1069627: Stormwater Management Plan, Hamilton City Council, December 2012 (Resource Consent 105279)
- TRIM D-1168323 NIWA - Streams and lakes in and near Hamilton and the issues for stormwater disposal - Hamilton City Council00213 -March 2001
- TRIM D-1168330 NIWA - Hamilton City stormwater - assessment of contaminant loads & impacts on Waikato River - Hamilton City Council00210- January 2001
- TRIM D-1598128 Hamilton City Council Stormwater Bylaw 2015

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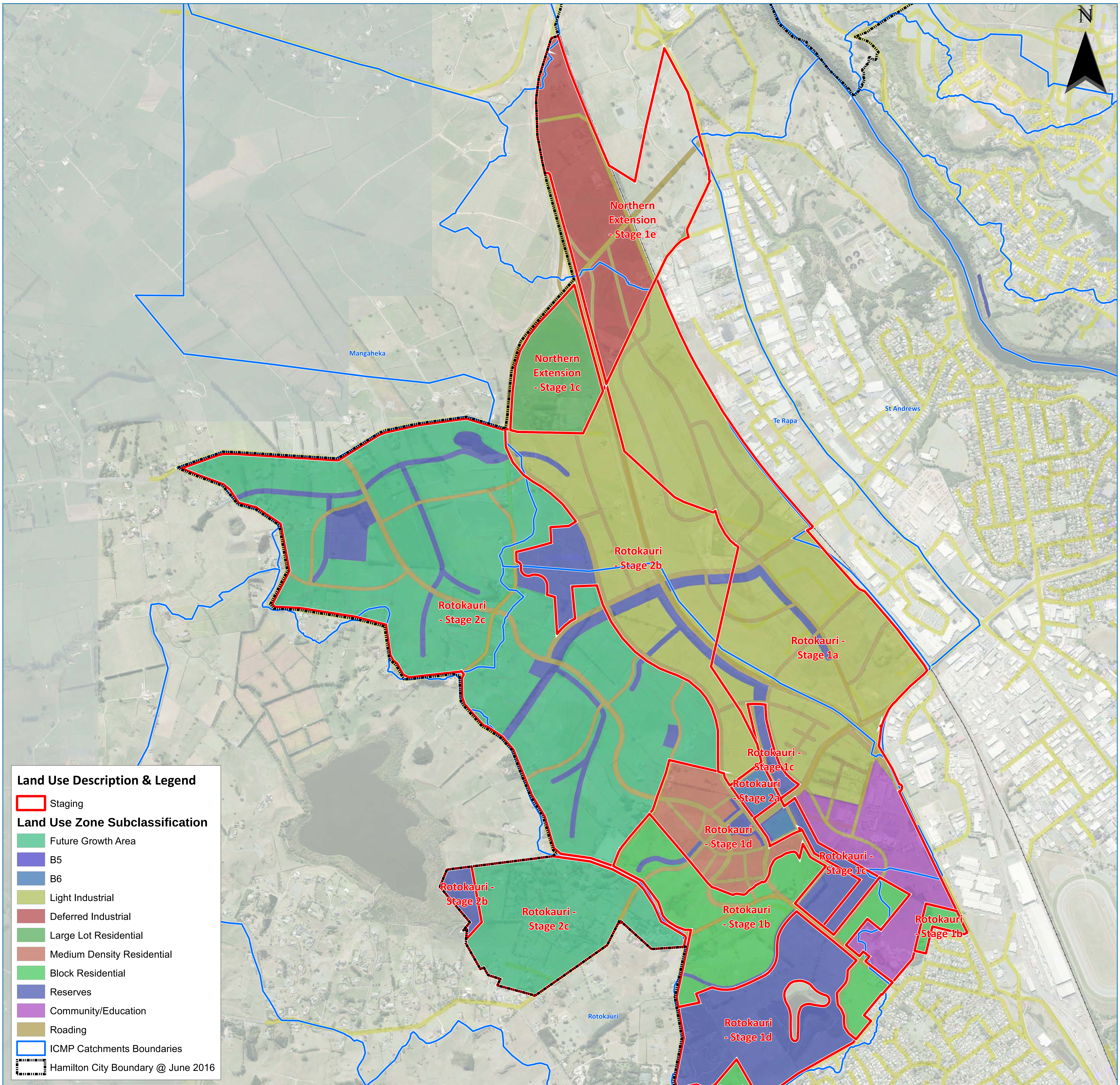
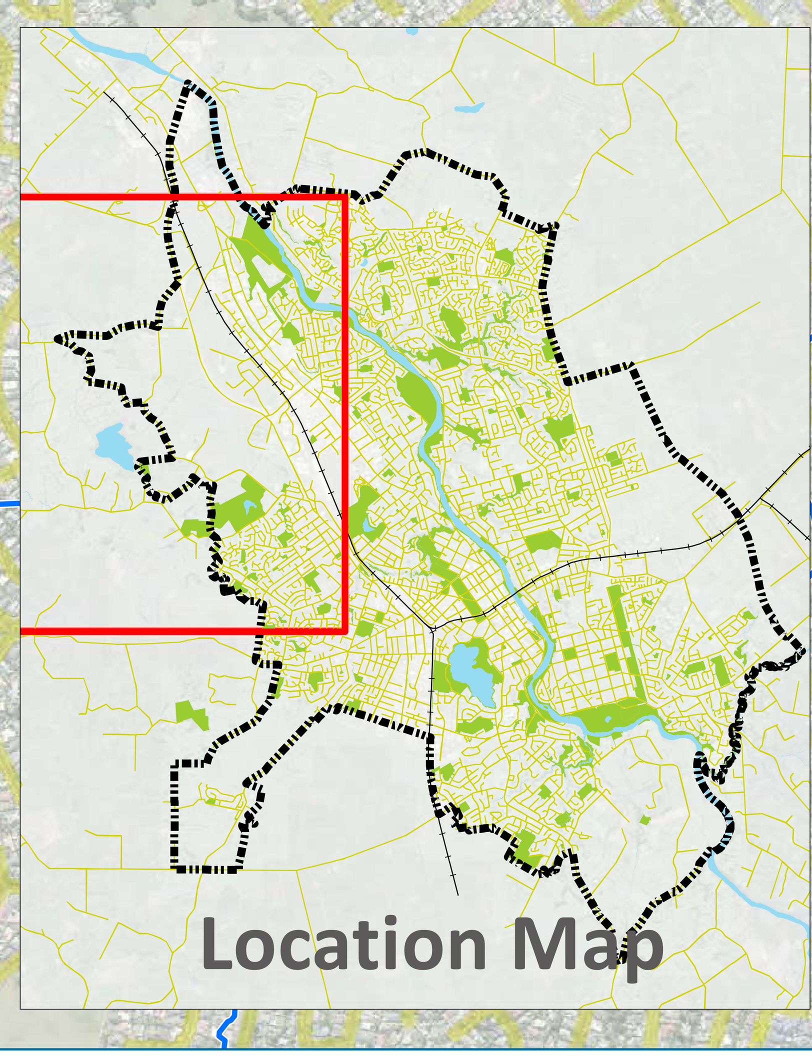
- TRIM D-1825095: Waikato Regional Council Technical Report 2014 - Managing Landuse Change and Councils Administered Areas
- Waikato Regional Council, April 2012: Waipa Zone Management Plan
- Waikato Regional Council, July 2012: Central Waikato Zone Management Plan Waikato Regional Council Stormwater Management Guidelines (2018).
- Waikato Tainui Environmental Management Plan.

Appendix A

Hamilton City Council Structure Plans



Area Name	Development Stage name	Land use Description	Area (ha)	Dwelling density (Dwelling per ha)	Occupancy Rate (People per Dwelling)	Current Development Population	Calculated total population	Projected Population Equivalent			City Full Development Projected Population Equivalent	Development		Maximum Impervious-ness
								2021	2041	2061		Start	End	
Rotokauri - Stage 1a	Rotokauri - Stage 1 - Industrial	Light Industrial	157.30	1	30	44.08	4719	1825	4719	4719	4719	2014	2034	0.9
		State Highway	5.51	0	0	0	0	0	0	0	0	2014	2034	0.95
		Major Arterial Road	5.71	0	0	0	0	0	0	0	0	2014	2034	0.95
		Minor Arterial Road	0.45	0	0	0	0	0	0	0	0	2014	2034	0.95
		Collector Road	24.10	0	0	0	0	0	0	0	0	2014	2034	0.95
		Park Edge Road	1.86	0	0	0	0	0	0	0	0	2014	2034	0.95
		WINTEC	29.33	1	45	6.92	1320	507	1320	1320	1320	2014	2034	0.2
		Community Facilities	11.90	1	45	6.92	535	208	535	535	535	2014	2034	0.2
		Drainage Reserve	5.57	0	0	0	0	0	0	0	0	2014	2034	0.1
		Lake	3.61	0	0	0	0	0	0	0	0	2014	2034	0.1
Rotokauri - Stage 1b	Rotokauri - Stage 1 - Lake Waiwhkareke surrounds	Block Residential	69.71	11	3	34.99	2301	351	1405	2301	2301	2016	2058	0.6
		Minor Arterial Road	1.02	0	0	0	0	0	0	0	0	2016	2058	0.95
		Collector Road	5.10	0	0	0	0	0	0	0	0	2016	2058	0.95
Rotokauri - Stage 1c	Rotokauri - Stage 1 - Suburban Centre	B5 - Commercial	1.12	1	135	0	152	45	152	152	152	2019	2028	0.8
		B6 - Commercial	1.80	1	30	0	54	16	54	54	54	2019	2028	0.8
		Major Arterial Road	0.91	0	0	0	0	0	0	0	0	2019	2028	0.95
		Collector Road	11.68	0	0	0	0	0	0	0	0	2019	2028	0.95
		Drainage Reserve	3.74	0	0	0	0	0	0	0	0	2019	2028	0.1
Rotokauri - Stage 1d	Rotokauri - Stage 1 - Medium density	Medium Density Residential	23.36	25	2.6	4.62	1518	5	631	1518	1518	2030	2058	0.5
		Collector Road	1.72	0	0	0	0	0	0	0	0	2030	2058	0.95
		Neighbourhood Recreational	65.35	1	1	0	65	0	27	65	65	2030	2058	0.1
		Drainage Reserve	1.28	0	0	0	0	0	0	0	0	2030	2058	0.1
Rotokauri - Stage 2a	Rotokauri - Stage 2 - Suburban Centre	B5 - Commercial	0.59	1	135	0	80	0	31	80	80	2029	2061	0.8
		B6 - Commercial	3.87	1	30	0	116	0	46	116	116	2029	2061	0.8
		State Highway	4.99	0	0	0	0	0	0	0	0	2029	2061	0.95
		Collector Road	8.63	0	0	0	0	0	0	0	0	2029	2061	0.95
Rotokauri - Stage 2b	Rotokauri - Stage 2 - Employment	Light Industrial	82.89	1	30	14.61	2487	15	585	2487	2487	2036	2061	0.9
		Minor Arterial Road	9.58	0	0	0	0	0	0	0	0	2036	2061	0.9
		Collector Road	22.04	0	0	0	0	0	0	0	0	2036	2061	0.95
		Neighbourhood Recreational	29.17	1	1	0	29	0	7	29	29	2036	2061	0.1
		Drainage Reserve	11.10	0	0	0	0	0	0	0	0	2036	2061	0.1
Rotokauri - Stage 2c	Rotokauri - Stage 2 - Low density	Future Growth Area	320.90	16	2.7	257.22	13863	257	257	4792	13863	2056	2073	0.5
		Collector Road	3.12	0	0	0	0	0	0	0	0	2056	2073	0.95
		Neighbourhood Recreational	17.51	1	1	0	18	0	0	6	18	2056	2073	0.1
		Drainage Reserve	1.65	0	0	0	0	0	0	0	0	2056	2073	0.1
ROTOKAURI DEVELOPMENT AREA SUMMARY			**948.17**			**369.36**	**27256**	**3230**	**9769**	**18174**	**27256**	**2014**	**2073**	**varies**



NOTES:

This plan presents the growth and population information (i.e. Population Equivalent projections and development timing) used in the HCC Waters Models (as at May 2016). Refer to Overview Plan for references to other future growth areas.

For mapping clarity some staging boundaries within individual growth areas have been adjusted. The tabulated information has not been modified to reflect these adjustments.

The wastewater network modelling uses the HCC ITS approach for future development design flows including a per capita flow of 200 litres per person per day.

The water network model assumes a per capita demand of 260 litres per person per day for future development areas.

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GIS & CAD Services

Trim No. D-2204036

version 1

Rotokauri

2015 Waters Model Development & Growth Area

FD_ID	DP_Zone	DP_Zone_Subclassificatio	Dev_Stage_Name	FD_Area_m	Shape_Area	Development_Label	AreaCheck
FD0657	Transport	Collector Road	Northern Extension - Stage 1a	6564.922213	6564.922213	Te Rapa North - Expressway Fonterra Dairy Factory	6565
FD0658	Industrial	Service Centre Industrial	Northern Extension - Stage 1d	698949.809546	698949.809546	Te Rapa North - Service Centre and Industrial	698950
FD0659	Residential	Large Lot Residential	Northern Extension - Stage 1c	9151.249195	9151.249195	Te Rapa North - HT2c	9151
FD0660	Residential	Large Lot Residential	Northern Extension - Stage 1c	283252.64964	283252.64964	Te Rapa North - HT2c	283253
FD0661	Industrial	Deferred Industrial	Northern Extension - Stage 1e	240122.190374	240122.190374	Te Rapa North - Deferred	240122
FD0662	Industrial	Deferred Industrial	Northern Extension - Stage 1e	71941.720129	71941.720129	Te Rapa North - Deferred	71942
FD0663	Industrial	Deferred Industrial	Northern Extension - Stage 1e	7175.937122	7175.937122	Te Rapa North - Deferred	7176
FD0664	Industrial	Deferred Industrial	Northern Extension - Stage 1e	91783.96587	91783.96587	Te Rapa North - Deferred	91784
FD0665	Industrial	Deferred Industrial	Northern Extension - Stage 1e	11706.374936	11706.374936	Te Rapa North - Deferred	11706
FD0666	Industrial	Deferred Industrial	Northern Extension - Stage 1e	185122.71436	185122.71436	Te Rapa North - Deferred	185123
FD0667	Industrial	Deferred Industrial	Northern Extension - Stage 1e	26939.332598	26939.332598	Te Rapa North - Deferred	26939
FD0668	Industrial	Deferred Industrial	Northern Extension - Stage 1e	197862.178224	197862.178224	Te Rapa North - Deferred	197862
FD0669	Industrial	Deferred Industrial	Northern Extension - Stage 1e	193973.482987	193973.482987	Te Rapa North - Deferred	193973
FD0670	Industrial	Deferred Industrial	Northern Extension - Stage 1e	82416.527596	82416.527596	Te Rapa North - Deferred	82417
FD0671	Industrial	Dairy Industrial	Northern Extension - Stage 1b	580150.2509	580150.2509	Te Rapa North - Fonterra West of SH1	580150
FD0672	Industrial	Heavy Industrial	Northern Extension - Stage 1a	417866.006482	417866.006482	Te Rapa North - Expressway Fonterra Dairy Factory	417866
FD0673	Industrial	Deferred Industrial	Northern Extension - Stage 1e	214753.156441	214753.156441	Te Rapa North - Deferred	214753
FD0674	Industrial	Deferred Industrial	Northern Extension - Stage 1e	19091.488437	19091.488437	Te Rapa North - Deferred	19091
FD2210	Transport	Major Arterial Road	Northern Extension - Stage 1a	6261.894783	6261.894783	Te Rapa North - Expressway Fonterra Dairy Factory	6262
FD2211	Transport	Minor Arterial Road	Northern Extension - Stage 1a	29115.255997	29115.255997	Te Rapa North - Expressway Fonterra Dairy Factory	29115
FD2212	Transport	State Highway	Northern Extension - Stage 1a	637.993122	637.993122	Te Rapa North - Expressway Fonterra Dairy Factory	638
FD2213	Transport	Major Arterial Road	Northern Extension - Stage 1a	61319.069498	61319.069498	Te Rapa North - Expressway Fonterra Dairy Factory	61319
FD2214	Transport	Collector Road	Northern Extension - Stage 1a	19357.703196	19357.703196	Te Rapa North - Expressway Fonterra Dairy Factory	19358
FD2215	Transport	Collector Road	Northern Extension - Stage 1a	29647.117383	29647.117383	Te Rapa North - Expressway Fonterra Dairy Factory	29647
FD2216	Industrial	Deferred Industrial	Northern Extension - Stage 1e	42888.448893	42888.448893	Te Rapa North - Deferred	42888
FD2217	Transport	Major Arterial Road	Northern Extension - Stage 1a	153.74753	153.74753	Te Rapa North - Expressway Fonterra Dairy Factory	154
FD2218	Transport	State Highway	Northern Extension - Stage 1a	153.74753	153.74753	Te Rapa North - Expressway Fonterra Dairy Factory	154
FD2219	Transport	Major Arterial Road	Northern Extension - Stage 1a	5294.776746	5294.776746	Te Rapa North - Expressway Fonterra Dairy Factory	5295
FD2220	Transport	Major Arterial Road	Northern Extension - Stage 1a	4420.385626	4420.385626	Te Rapa North - Expressway Fonterra Dairy Factory	4420
FD2221	Transport	Major Arterial Road	Northern Extension - Stage 1a	7870.342032	7870.342032	Te Rapa North - Expressway Fonterra Dairy Factory	7870
FD2222	Transport	Minor Arterial Road	Northern Extension - Stage 1a	31336.750274	31336.750274	Te Rapa North - Expressway Fonterra Dairy Factory	31337
FD2223	Transport	State Highway	Northern Extension - Stage 1a	37454.973725	37454.973725	Te Rapa North - Expressway Fonterra Dairy Factory	37455
FD2224	Transport	Collector Road	Northern Extension - Stage 1a	26372.808132	26372.808132	Te Rapa North - Expressway Fonterra Dairy Factory	26373
FD2225	Transport	Collector Road	Northern Extension - Stage 1a	5392.513957	5392.513957	Te Rapa North - Expressway Fonterra Dairy Factory	5393
FD2226	Transport	Collector Road	Northern Extension - Stage 1a	14142.823007	14142.823007	Te Rapa North - Expressway Fonterra Dairy Factory	14143
FD2227	Industrial	Deferred Industrial	Northern Extension - Stage 1e	143674.732566	143674.732566	Te Rapa North - Deferred	143675

Appendix B

Flooding Assessments

Report

Te Otamanui Fatal Flaw Assessment

Prepared for Hamilton City Council

Prepared by CH2M Beca Ltd

30 May 2017

Revision History

Revision Nº	Prepared By	Description	Date
1	**Angela Pratt**	Draft for client review	3/5/17
2	**Angela Pratt**	Final Report	30/5/17

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Angela Pratt**		30/5/17
Reviewed by	**Michael Law**		30/5/17
Approved by	**Kristina Hermens**		30/5/17
on behalf of	**CH2M Beca Ltd**		

Executive Summary

CH2M Beca Ltd has been engaged by Hamilton City Council (HCC) to carry out a fatal flaw assessment to confirm whether flow could be diverted from the Mangaheka Stream catchment into the Te Otamanui Lagoon catchment. The following tasks have been carried out as part of this work:

- Site Visit (high level walkover)
- Consideration of tasks required to assess feasibility
- Survey of the upper reaches of the Te Otamanui Stream catchment
- Analysis of survey data to determine if water can discharge into the Te Otamanui Stream already
- Desktop study to determine if there are any issues with discharging water in to the Lagoon catchment including tasks such as:
  - Aerial photo inspections
  - Consent searches
  - High level catchment area, runoff generation and channel capacity calculations
  - Contact Waikato Regional Council (WRC) to determine if there are any existing flooding issues in the catchment that may be exacerbated by discharging water from the Mangaheka and the effects on both catchments will occur at a later stage (Task 8b).

Table 8 below provides a summary of the findings of this investigation. The final column has been coloured green, where there is a potential benefit seen in supplementing Te Otamanui Flows with flows from the Mangaheka Catchment. Items coloured yellow need further investigation.

Summary of Findings

	Comments	Fatal flaw or not?
Te Otamanui Stream Obstructions	There are a number of obstructions including buildings within 5m of the stream and culverts which may cause issues if flood levels were increased. These obstructions would need to be viewed during a site visit to confirm if this would be an issue or not.	**Unclear until a further site visit is carried out.**
Consented Activities	A number of consented activities in the catchment may cause issues if additional flows were discharged. These works would need to be viewed during a site visit to confirm if this would be an issue or not. Groundwater and surface water takes in the Mangaheka catchment may also be impacted.	**Unclear until a further site visit and investigations (GW and SW takes) are carried out.**
Flooding records	Flooding records indicate that diversions from the Te Otamanui catchment have occurred in the past. Since then, development may have occurred within the previous floodplain that may now be impacted if additional water was diverted from the Mangaheka catchment.	**Unclear until a further site visit is carried out.**
Existing Stream Capacity and Existing Flows	Our basic rational method calculations have identified that there is approximately 250L/s of capacity in the upper Te Otamanui catchment. This provides an opportunity to discharge flows from the Mangaheka Catchment	**No**

	Comments	Fatal flaw or not?
Device 6 size	Our basic calculations have shown that whilst discharging 250L/s is not likely to have an impact on the device 6 size, if more (1m^3/s) can be discharged by appropriately timing the discharge, there is likely to be a significant reduction in pond volume required.	**No**

Based on our above investigations and the above summary table, it is concluded that no fatal flaws have been found relating to supplementing flows in the Te Otamanui Catchment.Before these tasks are carried out, it is recommended that a cost/benefit study be carried out. This will help to identify if the further project stages identified below are worth carrying out.

If the cost/benefit analysis indicates financial benefits in the diversion, the following is a set of tasks that should be undertaken:

Detailed Assessment

Task a: Site Walkover to confirm:
- Have any farmers/landowners constructed structures over stream that may be flooded?
- Are there any small culverts that may be under capacity if flows increased?

Task b: Flow Analysis
- What flows would we take (low flows/mid flows/high flows? When and how much?
- Comparison of flows with stream capacity (refer section 8).

Task c: Modelling
- Updating the Mangaheka 1D model to determine the effect of the diversion on the Mangaheka catchment. This would involve a simple discharge arrangement for the diverted flows and would not include an assessment of effects on the Te Otamanui Lagoon catchment.

In addition to the above, based on our work carried out, we have also identified that the following investigations will also need to occur to further confirm feasibility.

- A site visit should also confirm:
  - If any of the buildings that are close to the Te Otamanui stream are habitable or if significant effects are likely if these are flooded due to increased flows
  - Any additional obstructions that were not seen on the aerial photos
- Effects of reduction in base flows in the Mangaheka catchment
- Will discharging flood flows from the Mangaheka catchment have any impact on base flows in the Te Otamanui catchment and the lagoon water levels? If so, there may be little benefit to the Te Otamanui catchment in discharging additional flows
- The cultural effects of mixing of waters from two different catchments needs to be investigated.
- Discharging low flows may have ecological effects on the Mangaheka catchment.
- Erosion assessment of the stream and its capacity to take the additional flows (this may require soils/geotech information).
- Assessment of effects on any existing groundwater and surface water takes in the Mangaheka catchment.

Contents

Appendices

1 Introduction

CH2M Beca Ltd has been engaged by Hamilton City Council (HCC) to carry out a fatal flaw assessment to confirm whether flow could be diverted from the Mangaheka Stream catchment into the Te Otamanui Lagoon catchment.

The Te Otamanui Lagoon catchment lies alongside the larger Mangaheka Stream catchment on the north-west side of Hamilton. The Te Otamanui Lagoon is located in the downstream part of the catchment, just upstream of the discharge point to the Waipa River. This lagoon has appeared to be drying out in recent times and supplementing flows is seen as something that may improve this situation.

This report does not seek to confirm why the lagoon appears to be drying out, rather whether flows could be supplemented from the nearby Mangaheka Stream catchment and hence whether it would be feasible to carry out further investigations to do this.

Figure 1 shows the location of the Te Otamanui Stream catchment, the Mangaheka Stream catchment and Hamilton City.

Figure 1 Te Otamanui Catchment Location

2 Background

The Te Otamanui catchment lies alongside the Mangaheka Stream catchment to the north-west of Hamilton City. The Te Otamanui Stream catchment is approximately 9.5km long and 500 hectares in area with an approximate grade of 1 in 550. The stream flows through farmland and a rural town (Te Kowhai) before discharging into the Waipa River.

The current Te Otamanui Lagoon catchment starts near the Koura Drive roundabout with Te Kowhai Road. The upper part of this catchment (upstream of Koura Drive) appears to have been disconnected at some stage in the past, and now drains towards the Mangaheka Stream. The construction of Koura Drive as part of the Te Rapa Bypass project, has further reinforced the disconnection by not providing a flow path under Koura Drive into the Te Otamanui Stream.

The history is unclear but it is possible that that the two catchments were previously one, and that there were two outlets to the catchment. LiDAR for the area indicates that this is possible. Figure 2 below shows an extract of the 2007/2008 LiDAR data, which indicates that the floodplain of the Mangaheka Stream south of Te Kowhai Drive flows into the Te Otamanui Stream catchment.

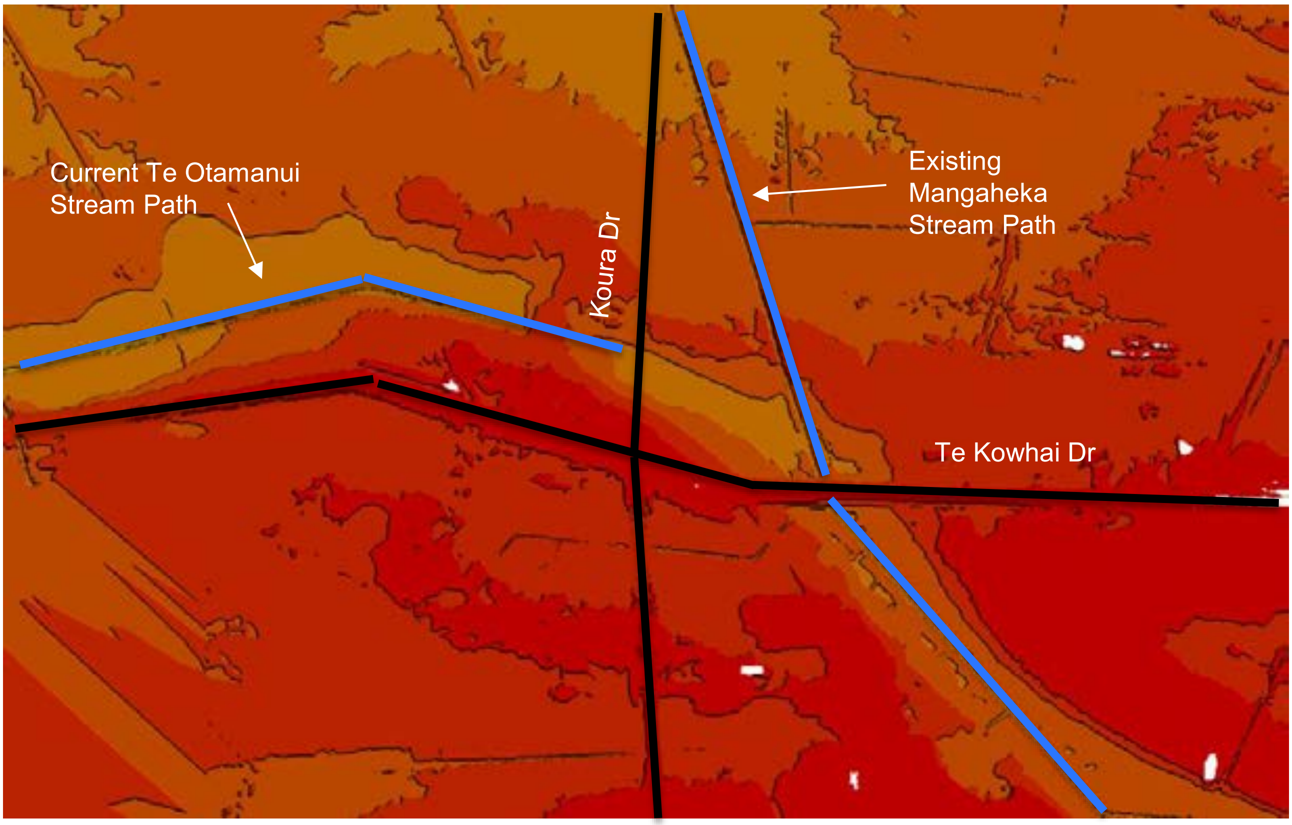


Figure 2 LiDAR data in the upper Te Otamanui catchment.

If this connection were re-established in some form, this could help the Te Otamanui Lagoon (depending on the hydrology of the lagoon and whether baseflows or storm flows are used to supplement it) but also potentially reduce the mitigation requirements for development in the Mangaheka catchment, which forms part of the Mangaheka Integrated Catchment Management Plan.

Figure 3 below shows a plan of the current upper Te Otamanui catchment.

Figure 3 Upper Te Otamanui Catchment

3 Scope

The overall objective of this report is to assess the feasibility of discharging flows into the Te Otamanui Stream from the Mangaheka Stream.

A multiple stage approach has been proposed and this report covers the results of the Stage 1 and 2 tasks set out below.

Stage 1: Survey and Site Visit

- Site Visit
- Consideration of tasks required to assess feasibility
- Survey of the upper reaches of the Te Otamanui Stream catchment

The above tasks have already been undertaken.

Stage 2: Desktop Study

This report covers the following tasks:

- Analysis of survey data to determine if water can discharge into the Te Otamanui Stream already
- Determine if there are any issues with discharging water in to the Lagoon catchment, based on:
  - Aerial photo inspections
  - Consent searches
  - High level catchment area, runoff generation and channel capacity calculations
  - Contacting Waikato Regional Council (WRC) to determine if there are any existing flooding issues in the catchment that may be exacerbated by discharging water from the Mangaheka and the effects on both catchments will occur at a later stage).

During the scoping of this project it was identified that further stages would likely be needed if no fatal flaws were identified during the desktop study. These are further described in Section 12 – Recommendations.

4 Existing Stream Constraints

There are numerous restrictions along the channel in the Te Otamanui catchment, including several culverts, footbridges and two buildings within 5 m of the channel.

Appendix A shows a list of the obstructions which were clear in aerial photography as well as a map showing the location of each obstruction.

If more water is put into the catchment, there could be potential flooding effects as a result of increased water levels. Even if the stream channel has the capacity to convey flood flows, more flow may result in increased flooding upstream of culverts which currently restrict flows, and could cause overtopping of driveways causing access issues. There is also risk of flooding of structures located close to the stream. These buildings seen in aerial photographs appear to be sheds, so additional flooding (frequency and depth) may not be as much of an issue as if they were habitable dwellings. It is however unknown at this stage what the current flood levels are and hence what the exact effect on flood levels will be if more water is flowing in the channel than does currently.

To be able to determine if any of these obstructions are likely to cause issues if additional flows are discharged to the catchment, a further detailed site visit to gather details on these obstructions, as well as further modelling would likely be required. This is discussed further in section 12 .

5 Consented Activities

There are a number of resource consents granted (or in process) by the Waikato Regional Council for activities in the catchment which may have an impact on the Te Otamanui stream and its hydrology especially if additional water is discharged. The locations of these are shown in Appendix A.

Table 1 Resource Consents

ID	Type	WRD ID	Description
R1	Bed disturbance	Auth 126346.01.01	Culvert extension
R2	Bed disturbance	Auth 126346.01.01	Culvert extension
R3	Bed disturbance	Auth 126346.01.01	Culvert extension
R5	Land -Disturbance	Auth 135666.02.01	Discharging clean fill to land – sand mining operation and walkway construction
R6	Bed- disturbance	Auth 131348.02.01	Rechannelising and stream restoration

Note: There are other consents shown in Appendix C. However only the ones that could potentially have an impact on stream hydrology are shown here.

Consents R1, R2 and R3 appear to relate to culvert widening for the purposes of constructing driveways. Such consents have the potential to impact on the stream if the design of the extensions caused changes to the hydraulics and hence flood water levels in the area of the culvert.

In regard to resource consent R5 and 56, sand mining operations, walkway construction and stream rechannelising also have potential to have hydraulic implications and hence might influence water levels during high flows.

In addition, there may also be groundwater and surface water takes in the Mangaheka catchment that may be impacted if a discharge to the Te Otamanui stream proceeds. Further investigations as to the types of abstraction will need to be done at a later stage to confirm if these will be impacted.

A site visit to each consent location will likely be required to be able to confirm whether the works carried out will have implications if additional water is discharged from the Mangaheka stream.

6 Existing Flooding Records

6.1 Overview

Existing flooding records can be a good way to see how a catchment reacts to high flows and hence can help to gauge the effects that additional flows may have on the catchment. We have carried out a general internet search for flooding records in the Te Otamanui Catchment and contacted WRC and WDC staff. The following limited records have been found.

6.2 Internet Search Results

- WRC, 2011 notes that: "Much of the catchment's water had been diverted leading to the lagoon drying out. Restrictions at the culvert. Flooding frequency is close to 1 in 10 years, where it would normally have been around 1 in 2 years." Unfortunately this report does not go into detail as to what this means or where the culvert is, but it is possible that there is out of bank flows in a 10-year ARI[1] event.
- NIWA's Historic Weather Events Catalogue refers to a flooding event in the Te Kowhai area in July 1953, where the Te Kowhai to Whatawhata and Te Kowhai to Ngaruawahia roads were under some feet of water in multiple places. Exact locations were not given

Aside from this, little record could be found of any other flooding events in this area.

6.3 Conversations with WRC

During conversations with Graham McBride, a previous Waipa Zone Liaison Committee Chairman, Graham could not recall any specific flooding events but he did mention that there is no connectivity from the Mangaheka Catchment to the Te Otamanui Catchment at Koura Drive. He also noted that in the past there was a diversion at Ken Commons' property at 714 Te Kowhai Road in Te Kowhai. It was proposed build a hay barn over a drain at 714 Te Kowhai Road but at the time there was no record of the drain and therefore the consenting authority granted the consent. Having granted consent, they then had to allow a drain diversion to occur. Instead of going underneath Horotiu Road to the Te Otamanui catchment, the drain was apparently diverted into the Mangaheka Catchment. Mr McBride also suggested that Te Otamanui is an old path of the Waipa River. It is possible that this diversion has impacted on the water levels in the Te Otamanui catchment and lagoon.

Figure 4 shows the approximate location of the diversion and hay shed. Note that the location and presence of a diversion has not has been verified by either Graham McBride or Beca.

[1] ARI: Average Recurrence Interval

Figure 4: 714 Te Kowhai Road property

6.4 Discussion

The above information gathered does not provide any particularly strong insights into whether the catchment would handle the additional flows, other than to say that if diversions from the catchment have occurred, the catchment would likely have had to manage higher flows in the past. Since the diversions have occurred, development in the catchment (new culverts, dwellings, buildings) may have encroached on areas that may have once been floodplain. If the catchment did convey higher flows, additional flooding effects may be seen.

7 Can Flows Already Enter?

7.1 Overview

When undertaking our site visit on the 8th of June 2016, it appeared that it may have been possible for water to enter the Te Otamanui catchment from the Mangaheka Stream, either via what appeared to be a culvert or by overflow from the swale alongside Koura Drive. The potential point of discharge is shown in Figure 5 and Figure 6 below.

To be able to confirm whether water can enter the Te Otamanui catchment, we have carried out surveying of the area to determine levels and presence (or not) of a culvert.

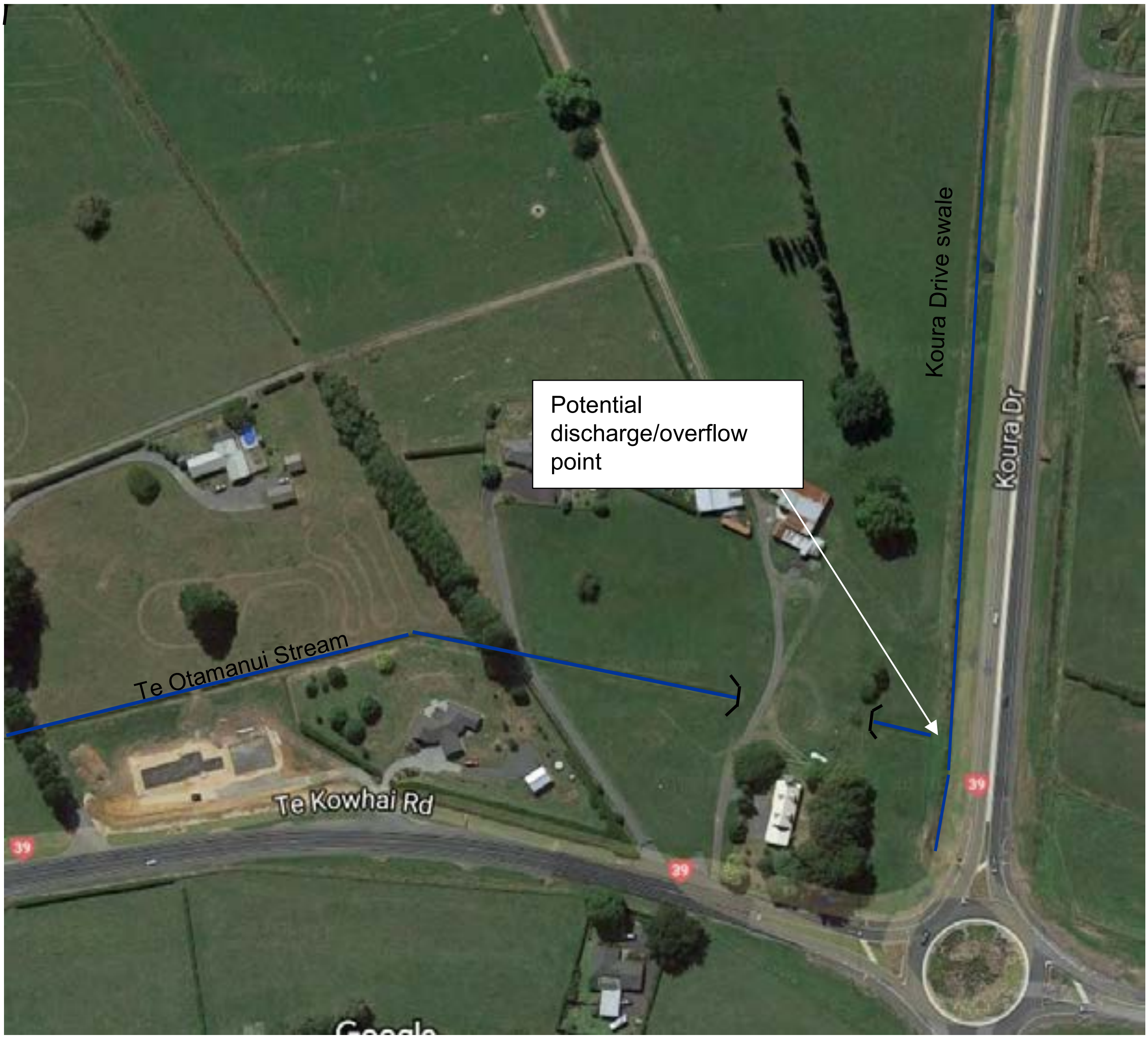


Figure 5 Upper Te Otamanui Stream

Figure 6 Photo Te Otamanui Stream upper reach looking from the Koura Drive swale

7.1.1 Surveying

Based on the survey, there is no direct culvert connection to the upper Te Otamanui catchment from the swale alongside Koura Drive. Table 2 below shows the ground and invert levels in the Koura Drive swale, the upper Te Otamanui catchment. This shows that there is almost 1 m of level difference between the swale and the Te Otamanui Stream. This means that it may be feasible to discharge flows via some sort of connection in this location.

Table 2 Ground and Invert Levels

Description	Level (mRL)
Invert level in swale alongside Koura Drive	29.37
Invert level in most upper part of Te Otamanui Stream	28.29

7.1.2 Existing Discharges

As mentioned above, there is no direct connection from the Mangaheka catchment into the Te Otamanui catchment via a culvert. Although there is no direct connection under normal flow conditions, it is possible that overland flows could discharge during flooding events. Whether and how often flows already discharge from the Mangaheka catchment to Te Otamanui, relates to how high water levels get in the Mangaheka Catchment and the frequency of these high flows. Table 3 shows the 10-year and 100-year ARI flood levels in two locations (6 and 8 on Appendix C) in Mangaheka stream catchment, which are close to the upper reaches of the Te Otamanui catchment i.e. locations where flow could be diverted from. These flood levels have been taken from Beca, 2016.

Table 3 Flood Levels

Description	Level (mRL)
100-year water level at Koura Dr culverts (Location 8)	29.38
100-year water level just downstream of Device 6 (Location 6)	30.49
10-year water level (Location 8)	29.23
10-year water level (Location 6)	30.10

Table 3 above shows that water levels at location 8 are only slightly higher than the invert of the Te Otamanui Stream upper reaches in a 100 year event (refer Table 2), but at Location 6, water levels are higher in both a 10 year and a 100 year event. This means that, if a channel or pipe from the location 6 to the Te Otamanui was constructed, water could potentially be diverted to the Te Otamanui stream from this location, much more easily than from location 8.

8 Catchment Flows and Capacity

8.1 Overview

To be able to discharge flows from the Mangaheka Catchment into the Te Otamanui Catchment, the Te Otamanui catchment needs to be able to have additional capacity in the channel compared to the runoff that is generated by the contributing catchment. To be able to confirm if there is additional capacity, peak flows have been calculated and compared to calculated channel capacity. Note that this part of the assessment has only been based on the upper Te Otamanui catchment, where surveying was carried out. Whilst this cannot be relied on as an indicator that the whole catchment can handle additional flows, if the upper catchment cannot accept additional flows, this is likely to be a fatal flaw. If the catchment can take extra flows based on this simplistic approach, a more detailed capacity check of the whole catchment would be justified.

8.2 Existing Flows – Upper Catchment

Peak flows for the 10 and 100-year storm events, with and without climate change, have been calculated for the current Te Otamanui upper catchment, using the catchment shown in Figure 7, below. Note that whilst the survey locations have numerical location references, they are not the same as the locations described in Beca, 2011, which are described earlier in the report.

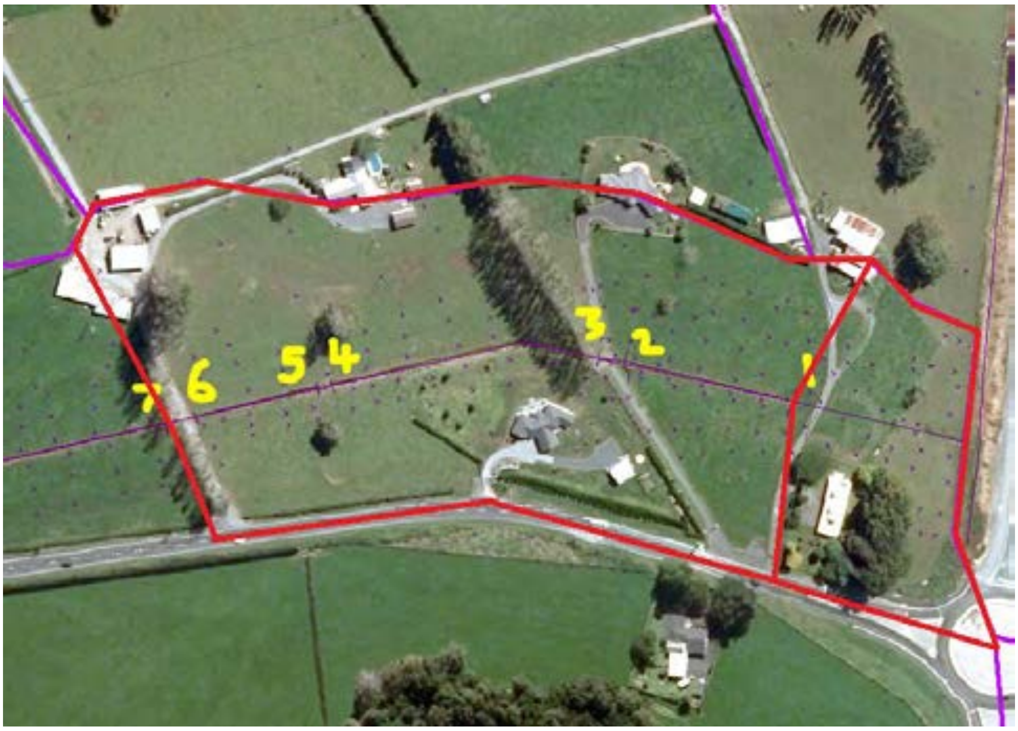


Figure 7: Catchment area (outlined in red) and location of surveyed cross-sections for Te Otamanui upper catchment

Table 4 shows the catchment parameters used to determine flows, which are shown in Table 5, together with the associated rainfall intensity for each storm event.

The rational method was used to calculate peak flows using the catchment parameters shown in Table 4. With the area assumed to be 5% impervious, the catchment was considered to have a weighted average SCS Curve Number of 70.5 which is equivalent to a 55% runoff coefficient. Time of concentration was calculated as 25 minutes using the method described in Auckland Council's TP108 document. Peak flow calculations for each storm event were then based on rainfall intensities referred to in the HCC Standard Stormwater Modelling Methodology, for a 25 minute storm duration.

Table 4: Catchment parameters for Te Otamanui upper catchment

Catchment Parameter	Value
Catchment area (ha)	5.68
Catchment length (km)	0.44
Gradient (%)	0.66
Channelisation coefficient	0.8
Percentage impervious (%)	5
Weighted SCS Curve Number	70.5
Runoff coefficient (%)	55
Time of concentration (min)	25

Table 5: Peak flows for Te Otamanui upper catchment

Storm Event	Rainfall Intensity (mm/hr)	Peak Flow (m^3/s)
10 yr	63.5	0.55
10 + CC	73.7	0.64
100 yr	93.2	0.81
100 yr + CC	108.8	0.94

8.3 Existing Channel Capacity

To be able to discharge flows into the Te Otamanui stream, the stream channel needs to have sufficient capacity to accept additional flows above that generated currently. We have therefore determined the capacity of the channel using Manning's Equation. This has been done using the cross-section data from our survey of the upper reaches of the catchment.

Based on surveyed cross-section data, the channel capacity at each cross-section is shown in Table 6 below. This is based on a Mannings 'n' roughness value of 0.035 and an average channel slope of 0.16%.

Table 6: Te Otamanui Stream upper catchment capacity

Cross-section	Capacity (m^3/s)
1	1.93
2	0.83*
3	1.63
4	2.75
5	3.76
6	1.14
7	1.18

*Cross-section 2 appears to have a lower capacity that the other cross-sections. The reason for this has not been investigated, and the cross-section has been ignored for the purposes of the overall capacity assessment as all other cross-sections have higher capacity, and it may be an anomaly.

Based on Table 6 above, it appears that the upper catchment can convey upwards of 1.1m^3/s. Comparing this to the peak flow that the upper catchment produces (0.93m^3/s) it is likely that there is additional capacity in the upstream part of the catchment in the order of 250L/s. This extra capacity could potentially be utilised by inputting flows from the Mangaheka catchment into the upper Te Otamanui catchment.

9 Diversion Scenarios

9.1 Scenarios

There are a number of possible ways of supplementing flows in the Te Otamanui catchment using flows from the Mangaheka catchment. Discharges of either flood flows, mid-flows or low flows could occur and there are a number of possible discharge locations.

Options include:

- Divert flood flows from Mangaheka directly from Device 6; a proposed attenuation pond for mitigating runoff from development of the Upper Mangaheka catchment. This device is located at a higher level than the upper reaches of the Te Otamanui Stream. Therefore, a diversion from Device 6 could occur under gravity. Such a diversion could provide positive effects on the Te Otamanui stream but could also reduce the size of Device 6. Device 6 is shown in Appendix C.
- Divert flood flows from Mangaheka Stream via the swale along west side of Koura Drive. As noted in Table 3, there is only 100mm difference between the 100 year flood level in Mangaheka Stream (Location 8) and the Te Otamanui Stream. This means that the duration and quantity of diverted flows would be dependent on the timing of flood hydrographs in the two catchments. More detailed modelling would be required to confirm feasibility.
- Divert flood flows from Mangaheka Stream around location 6, within the Mangaheka Stream. Diversion from this location, rather than a device may be able to have benefits in terms of reducing the size of other devices other than just device 6.
- Divert low flows from Mangaheka Stream. This would likely need to occur under gravity and not from a device as these will not be discharging flows when it is not raining. Other effects of a low-flow discharge would also need to be investigated further including minimum flow requirements for environmental purposes.
- A combination of two or more of the above options.

For this stage of the project, all of the above scenarios have not been investigated further. We have only investigated a diversion from Device 6 as this was possible using a simplistic approach (refer section 16), whereas other scenarios will require more detailed modelling. However if benefits are seen via a diversion from Device 6, other types of diversions would likely also have benefits. The other scenarios could be investigated at a later stage.

A combination of discharging low flows as well as higher flows would potentially provide the environmental benefits that may remediate the possible drying out of the Te Otamanui Lagoon, whilst also reducing the Device 6 volume.

10 Diversion from Device 6

To assess the reduction in storage volume required in Device 6 as a result of discharging flow to the Te Otamanui catchment via a weir, we have undertaken a basic flood routing calculation (spreadsheet based) using the following outputs from our 1D HEC-RAS model:

- Inflows to Device 6 from the contributing catchment
- Outflows through the simple culvert outlet structure located in the base of the pond. This was used to approximate a linear relationship between pond stage and outflow rate.
- The pond stage vs volume curve generated as an input to our model.

The spreadsheet developed was used to determine what flows would discharge over a simple weir structure) based on weir height and weir length. The spreadsheet then determined the reduction in required stored volume in the Device 6 pond based on changing the weir parameters.

Initially our spreadsheet model was used to determine the reduction on Device 6 volume using a target 250L/s weir discharge, as this was the additional capacity of the catchment, however this flowrate had little impact on the pond volume i.e this discharge would be of little benefit to Device 6. Instead a flowrate of $1m^3/s$ was used. Whilst $1m^3/s$ is higher than the additional capacity that the Te Otamanui catchment has, if the timing of the discharge was controlled, such that the discharge occurred after the peak of the Te Otamanui catchment, it is possible that the water levels in the wider catchment are not increased. This timing will need to be further investigated at a later stage, however we have determined that the time of concentration of the Te Otamanui catchment is roughly 4 hours.

Table 7 shows the pond size reduction based on discharging $1m^3/s$. To do this, the weir width was determined based on passing this flow over a weir of a nominated elevation. The weir width was varied to ensure a maximum of $1m^3/s$ was discharged.

Table 7: Pond storage in relation to proposed weir parameters ($1m^3/s$ discharge)

Weir Elevation	Weir width (m)	Max pond depth (m RL)	Max pond volume (m^3)	Reduction in volume (m^3)	Reduction in volume (%)
No weir (current HEC-RAS model)	(none)	31.20	35,800	N/A	N/A
31.0	42.1	31.11	34,409	1,391	4%
30.5	3.9	31.05	33,407	2,393	7%
30.0	1.6	31.02	32,852	2,948	9%
29.5	0.9	30.99	32,379	3,421	10%
29.0	0.6	30.92	31,390	4,410	12%
28.5	0.5	30.80	29,496	6,304	18%
28.0	0.5	30.58	26,115	9,685	27%

Table 6 shows that by discharging 1 m^3/s of flow, a reasonable reduction in pond size could be achieved. It should be noted that the invert of Device 6 is at 28.0m. Therefore, the final line in Table 6 is for a discharge occurring throughout the storm. This arrangement (and some of the other lower weir elevations) may restrict the opportunities to delay a discharge until after the peak of the Te Otamanui catchment. By increasing the height of the weir, this means that the discharge would not start occurring until later in a storm event. This does however need further investigation, and more detailed modelling.

11 Conclusions

Table 8 below provides a summary of the findings of this investigation. The final column has been coloured green, where there is a potential benefit seen in supplementing Te Otamanui Flows with flows from the Mangaheka Catchment. Items coloured yellow need further investigation.

Table 8 Summary

	Comments	Fatal flaw or not?
Te Otamanui Stream Obstructions	There are a number of obstructions including buildings within 5m of the stream and culverts which may cause issues if flood levels were increased. These obstructions would need to be viewed during a site visit to confirm if this would be an issue or not.	**Unclear until a further site visit is carried out.**
Consented Activities	A number of consented activities in the catchment may cause issues if additional flows were discharged. These works would need to be viewed during a site visit to confirm if this would be an issue or not. Groundwater and surface water takes in the Mangaheka catchment may also be impacted.	**Unclear until a further site visit and investigations (GW and SW takes) are carried out.**
Flooding records	Flooding records indicate that diversions from the Te Otamanui catchment have occurred in the past. Since then, development may have occurred within the previous floodplain that may now be impacted if additional water was diverted from the Mangaheka catchment.	**Unclear until a further site visit is carried out.**
Existing Stream Capacity and Existing Flows	Our basic rational method calculations have identified that there is approximately 250L/s of capacity in the upper Te Otamanui catchment. This provides an opportunity to discharge flows from the Mangaheka Catchment	**No**
Device 6 size	Our basic calculations have shown that whilst discharging 250L/s is not likely to have an impact on the device 6 size, if more ($1m^3/s$) can be discharged by appropriately timing the discharge, there is likely to be a significant reduction in pond volume required.	**No**

Based on our above investigations and the above summary table, it is concluded that no fatal flaws have been found relating to supplementing flows in the Te Otamanui Catchment.

Depending on which flows are discharged (ie low flows, high flows or a combination) it is likely that there will be environmental benefits associated with the discharge, however it is likely be the financial benefits that provide the main driver for pursuing the discharge.

Table 7 indicates that there is potentially up to an almost 30% decrease in the pond volume of Device 6 if the discharge occurred. We have not carried out an estimate of the reduction in construction costs that would result, however a reduction in Device 6 volume will reduce the earthworks required, reduce the land purchase costs and also reduce the future pond maintenance requirements. There will be costs associated with the structures required for the diversion which also need to be taken into account. It is recommended that this be investigated further before pursuing further investigations.

There is however additional work that needs to be carried out to better confirm feasibility with the primary action involving analysing the cost savings involved and. Section 12 provides a series of recommended next actions to further confirm feasibility of the discharge.

12 Recommendations

When preparing a scope of works for this project, we identified that a range of further tasks would likely need to be carried out if no fatal flaws were identified during the desktop study. Before these tasks are carried out, it is recommended that a cost/benefit study be carried out. This will help to identify if the further project stages identified below are worth carrying out.

If the cost/benefit analysis indicates financial benefits in the diversion, the following next set of tasks that should be undertaken:

Detailed Assessment

Task a: Site Walkover to confirm:
- Have any farmers/landowners constructed structures over stream that may be flooded?
- Are there any small culverts that may be under capacity if flows increased?
- Scope survey for additional modelling (see Task c)

Task b: Flow Analysis
- What flows could be diverted (low flows/mid flows/high flows? When and how much?
- Comparison of flows with stream capacity (refer section 8).

Task c: Modelling
- Updating the Mangaheka 1D model to determine the effect of the diversion on the Mangaheka catchment. This would involve a simple discharge arrangement for the diverted flows and would not include an assessment of effects on the Te Otamanui Lagoon catchment.
- Hydraulic/flood model of the Te Otamanui stream

A further assessment of effects on the Te Otamanui Lagoon/catchment will also likely be required. Refer to our 2016 VO for further details (Item’s 9 and 10).

In addition to the above, based on our work carried out, we have also identified that the following investigations will also need to occur to further confirm feasibility.

- A site visit should also confirm:
  - if any of the buildings that are close to the Te Otamanui stream are habitable or if significant effects are likely if these are flooded due to increased flows
  - Any additional obstructions that were not seen on the aerial photos
- Effects of reduction in base flows in the Mangaheka catchment
- Will discharging flood flows from the Mangaheka catchment have any impact on base flows in the Te Otamanui catchment and the lagoon water levels? If so, there may be little benefit to the Te Otamanui catchment in discharging additional flows
- The cultural effects of mixing of waters from two different catchments needs to be investigated.
- Discharging low flows may have ecological effects on the Mangaheka catchment.
- Erosion assessment of the stream and its capacity to take the additional flows (this may require soils/geotech information).
- Assessment of effects on any existing groundwater and surface water takes in the Mangaheka catchment.

13 References

Beca, 2016, *Mangaheka 1D Modelling Report*, CH2M Beca Ltd, 8th December 2016.

WRC, 2011, *Significant Natural Areas of the Waikato Region – Lake Ecosystems*, Waikato Regional Council Technical report 2011/05, prepared by Wildland Consultants, April 2011.

Appendix A

Te Otamanui Stream Obstructions

Click here and then click 'insert picture'

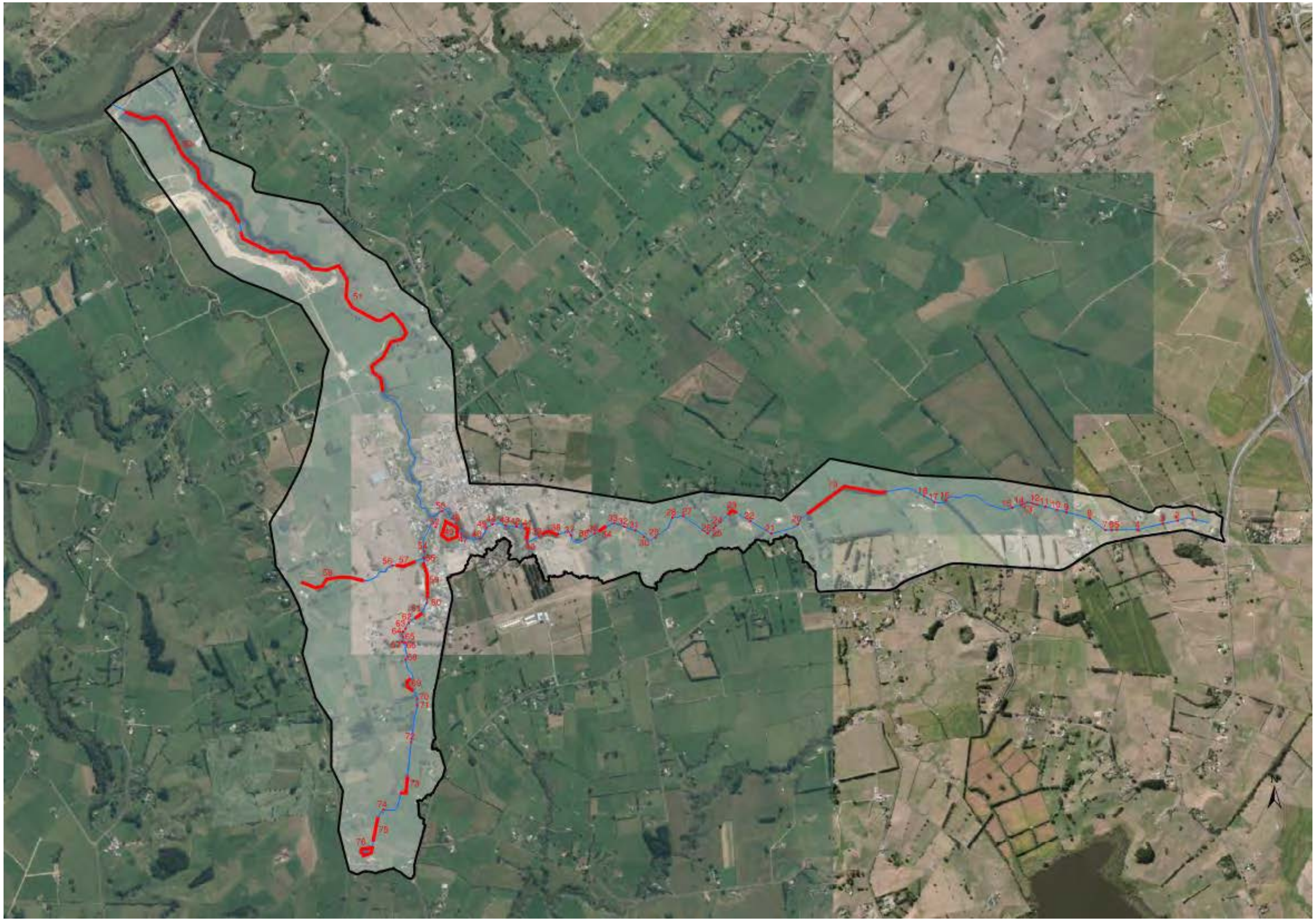
Te Otamanui Fatal Flaw exercise
Obstructions, culverts, buildings etc

ID	Obstruction T	Description	Comments
1	A	Gravel/seal driveway - bridge/culvert	
2	B	Grass covered bridge /culvert	
3	A	Gravel/seal driveway - bridge/culvert	
4	A	Gravel/seal driveway - bridge/culvert	
5	D	Pipe across stream	
6	A	Gravel/seal driveway - bridge/culvert	
7	A	Gravel/seal driveway - bridge/culvert	
8	D	Pipe across stream	unclear
9	A	Gravel/seal driveway - bridge/culvert	
10	E	Trees - unclear if stream blocked from aerial	
11	B	Grass covered bridge /culvert	
12	E	Trees - unclear if stream blocked from aerial	
13	F	Debris (e.g. logs) over stream	logs
14	B	Grass covered bridge /culvert	
15	A	Gravel/seal driveway - bridge/culvert	
16	E	Trees - unclear if stream blocked from aerial	
17	A	Gravel/seal driveway - bridge/culvert	
18	A	Gravel/seal driveway - bridge/culvert	
19	E	Trees - unclear if stream blocked from aerial	
20	G	Major road culvert/bridge	Te Kowhai Rd
21	A	Gravel/seal driveway - bridge/culvert	
22	B	Grass covered bridge /culvert	
23	E	Trees - unclear if stream blocked from aerial	
24	E	Trees - unclear if stream blocked from aerial	
25	B	Grass covered bridge /culvert	
26	E	Trees - unclear if stream blocked from aerial	
27	H	Fence across stream	unclear
28	I	Building within 5m of stream	shed
29	A	Gravel/seal driveway - bridge/culvert	
30	F	Debris (e.g. logs) over stream	unclear
31	H	Fence across stream	unclear
32	A	Gravel/seal driveway - bridge/culvert	32 + 33 one culvert combined
33	A	Gravel/seal driveway - bridge/culvert	32 + 33 one culvert combined
34	J	Stream opens out into pond	
35	C	Other bridge/culvert	unclear
36	B	Grass covered bridge /culvert	small grass bridge
37	B	Grass covered bridge /culvert	
38	E	Trees - unclear if stream blocked from aerial	
39	A	Gravel/seal driveway - bridge/culvert	
40	J	Stream opens out into pond	
41	K	Wetland area with vegetation	also trees - unclear if stream blocked
42	C	Other bridge/culvert	stream emerges from culvert
43	F	Debris (e.g. logs) over stream	logs?
44	C	Other bridge/culvert	small bridge
45	E	Trees - unclear if stream blocked from aerial	
46	C	Other bridge/culvert	small bridge
47	E	Trees - unclear if stream blocked from aeria	one bridge, rest of area unclear

Legend

Obstruction T	Description	Number of obstructions Colu
A	Gravel/seal driveway - bridge/culvert	21
B	Grass covered bridge /culvert	9
C	Other bridge/culvert	6
D	Pipe across stream	2
E	Trees - unclear if stream blocked from aeria	18
F	Debris (e.g. logs) over stream	3
G	Major road culvert/bridge	3
H	Fence across stream	2
I	Building within 5m of stream	2
J	Stream opens out into pond	6
K	Wetland area with vegetation	4

48	J	Stream opens out into pond	
49	K	Wetland area with vegetation	
50	J	Stream opens out into pond	
51	K	Wetland area with vegetation	unclear if stream blocked
52	G	Major road culvert/bridge	Bedford Rd
53	G	Major road culvert/bridge	Horotiu Rd
54	I	Building within 5m of stream	shed + water tank. Tank may have been removed
55	E	Trees - unclear if stream blocked from aerial	
56	A	Gravel/seal driveway - bridge/culvert	
57	E	Trees - unclear if stream blocked from aerial	
58	E	Trees - unclear if stream blocked from aerial	
59	E	Trees - unclear if stream blocked from aerial	
60	A	Gravel/seal driveway - bridge/culvert	
61	J	Stream opens out into pond	
62	A	Gravel/seal driveway - bridge/culvert	
63	E	Trees - unclear if stream blocked from aerial	
64	C	Other bridge/culvert	small bridge
65	A	Gravel/seal driveway - bridge/culvert	
66	A	Gravel/seal driveway - bridge/culvert	
67	E	Trees - unclear if stream blocked from aerial	
68	B	Grass covered bridge /culvert	
69	E	Trees - unclear if stream blocked from aerial	
70	A	Gravel/seal driveway - bridge/culvert	
71	C	Other bridge/culvert	unclear
72	A	Gravel/seal driveway - bridge/culvert	
73	E	Trees - unclear if stream blocked from aerial	
74	B	Grass covered bridge /culvert	
75	K	Wetland area with vegetation	unclear if any blockages
76	J	Stream opens out into pond	



Appendix B

1D Modelling Reporting Locations

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then click
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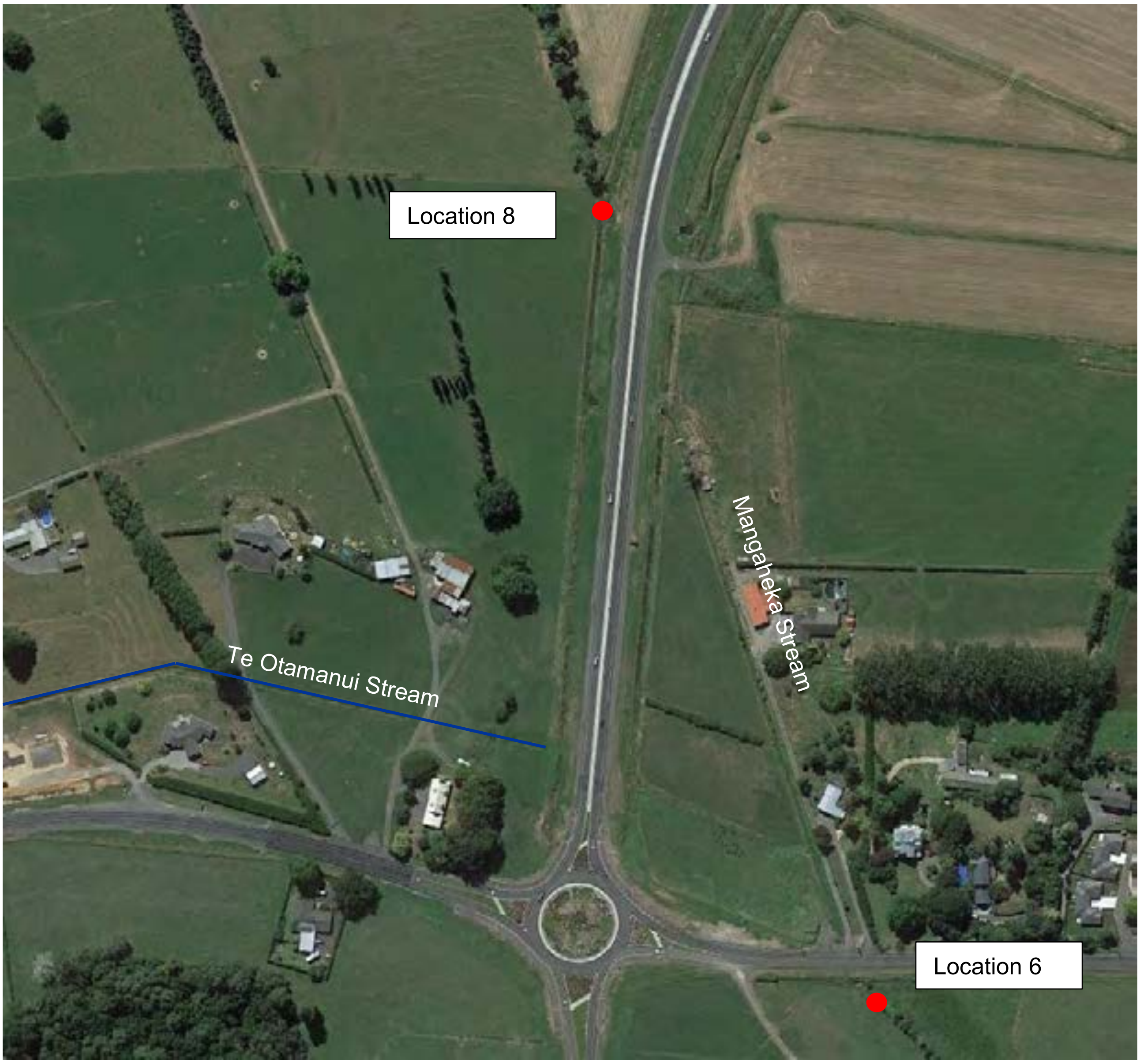
Location 8
Mangaheka Stream
Te Otamanui Stream
Location 6

Appendix C

Device 6 Location

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8
7
I
H
G
9
10
Porters Pond
(existing, online)
Device 5
(proposed, offline)
E
Te Otamanui
F
Device 6
(proposed, offline)
D
Device 7
(proposed, online)
C
HJV Pond
(existing, online)
B
A
4 Guys Pond
(proposed to be extended, online)
Beca
MANGAHEKA MAXIMUM PROBABLE DEVELOPMENT CATCHMENT BOUNDARIES CLOSE UP
FOR INFORMATION ONLY
A3

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Report

Mangaheka Integrated Catchment Management Plan - Stormwater 1D Modelling Report

Prepared for Hamilton City Council

Prepared by CH2M Beca Ltd

6 June 2017

Revision History

Revision Nº	Prepared By	Description	Date
1	**Angela Pratt**	Modelling Report	8/12/16
2	**Angela Pratt**	Updated based on Client comments	16/2/17
3	**Angela Pratt**	Updated based on Peer Review comments	6/6/17

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Angela Pratt**		6/6/17
Reviewed by	**Michael Law**		6/6/17
Approved by	**Kristina Hermens**		6/6/17
on behalf of	CH2M Beca Ltd		

Contents

Appendices

Table of Figures

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1 Introduction

CH2M Beca Ltd has been engaged by Hamilton City Council (HCC) to undertake 1D hydraulic modelling of the Mangaheka Stream catchment in the north-west part of Hamilton. This catchment sits across the boundary of Hamilton City and Waikato District. The section of catchment within the Hamilton City boundary (upper part of the catchment and model) has been designated for future development and is currently underway in the Partly Operative District Plan. To support this development, HCC is preparing an Integrated Catchment Management Plan (ICMP).

The modelling undertaken has sought to assess the effects of development on stream water levels, peak flows and flooding duration. It has also sought to determine what size attenuation devices would be needed to mitigate these effects.

The modelling has been undertaken using the HEC-RAS modelling package. The basis of the modelling is an existing model developed by Lysaght Consultants Ltd during the development of the Hamilton Joint Venture Development and Porters Development in 2012. These developments are located in the upper reaches of the catchment. During design of these developments, AECOM also developed a Mike model as part of the detailed design of these developments.

The Lysaght HEC-RAS model has been updated to include the existing development (ED) and flood mitigation devices that have been installed as part of these developments. In addition, since 2012 the 4 Guys car yard and Z Energy petrol station have also been developed at the upper end of the catchment. This development includes an attenuation pond which has been included in the updated model.

Existing Development (ED) and unmitigated Maximum Probable Development (MPD) scenarios have been tested during 10-year and 100-year average recurrence interval (ARI) events, as well as an MPD with mitigation scenario. The effects of climate change have also been assessed.

2 Model Objectives

Objective 1: The primary objective of the modelling is to assess the impacts of future developments in the catchment on peak water levels and flows downstream, and to confirm what is required to mitigate these effects.

In addition, the following objectives were incorporated:

Objective 2: Update the Lysaght 1D model, to take account of currently-consented development (Porters/HJV/4 Guys developments) – this formed the Existing Development (ED) model in the current study.

Objective 3: Confirm the conclusions of the Lysaght/AECOM modelling, i.e. that to maintain flood levels downstream, mitigation is needed to reduce peak flows to 70% of pre-development.

Objective 4: For the Maximum Probable Development (MPD) scenario, confirm sizing of mitigation required to maintain current flood levels downstream

Objective 5: Confirm that the mitigation does not result in overbank flooding which is longer than 72 hours in duration. This is a requirement of Land Drainage Board managed by the Waikato Regional Council in relation to flooding of farmland. When flooded longer than 72 hours, grass die-off can occur which is a problem for livestock farmers.

Note that, in relation to the objectives, the focus of the modelling has been on the 100-year ARI event as this governs the overall size of attenuation devices and the design of the device outlet structures. We have also run 10-year ARI scenarios, however we have not specifically designed the outlet structures in terms of achieving the above objectives in this event. During detailed design, outlet structures will need to be optimised to achieve objectives in the 10-year ARI event.

3 Catchment Overview

The Mangaheka catchment is approximately 2100 ha in size with approximately 10% existing imperviousness, mainly focussed in the industrial areas in the upper catchment. At MPD it is likely that this will increase to approximately 15%.

There is a variety of roads dissecting the catchment, with the most major ones being the Te Rapa Bypass motorway in the upper catchment and Ngaruawahia Rd in the lower and western parts of the catchment. When Te Rapa Bypass was constructed, Koura Drive was also constructed to provide an on-off ramp system connecting the two sides of the motorway.

In terms of topography, the catchment is primarily flat, rural farmland, however the lower parts of the Mangaheka stream are quite incised and densely vegetated. The north-eastern boundary of the catchment is bounded by an area of higher rolling hills.

The above features are shown in Appendix A.

4 Model Inputs

4.1 Model Description

As described earlier, the modelling has been based on an existing HEC-RAS model developed by Lysaght Ltd. The hydrological inputs (hydrographs) to the HEC-RAS model were originally developed by Lysaght Ltd using Drains, an Australian hydrological modelling program. For our work, we have converted this Drains model to a HEC-HMS model as this directly links to HEC-RAS. This was considered a more efficient and accurate way to update the HEC-RAS model given you are not likely to have data transfer errors between two programs that don't have a direct interface, as was potentially the case with Drains.

4.2 Catchment Characteristics

The catchment has been broken down into sub-catchments for the purposes of determining runoff. These catchments are shown in Appendix B. Parameters used to determine the flow generated by each catchment are presented as Appendix C. These characteristics include:

- Catchment area
- Imperviousness
- Curve number
- Time of concentration

Note that as far as possible, sub-catchment divisions are consistent with those used in previous modelling (Lysaght, 2012). Some minor adjustments have been made to account for recent developments as well as the construction of the Te Rapa Bypass motorway.

4.3 Stream Channel Cross-sections

The bulk of the stream channel cross-sections have been taken directly from the previous Lysaght model. During a site visit it was noted that some of these cross-sections should be refined. Surveying in a number of locations has provided additional catchment boundary information and channel cross-section changes.

4.4 Mannings Roughness

The mannings roughness values used were as per the original Lysaght HEC-RAS model. We have however reviewed a selection of cross-sections through the model to check appropriateness of the values. Table 2 below shows the values used for the various surfaces in the model.

Table 1: Mannings Roughness Values

Surface Type	Mannings Roughness
Pipes	0.012
Channel bed	0.030
Channel sides	0.030
Floodplain	0.045

4.5 Downstream Water Levels

The HEC-RAS model extends to the downstream confluence with the Waipa River. At this location, a boundary condition in the form of a fixed water level has been applied. These have been taken from the existing Lysaght model, those being:

- 10-year ARI water level = 14.33 m RL
- 100-year ARI water level = 16.07 m RL

4.6 Rainfall Intensities and Storm Shape

Rainfall intensities and storm shape have been taken from the HCC Standard Stormwater Modelling Methodology (HCC, 2013).

4.7 Time of Concentration

Time of concentration for each catchment has been calculated using the method described in TP108. Whilst TP108 is an Auckland specific flow calculation method, in terms of determining the time of concentration, this aspect of TP108 is widely used outside of Auckland.

5 Model Scenarios

Table 2 below shows the scenarios that have been modelled. Note that this includes scenarios with and without climate change. Climate change adjustments are provided for in HCC, 2013 which incorporates a 2.08 degree increase in temperature.

Table 2: Model Scenarios

Scenario	10 year ARI	100 year ARI
Existing Development	✓	✓
Existing Development with Climate Change (CC)	✓	✓
MPD without mitigation	✓	✓
MPD without mitigation (with CC)	✓	✓
MPD with mitigation (with CC)	✓	✓

6 Reporting Locations

In assessing the effects of the proposed development, we have determined a number of key locations where effects have been compared in terms of water elevation, flow rate and drain-down duration data. Appendix D shows the twelve locations selected. Appendix D also has a table describing each location as well as their HEC-RAS model chainage. Note that locations 5 and 7 are the sites of proposed offline detention basins, while location 4 is downstream of a proposed inline basin. Results for these locations are therefore only important for the MPD with mitigation scenarios.

7 Model Results – Without Mitigation

7.1 Overview

To be able to determine what mitigation might be required, we have first assessed the impact of development. In accordance with HCC requirements, attenuation also takes account of the effects of climate change (i.e. increases in rainfall intensity)

Our assessment of effects is based on comparisons between ED and MPD water levels and peak flows.

7.2 100-year ARI Results

Table 3 below lists peak water level at each reporting location for 100-year ARI model scenarios without mitigation.

Table 3: Maximum water levels for 100-year ARI scenarios

Location Label	ED 100 yr	ED 100 yr with CC	MPD 100 yr	MPD 100 yr with CC	Difference: MPD 100 yr CC – ED 100 yr
	mRL	mRL	mRL	mRL	m
1	32.26	32.42	32.90	32.95	0.69
2	32.15	32.29	32.36	32.61	0.46
3	31.51	31.62	31.51	31.61	0.1
4	30.63	30.86	31.03	31.21	0.58
5	n/a	n/a	n/a	n/a	n/a
6	30.46	30.58	30.86	31.03	0.57
7	n/a	n/a	n/a	n/a	n/a
8	29.34	29.46	29.40	29.49	0.15
9	26.61	26.67	26.63	26.68	0.07
10	22.68	22.86	22.71	22.87	0.19
11	16.34	16.46	16.34	16.48	0.14
12	16.19	16.22	16.19	16.22	0.03

Table 4 shows the maximum flow rates for the 100-year ARI event without mitigation.

Table 4: Maximum flow rates for 100-year ARI scenarios

Location Label	ED 100 yr	ED 100 yr with CC	MPD 100 yr	MPD 100 yr with CC	Difference: MPD 100 yr CC – ED 100 yr
	m³/s	m³/s	m³/s	m³/s	
1	0.26	0.25	1.04	1.55	496%
2	0.55	0.58	0.60	0.66	20%
3	1.45	3.10	1.47	3.01	108%
4	3.70	4.40	4.83	5.33	44%
5	n/a	n/a	n/a	n/a	
6	3.48	5.52	3.70	3.93	13%
7	n/a	n/a	n/a	n/a	
8	5.84	6.87	7.90	8.64	48%
9	14.77	18.11	15.50	18.60	26%
10	21.05	32.90	22.87	34.32	63%
11	43.68	58.34	44.25	59.89	37%
12	60.65	78.53	61.26	80.08	32%

Table 3 and Table 4 above show that in comparing MPD 100 year (with CC) with ED 100 year, there is an increase in both water level and peak flows at all locations. This is the effect that we have then sought to mitigate by including a number of proposed attenuation devices in the model. Comparing ED 100 year and MPD 100 year indicates the effect of only the MPD development i.e. without considering climate change. The only location where (close to) no increase is seen in MPD 100 year is Location 3. This location is at the outlet of the HJV pond, which has already been designed to take account of climate change and also where the catchment area will reduce at MPD. At MPD the catchment south of Te Rapa Bypass (the Shark-fin) will flow into the Rotokauri catchment, rather than the Mangaheka catchment.

Long-sections of water levels in the catchment are shown in Section 9.1.1.

7.3 10-year ARI results

Table 5 below lists peak water level at each reporting location for 10-year model scenarios without mitigation.

Table 5: Maximum water levels for 10-year ARI scenarios

Location Label	ED 10 yr	ED 10 yr with CC	MPD 10 yr	MPD 10 yr with CC	Difference: MPD 10 yr CC – ED 10 yr
	mRL	mRL	mRL	mRL	m
1	31.92	32.03	32.52	32.70	+0.78
2	31.77	31.87	31.79	31.86	+0.09
3	31.15	31.30	31.14	31.29	+0.14
4	30.24	30.36	30.61	30.76	+0.52
5	n/a	n/a	n/a	n/a	n/a
6	30.04	30.20	30.49	30.63	+0.59
7	n/a	n/a	n/a	n/a	n/a
8	29.23	29.31	29.36	29.41	+0.18
9	26.22	26.43	26.34	26.47	+0.25
10	21.38	21.84	21.49	22.01	+0.63
11	15.26	15.44	15.27	15.45	+0.19
12	15.15	15.30	15.16	15.31	+0.16

Table 6 shows the maximum flow rates for the 10 year event without mitigation.

Table 6: Maximum flow rates for 10-year ARI scenarios

Location Label	ED 10 yr	ED 10 yr with CC	MPD 10 yr	MPD 10 yr with CC	Difference: MPD 10 yr CC – ED 10 yr
	m^3/s	m^3/s	m^3/s	m^3/s	%
1	0.18	0.20	0.41	0.48	267
2	0.39	0.47	0.41	0.46	118
3	0.70	0.85	0.68	0.82	117
4	2.05	2.66	3.58	3.97	194
5	n/a	n/a	n/a	n/a	n/a
6	2.53	2.81	3.18	3.37	133
7	n/a	n/a	n/a	n/a	n/a
8	3.62	4.18	5.40	6.05	167
9	7.62	10.23	8.94	11.06	145
10	10.20	11.84	10.61	12.37	121
11	21.27	26.84	21.82	27.45	129
12	29.28	36.64	29.77	37.22	127

Tables 5 and 6 above show that in comparing MPD 10 year (with CC) with ED 10 year, there is an increase in both water level and peak flows at all locations except location 3. Comparing ED 10 year and MPD 10 year also indicates an increase at all locations except location 3. As described earlier, location 3 is at the outlet of the HJV pond, which has already been designed to take account of climate change and also where the catchment area will reduce at MPD. This means that the target was ED 10 year

8 Proposed Mitigation

8.1 Overview

As shown in Table 7, a number of attenuation devices are proposed to mitigate the water level and peak flow increases as a result of development (MPD compared to ED) as well as climate change. The locations of these devices are depicted in Appendix E. Pond configurations were based on discussions with HCC. A summary of these discussions is attached as Appendix F.

Table 7: Existing and Proposed Flow Mitigation Devices

Device	Existing or New	Type	Mitigates for development in
Porters Pond	Existing	Inline	Catchment F
HJV Pond	Existing	Inline	Catchment B
4 Guys Pond	Existing, to be modified	Inline	Catchment A (MPD)
Device 7	Proposed	Inline	Catchment C
Device 6	Proposed	Offline	Catchment D*
Device 5	Proposed	Offline	Catchments G, H and E**

*Flows into this device only come from the south-west side of the stream, however the device attenuates for the whole catchment i.e it over attenuates the flows which reach the basin to account for the parts of the catchment that won't reach the basin.

**This device over attenuates flows from catchments E and H, thus also providing attenuation for catchment G.

In accordance with HCC requirements, attenuation has been sized to mitigate the effects of development as well as climate change. The criteria for achieving this is shown in Section 8.2.

8.2 Device Design Targets and Constraints

In designing the modifications to the existing 4 Guys pond and the proposed new devices, a number of constraints and design targets needed to be met/achieved. In terms of the constraints, we have sought to not increase the water levels in the existing devices, such that existing flood levels upstream are not increased.

Table 8 lists flow and water level design constraints of the existing device that is to be modified (4 Guys Pond) and design criteria for the proposed devices. Depending on the location, either the water level or flow rate governed. Table 13: details which governed for each of model reporting locations.

In sizing devices, we began with the previous modelling target of reducing peak flows to 70% of predevelopment and then assessed whether this is still appropriate for MPD. This is discussed further as part of the results in Section 9.1.5.

Table 8: Mitigation design targets/constraints

Device	Targets/Constraints
4 Guys Pond	▪ Water level in 4 Guys Pond (location 1) must be ≤ 32.31 mRL ('ED 100 yr' scenario) ▪ Water level downstream of 4 Guys Pond (location 2) must be ≤ 32.17 mRL ('ED 100 yr' scenario)
Device 7	▪ Water level in HJV pond (location 3) must be ≤ 31.7 mRL ('ED 100 yr with CC' scenario) ▪ Outflow from Device 7 (location 4) must be ≤ 5.7 m^3/s (equivalent to 70% contribution of 'ED 100 yr' flow from catchment C plus flow coming from upstream i.e. HJV pond outlet) ▪ Water level downstream of Device 7 bund (location 4) must be ≤ 30.76 mRL ('ED 100 yr' scenario)
Device 6	▪ Water level in Device 6 basin (location 5) must be ≤ 31.2 mRL (minimum ground elevation in nominal basin location) ▪ Outflow from Device 6 (location 5) must be ≤ 0.93 m^3/s (equivalent to 70% of 'ED 100 yr' flow from Catchment D). ▪ Water level downstream of Device 6 (location 6) must be ≤ 30.53 mRL ('ED 100 yr' scenario)
Device 5	▪ Water level in Device 5 basin (location 7) must be ≤ 29.7 mRL (300 mm lower than ground surface on the eastern side of this pond) ▪ Combined total outflow from Device 5 (location 7) must be ≤ 3.46 m^3/s (equivalent to 70% of 'ED 100 yr' flow from catchments E, H and G) ▪ Water level downstream of confluence of Porters Drain and Mangaheka Stream (location 8) must be ≤ 29.37 mRL ('ED 100 yr' scenario')

8.3 Proposed Device Characteristics

Table 9 lists device sizes required to achieve the above targets. Note that basins have been included in the model as having flat invert and 1:4 batter slopes. Basins will need to be refined further during detailed design. Refer to Appendix B for catchment locations.

Table 9: Proposed Device sizes and characteristics

Device	Catchment	Catchment Area	Type	Stored volume	Basin invert	Max water surface elevation	Max depth	Water surface area	Outlet diameter	Outlet invert (u/s end)	Outlet grade
		Ha		m^3	m RL	m RL	m	ha	mm	m RL	
4 Guys	A	7.0	Inline	5000	31.3	32.31	1.0	0.5	700	31.3	1 in 277
Basin 7	C	38.4	Inline	26000*	30.0†	31.7	1.7	3.4	1050	29.4	1 in 62
Basin 6	D	49.4	Offline	36000	28.6	31.2	2.6	1.7	560	28.6	1 in 5
Basin 5	E, G, H	40.7	Offline	44000	28.3	29.7	1.4	3.2	375	28.3	1 in 5

** Maximum volume retained between downstream outlet/embankment and HJV pond in MPD 100 yr with CC and mitigation scenario.*
† Excluding low flow channel

Device 7, which is an inline pond, has been sized against its own design targets (as per Table 8), with the assumption that Devices 5 and 6 do not exist. Building these latter ponds will further reduce peak water level downstream of the Device 7 bund.

Each device should be built as their corresponding catchments are developed (see “Mitigates for development” column in Table 7).

9 Model Results with Mitigation

9.1 100-year ARI

9.1.1 Peak Water Levels

Table 10 lists maximum water levels for the ‘MPD 100-yr ARI with CC and mitigation’ scenario against the ‘ED 100 yr’ scenario. All corresponding mitigation targets given in Table 8 are satisfied, with the exception of the criteria on water level downstream of the confluence between Porters Drain and Mangaheka Stream (location 8). In this case, ‘MPD 100 yr with CC and mitigation’ water level is 10 mm greater than the target of 29.37 mRL. This is considered to be within the modelling margin of error.

Note that:

- ‘MPD 100 yr with CC and mitigation’ water levels at locations 9 to 12 are expected to be higher than equivalent ‘ED 100 yr’ water levels. This is because of increased inflows from catchments 7 to 21 (i.e. rural areas) due to climate change effects, for which mitigation is not proposed or expected.
- Water levels at locations 11 and 12 are influenced by the water level boundary condition set at Waipa River of 16.07 for all 100-year ARI scenarios.
- Locations 9 and 10 are immediately upstream of surcharged culverts, which have a similar effect to the boundary condition affecting locations 11 and 12.

As stated in Table 8, the target water level in the HJV pond (location 3) was 31.7 mRL, as determined with respect to the ED 100 yr with CC scenario. This is because this device has already been designed for the effect of climate change. Therefore the comparison in this table with the ED 100 yr value is of only nominal interest.

Table 10: Maximum water levels for ‘MPD 100 yr with CC and mitigation’ against ‘ED 100 yr’.

Location Label	ED 100 yr	MPD 100 yr with CC and mitigation
	mRL	mRL
1	32.26	32.29*
2	32.15	32.10
3	31.51	31.62
4	30.63	30.62
5	n/a	31.08
6	30.46	30.43
7	n/a	29.57
8	29.34	29.35
9	26.61	26.67
10	22.68	22.85
11	16.34	16.46
12	16.19	16.22

*Note that at location 1, the MPD 100 year with CC and mitigation value is 30mm higher than the ED100 year value. This is due to a minor error that was found whilst finalising this report. The 4 Guys pond will need to be slightly larger to meet the target value at this location, however this is within the bounds of normal modelling errors therefore it was not considered necessary to iterate the model. This does not affect the conclusions of this report. Other more minor increases at Location 3 and 10 and considered to be within normal modelling errors.

The below long sections show the water levels along the stream channels within the model. Three sections are presented, as illustrated in Figure 1:

1. Porters Drain (Figure 2)
2. Upper Mangaheka Stream above the Mangaheka stream/Porters drain confluence (Figure 3)
3. Lower Mangaheka Stream, from the Waipa River confluence to the Mangaheka stream/Porters drain confluence (Figure 4)

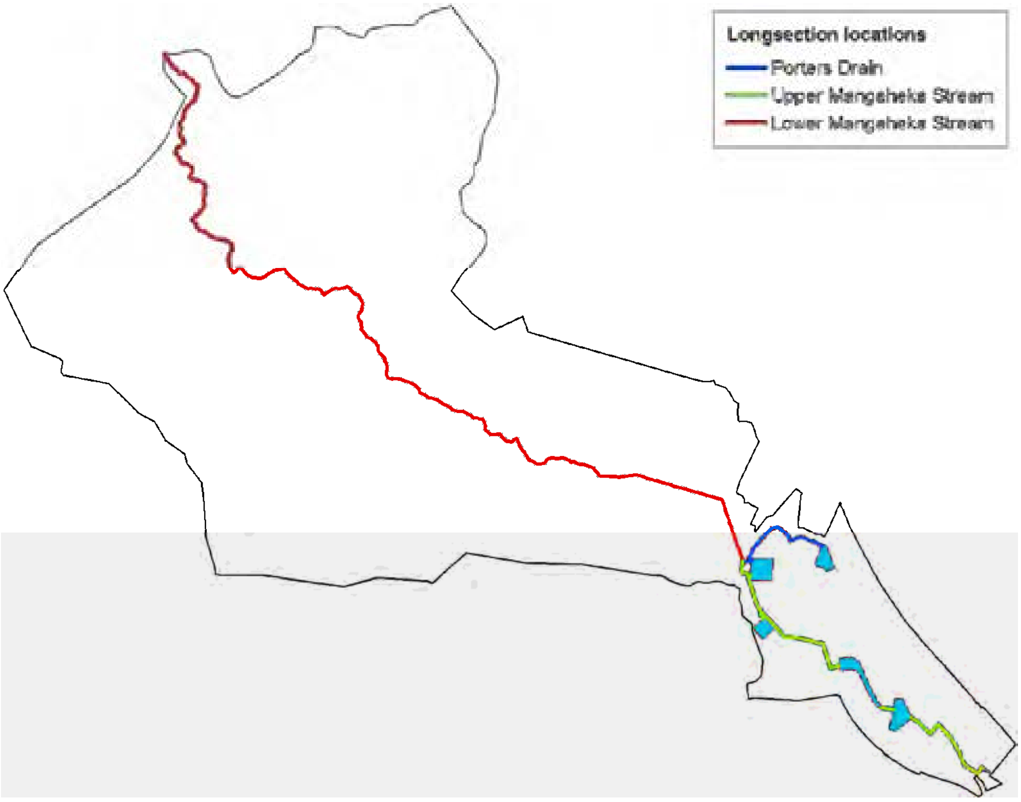


Figure 1: Plan View of Channel Long Sections

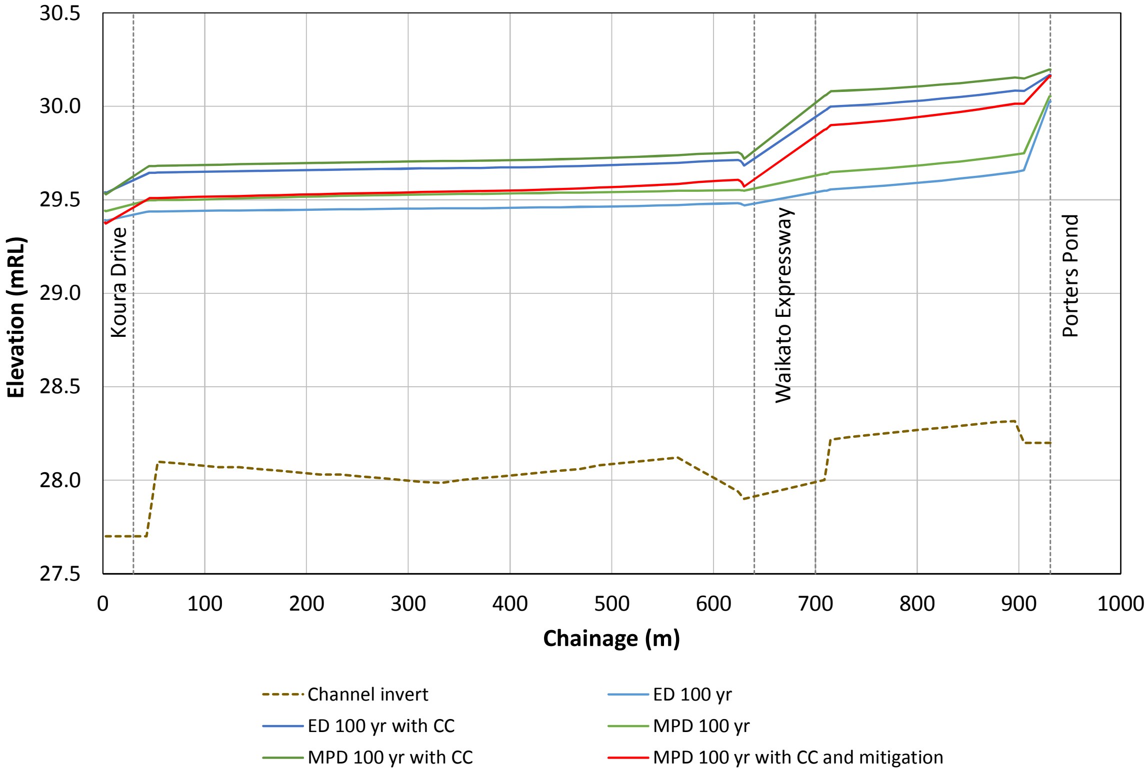


Figure 2: Water Levels - Porters Drain

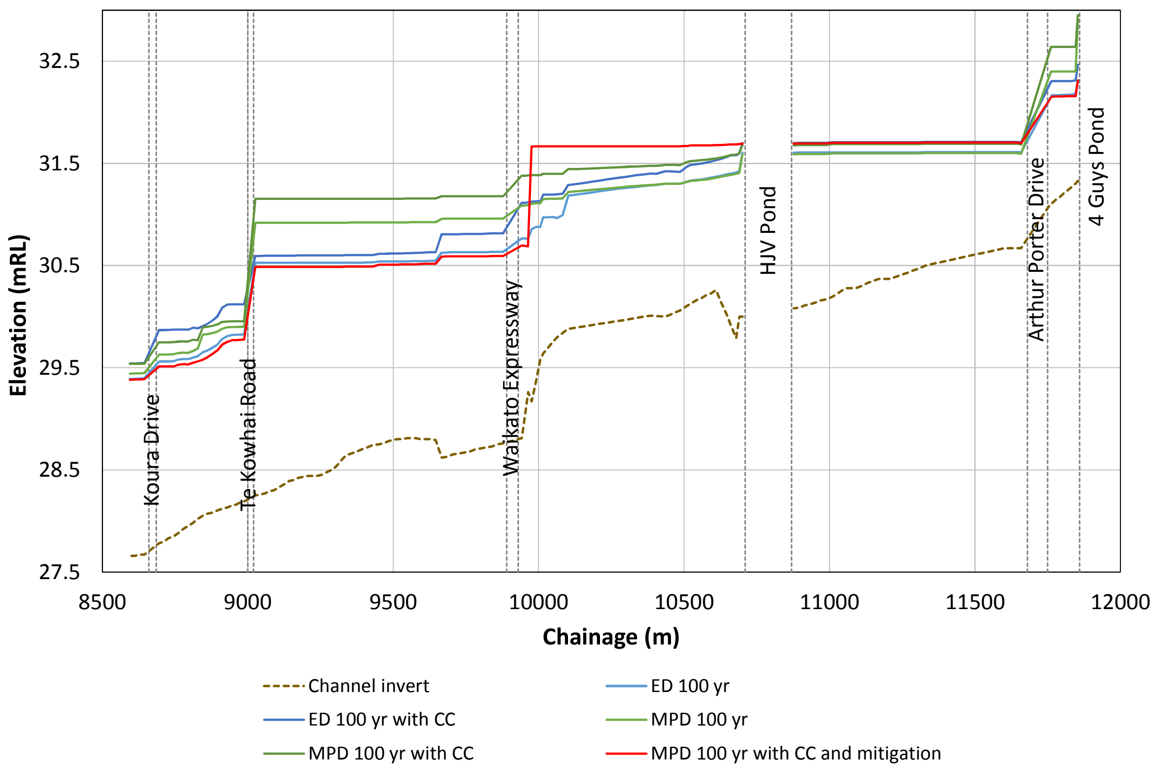


Figure 3: Water Levels - Upper Mangaheka Stream, from Koura Drive to 4 Guys Pond

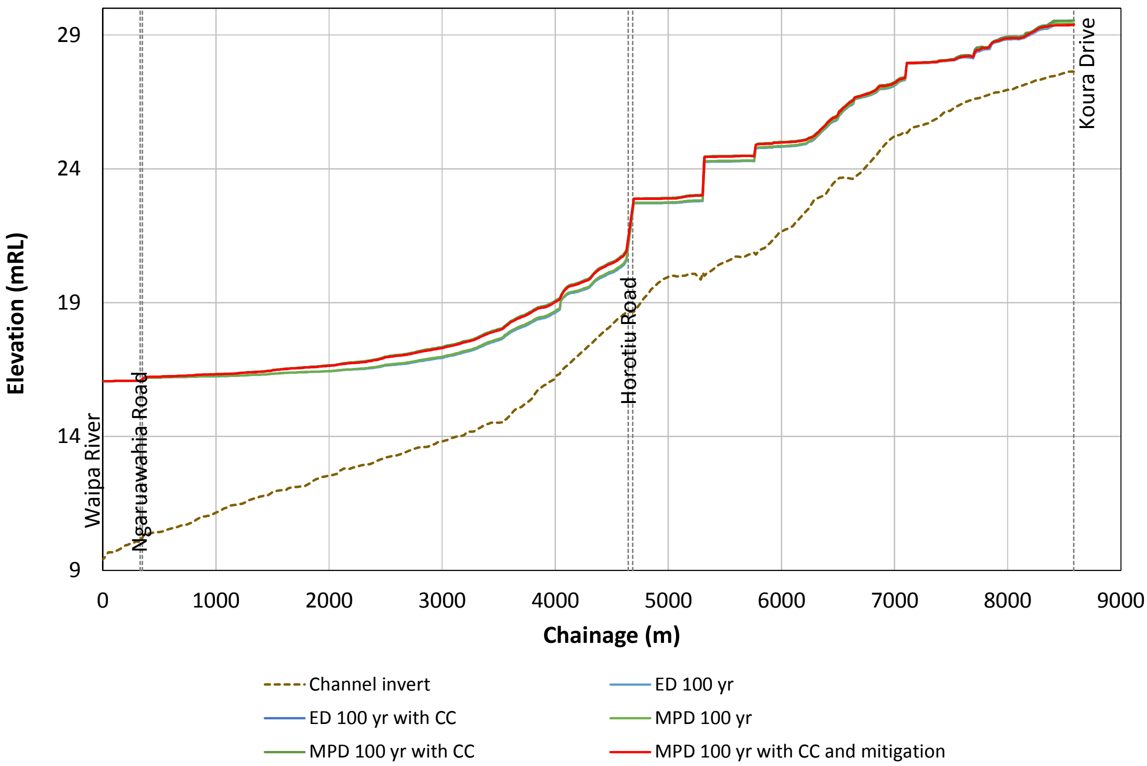


Figure 4: Water levels - Lower Mangaheka Stream, from Waipa River to Koura Drive

The above long sections show that the MPD 100 year with CC and mitigation water levels are at or below the ED 100 year water levels, other than in Porters Drain. In this location, water levels are higher as flows from the future development catchment (G) are mitigated by over-attenuation in Device 5. It is worth nothing that the elevated water levels are within the stream banks and are therefore not considered an issue.

9.1.2 Peak Flows

Table 11 lists maximum flow rates for the 'MPD 100 yr with CC and mitigation' scenario against the 'ED 100 yr' scenario as well as velocities. All corresponding mitigation targets given in Table 8 are satisfied. Whilst peak flow and water level are the main drivers, it is also helpful to understand velocities at each location as this is a key factor in erosion potential.

Table 11: Maximum flow rates and velocities for ‘MPD 100 yr with CC and mitigation’ against ‘ED 100 yr’

Location Label	ED 100 yr		MPD 100 yr with CC and mitigation	
	Flow (m^3/s)	Velocity (m/s)	Flow (m^3/s)	Velocity (m/s)
1	0.26	0.03	0.59	0.06
2	0.55	0.30	0.53	0.30
3	1.45	0.02	3.03	0.05
4	3.70	1.43	2.85	1.03
5	n/a	n/a	0.88	
6	3.48	0.43	3.41	0.47
7	n/a	n/a	0.22	
8	5.84	1.06	5.53	0.96
9	14.77	0.96	17.78	1.09
10	21.05	0.73	32.63	0.72
11	43.68	0.58	58.27	0.74
12	60.65	0.31	78.47	0.40

Note that:

- Whilst the peak flow at location 1 for the ‘MPD 100 yr with CC and mitigation’ scenario is greater than for either ED scenario, water level criteria at this location are satisfied, as seen in Table 10. Velocities at this location are significantly lower than 0.1 m/s and therefore unlikely to lead to erosion.
- The HJV pond, which has already been built, is expected to mitigate peak outflow rates to pre-development levels. ED scenarios in this current study include this development, and therefore it is appropriate that peak pond outflow rates (location 3) in the ‘MPD 100 yr with CC and mitigation’ scenario are no greater than in the ‘ED 100 yr with CC’ scenario. A comparison between Table 9 and Table 4 shows this to be the case.
- ‘MPD 100 yr with CC and mitigation’ flow rates as well as velocities at locations 9 to 12 are expected to be higher than equivalent ‘ED 100 yr’ flow rates. This is because of increased inflows from catchments 7 to 21 (i.e. rural areas) due to climate change effects.

9.1.3 Drain down times

In assessing drain down times, we have determined the length of time that water levels have increased above bank levels at each reporting location. Bank levels have been assessed using aerial photography compared against the cross-section level data. Table 12 shows the drain down times for each of the 100 year scenarios.

Table 12: Drain down times

Location Label	Reference elevation	ED 100 yr	ED 100 yr with CC	MPD 100 yr	MPD 100 yr with CC	MPD 100 yr with CC and mitigation
	mRL	hours	hours	hours	hours	hours
2	32.11	1.0	1.7	2.5	3.1	1.6
4	30.5	1.6	5.0	6.1	9.1	5.8
6	29.5	9.6	12.6	12.4	14.1	16.1
8	29.5	0	0	0	0	0
9	25.7	13.6	15.0	14.7	16.9	18.2
10	21.1	7.8	10.9	8.9	12.1	10.2
11	20.5	0	0	0	0	0

Location 12 has been excluded as this is flooded throughout the whole event due to the fixed downstream water level control at the discharge point to the Waipa River.

Table 12 above show that at all locations, the drain down times are less than the required 72 hours.

9.1.4 Attenuation Target Achievement

As described earlier, the attenuation target that governed (flow rate or water level) differed for each reporting location. Table 13: provides the results against the governing target for each location.

Table 13: Attenuation targets at each reporting location.

Location Label	Target	Target basis	MPD 100 yr with CC and mitigation value
1	32.31 m RL	ED 100 yr water level	32.29
2	32.17 m RL	ED 100 yr water level	32.10
3	31.7 m RL	ED 100 yr with CC water level	31.62
4	30.76 m RL	ED 100 yr water level	30.62
4	5.7 m^3/s	70% contribution of 'ED 100 yr' flow from catchment C plus flow coming from upstream	2.85*
5	31.2 m RL	Minimum ground elevation in nominal basin location	31.08
5	0.93 m^3/s	70% of ‘ED 100 yr’ flow from Catchment D	0.88
6	30.53 m RL	ED 100 yr water level	30.43
7	29.7 m RL	300 mm lower than ground surface on the eastern side of this pond	29.57
7	3.46 m^3/s	70% of ‘ED 100 yr’ flow from catchments E, H and G	0.22*
8	29.37 m RL	ED 100 yr water level	29.35

* For these reporting locations, reducing the peak flow to at or below the target was not enough to also achieve the water level target, hence the water level target governed.

9.1.5 Attenuation Requirements for Developers

One of the overall objectives of this modelling is to confirm that flood levels are not raised by future development. A common method to do this—and one previously recommended by AECOM (2013)—is to reduce peak flows in order to mitigate water level increases. However due to the flat nature of the catchment (the upper catchment in particular), peak flows do not directly correlate with water levels and therefore it is the water levels that have directly governed the device sizing. This includes the effect that coincidence of flows have on water levels. This has meant that attenuation requirements (in terms of peak flow reduction) are different for each of the devices. Table 14 below outlines the attenuation requirements for each proposed device in terms of peak discharge from the catchment(s) served and also in terms of what flow would be expected downstream of each device, if they are designed and built correctly.

Table 14: Attenuation Requirements

	Catchment Served	Peak discharge from catchment as % of ED	Peak flow downstream of device as % of ED
Device 5	E, H, G	9	101
Device 6	D[1]	70	96
Device 7	C	-27	73
4 Guys	A	76	96

Note that pond sizing has been carried out in the model assuming all development (MPD) and devices are present and working together to achieve appropriate mitigation across the whole catchment. If one sub-catchment was developed in isolation, further modelling would be needed to determine interim mitigation requirements.

In relation to Device 5, this is located in a very flat part of the catchment. On the basis of comparing peak flows generated by this catchment in isolation, the percentage reduction in peak flows is very high. This however should be considered against the results in Table 10 (location 8), which shows that water levels downstream of the device at MPD (with CC and mitigation) match ED (without CC).

Note also that MPD peak flows need to be less than ED peak flows for Device 7 in order that water levels downstream are not higher than ED. This is because Device 7 is an inline pond, and is therefore affected by both upstream (which are higher as a result of climate change) and downstream water levels. A very high level of mitigation is therefore required in terms of managing MPD flows from the local catchment draining to Device 7. When compared to Table 10 (location 4), the water level is slightly lower at MPD (with mitigation and CC) as compared to ED. This is why the % change in Table 12 is negative for this device. If Device 7 were considered in isolation i.e. no other development occurred, it is possible that less mitigation would be required (smaller pond).

9.2 10-year ARI

9.2.1 Peak Water Levels

Table 15 lists maximum water levels for the ‘MPD 10 yr with CC and mitigation’ scenario against the ‘ED 10 yr’ scenario. Whilst mitigation targets (listed in Table 8) applied only to 100-year scenarios, equivalent

[1] Whilst only the southern side of catchment D drains into Device 6, this device over-attenuates for runoff from the remaining portion of this catchment. “Peak discharge from catchment as % of ED” for this device refers to total catchment flow; i.e. both sides of catchment D.

comparisons can be made, particularly with respect to water levels in the 'ED 10 yr' scenario for locations 1, 2, 4, 6, and 8.

Note that like the 100 year event, water levels in the lower parts of the catchment are affected by un-mitigated climate change in the rural catchments, and by the water level boundary condition set at Waipa River of 14.33 for all 10-year ARI scenarios.

Table 15: Maximum water levels for 'MPD 10 yr with CC and mitigation' against 'ED 10 yr'

Location Label	ED 10 yr	MPD 10 yr with CC and mitigation
	mRL	mRL
1	31.92	32.01
2	31.77	31.84
3	31.15	31.27
4	30.24	30.27
5	n/a	30.35
6	30.04	30.02
7	n/a	29.24
8	29.23	29.19
9	26.22	26.35
10	21.38	21.76
11	15.26	15.44
12	15.15	15.30

Long sections in Figures 6 to 8 show the water levels along the stream channels within the model.

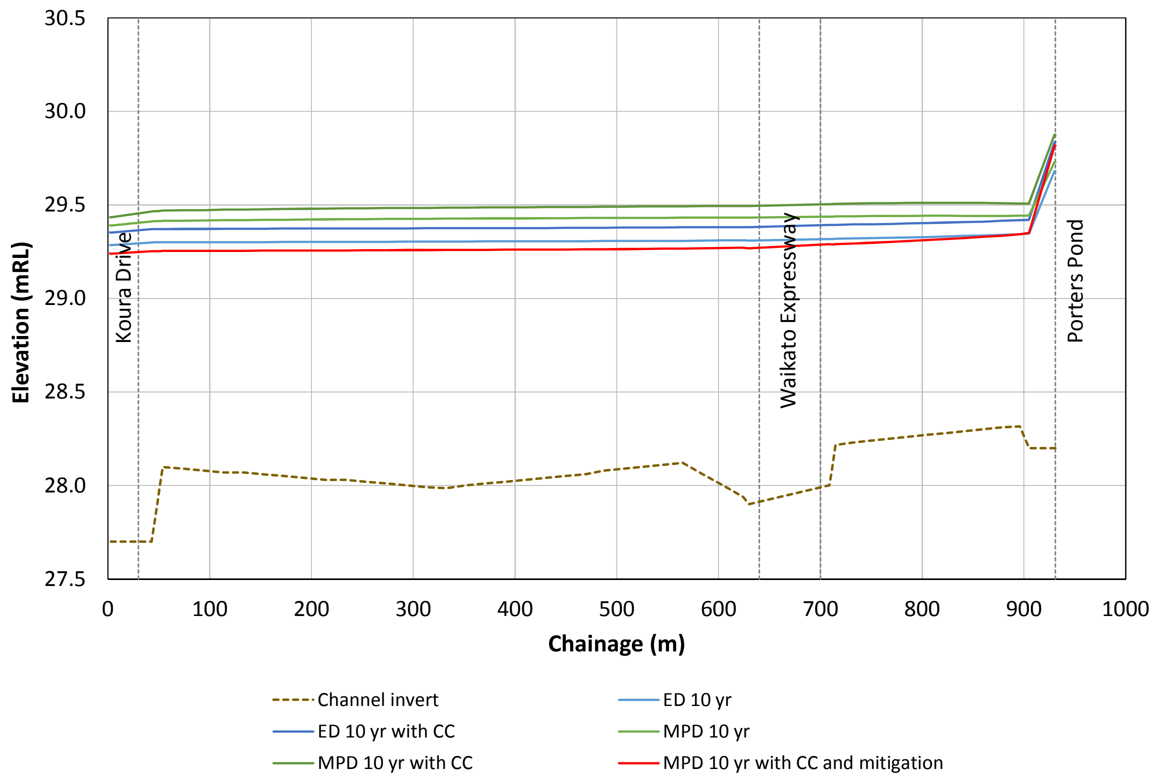


Figure 5: Water Levels - Porters Drain

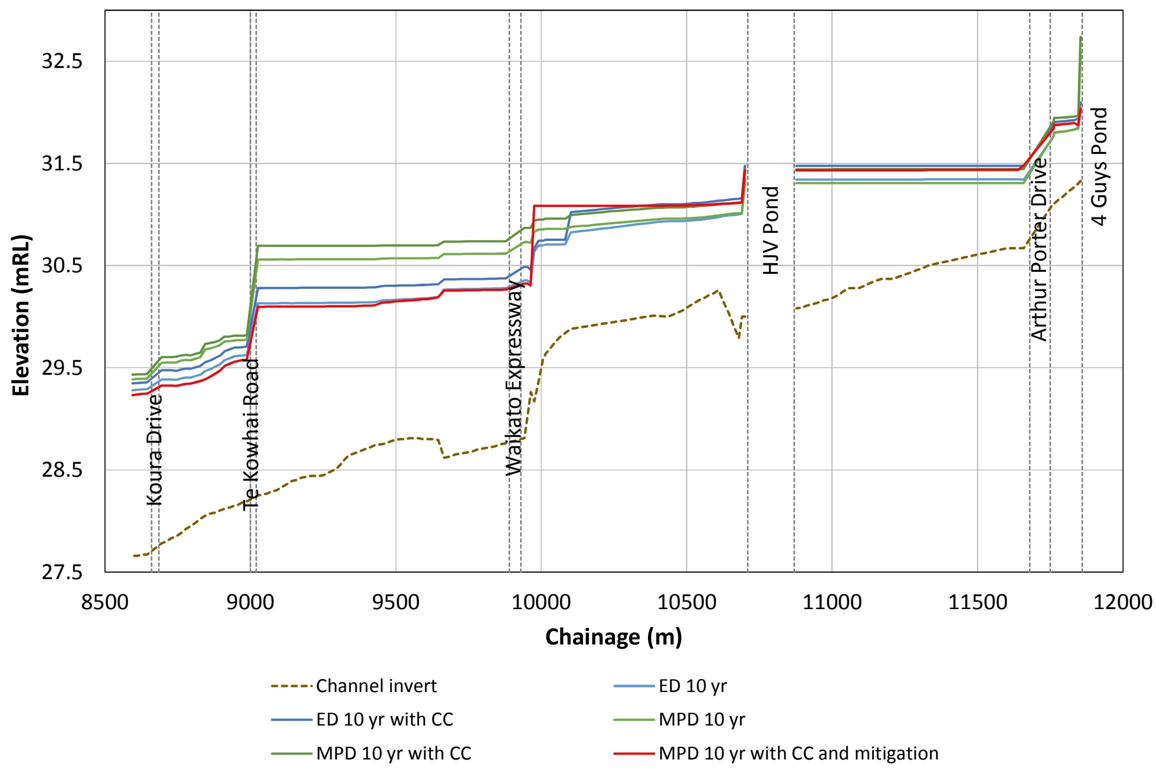


Figure 6: Water Levels - Upper Mangaheka Stream, from Koura Drive to 4 Guys Pond

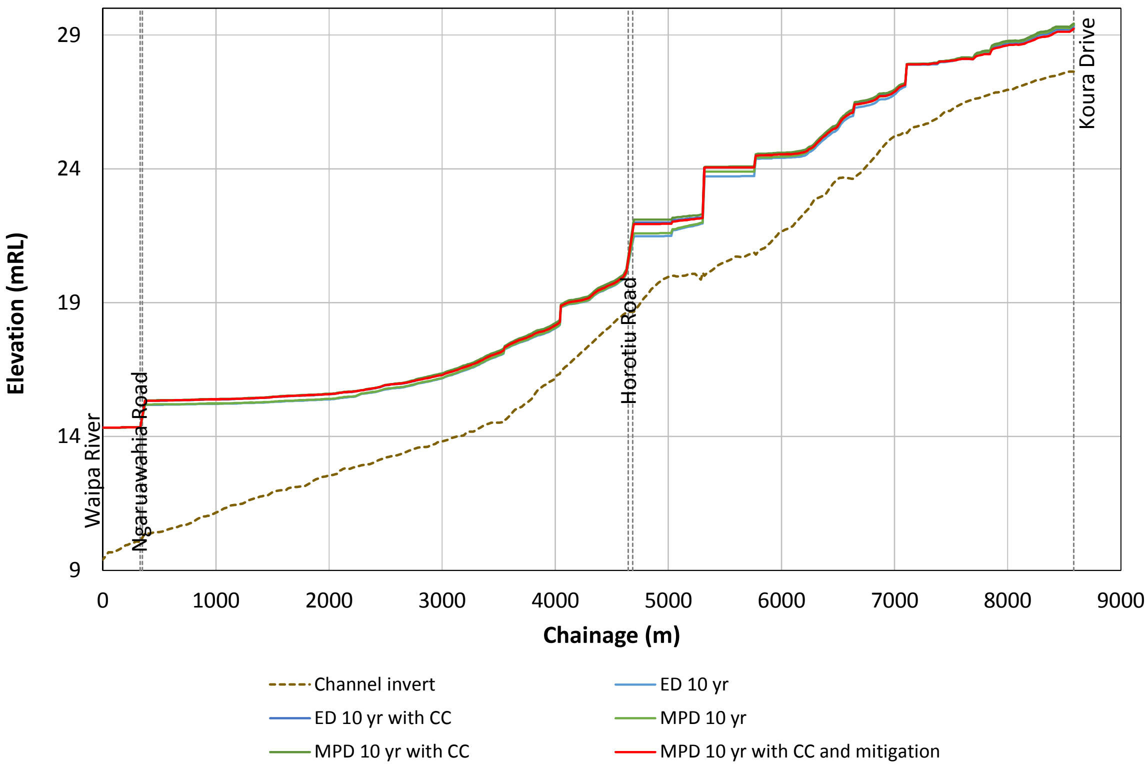


Figure 7: Water levels - Lower Mangaheka Stream, from Waipa River to Koura Drive

The above long sections show that the MPD 10 year with CC and mitigation water levels are at or below the ED 10 year water levels.

9.2.2 Peak Flows

Table 16 lists maximum flow rates for the ‘MPD 10 yr with CC and mitigation’ scenario against the ‘ED 100 yr’ scenario.

Note that:

- The HJV pond, which has already been built, is expected to mitigate peak outflow rates to pre-development levels. ED scenarios in this current study include this development, and therefore it is appropriate that peak pond outflow rates (location 3) in the ‘MPD 10 yr with CC and mitigation’ scenario are no greater than in the ‘ED 10 yr with CC’ scenario. A comparison between Table 12 and Table 4 shows this to be the case.
- ‘MPD 10 yr with CC and mitigation’ flow rates at locations 9 to 12 are expected to be higher than equivalent ‘ED 10 yr’ flow rates. This is because of increased inflows from catchments 7 to 21 (i.e. rural areas) due to climate change effects.

Table 16: Maximum flow rates for 'MPD 10 yr with CC and mitigation' against 'ED 10 yr'

Location Label	ED 10 yr	MPD 10 yr with CC and mitigation
	m^3/s	m^3/s
1	0.18	0.46
2	0.39	0.45
3	0.70	0.89
4	2.05	2.11
5	n/a	0.56
6	2.53	2.55
7	n/a	0.18
8	3.62	3.27
9	7.62	9.13
10	10.20	11.59
11	21.27	27.09
12	29.28	36.85

9.2.3 Drain down times

Table 17 below shows the drain down times for each reporting location.

Table 17: Drain down times

Location Label	Reference elevation	ED 10 yr	ED 10 yr with CC	MPD 10 yr	MPD 10 yr with CC	MPD 10 yr with CC and mitigation
	mRL	hours	hours	hours	hours	hours
2	32.11	0	0	0	0	0
4	30.5	0	0	1.5	2.9	0
6	29.5	3.8	6.2	6.8	8.4	10.7
8	29.5	0	0	0	0	0
9	25.7	7.7	9.9	9.6	11.9	13.2
10	21.1	3.5	5.4	4.5	6.2	6.2
11	20.5	0	0	0	0	0

Location 12 has been excluded as this is flooded throughout the whole event due to the fixed downstream water level control at the discharge point to the Waipa River.

Table 17 above shows that at all locations, the drain down times are less than the required 72 hours.

10 Flood Maps

10.1 Overview

Flood maps have been produced by interpolating flood extents from the HEC-RAS cross-sections and then overlaying these on an aerial photograph of the catchment. An alternative methodology is to drape the flood extents over a LiDAR surface. This however has not been possible given the lack of recent, accurate, high-resolution LiDAR data. Flood maps for all scenarios are presented as Appendices F (100 year) and G (10 year).

10.2 100-year ARI flood maps

The following observations can be made:

- Flood maps for ED 100-yr CC and MPD non-mitigation scenarios show evidence of ponding in the area where the Device 7 inline basin is proposed. That is, Device 7 would increase ponding levels and spatial extent in an area that is already subject to flooding.
- MPD non-mitigation maps show increased flooding along Mangaheka Stream between Te Rapa Bypass and Te Kowhai Road when compared against ED maps
- Both ED 100-yr CC and MPD 100-yr CC maps show increased flooding extents around the Porters Drain / Mangaheka Stream junction when compared with their non-CC versions. This includes a narrow 'sliver' of flooding extending 300 m towards the south-west, where water depths are approx. 25 mm. Cross-section elevations are constant over this extent, which is unlikely to be true in reality.
- The map for MPD 100-yr CC with mitigation depicts flooding extents that are very similar to those seen in the ED 100-yr scenario, with the exception of intentionally-increased ponding at Device 7 and within Porters Drain.

10.3 10-year ARI flood maps

The following observations can be made:

- Non-mitigation flooding extents in the area occupied by the proposed Device 7 are much smaller than seen in equivalent 100-year runs.
- ED models predict flooding immediately downstream of the junction between Mangaheka Stream and Porters Drain, but not upstream of Koura Drive. However this area is flooded in MPD non-mitigation scenarios.
- Flood extents for MPD 10-yr CC with mitigation are very similar to those for ED 10-yr, with the exception of increased extents at a) Device 7, because this is an inline device and b) in an area 700 m downstream of the junction between Mangaheka Stream and Porters Drain. Here, water levels are higher because of effect of climate change on rural catchments which are not mitigated.

11 Conclusions

In terms of the primary modelling objective (**Objective 1**), the modelling carried out has shown that the effect on water levels resulting from MPD can be mitigated by using attenuation basins such that there is no more than minor downstream flooding effect. This mitigation also results in peak flows which are at or below ED water levels (except where increases have been deemed appropriate and acceptable).

In the lower catchment, if climate change occurs, water levels will increase as a result of the predicted increases in rainfall intensity. In this part of the catchment mitigation is not proposed as no development (beyond normal rural development) is proposed.

As discussed in section 9.1.5, water levels have driven the sizing of the attenuation devices. In terms of peak flows and the objective to confirm the conclusions of the Lysaghts/AECOM modelling (**Objective 3**), this modelling indicates that a different target will be required at each of the devices due to the differing constraints on each. Table 18 below provides details of the peak flow reductions required by each.

Table 18: Attenuation Percentages

Device	Catchment Served	Peak discharge from catchment as % of ED	Peak flow downstream of device as % of ED
Device 5	E, H, G	9 (a)	101
Device 6	D	70	96
Device 7	C	-27 (b)	73
4 Guys	A	76	96

In terms of **Objective 4**, to mitigate the increases in water levels associated with development in the upper catchment, attenuation devices will likely be required. These are shown in Figure 8 below (refer also Appendix E). Their details are shown in Table 19.

Table 19: Proposed device sizes and characteristics

Device	Catchment	Catchment Area	Type	Stored volume	Basin invert	Max water surface elevation	Max depth	Water surface area	Outlet diameter	Outlet invert (u/s end)	Outlet grade
		ha		m^3	m RL	m RL	m	ha	mm	m RL	
4 Guys	A	7.0	Inline	5000	31.3	32.31	1.0	0.5	700	31.3	1 in 277
Basin 7	C	38.4	Inline	26000*	30.0†	31.7	1.7	3.4	1050	29.4	1 in 62
Basin 6	D	49.4	Offline	36000	28.6	31.2	2.6	1.7	560	28.6	1 in 5
Basin 5	E, G, H	40.7	Offline	44000	28.3	29.7	1.4	3.2	375	28.3	1 in 5

** Maximum volume retained between downstream outlet/embankment and HJV pond in MPD 100 yr with CC and mitigation scenario*

† Excluding low flow channel

In terms of **Objective 5**, section 9.1.3 and 9.2.3 provide details of drain down times in the 100 year and 10 year events respectively. These sections indicate that the requirement that mitigation does not result in overbank flooding which is longer than 72 hours in duration is met.

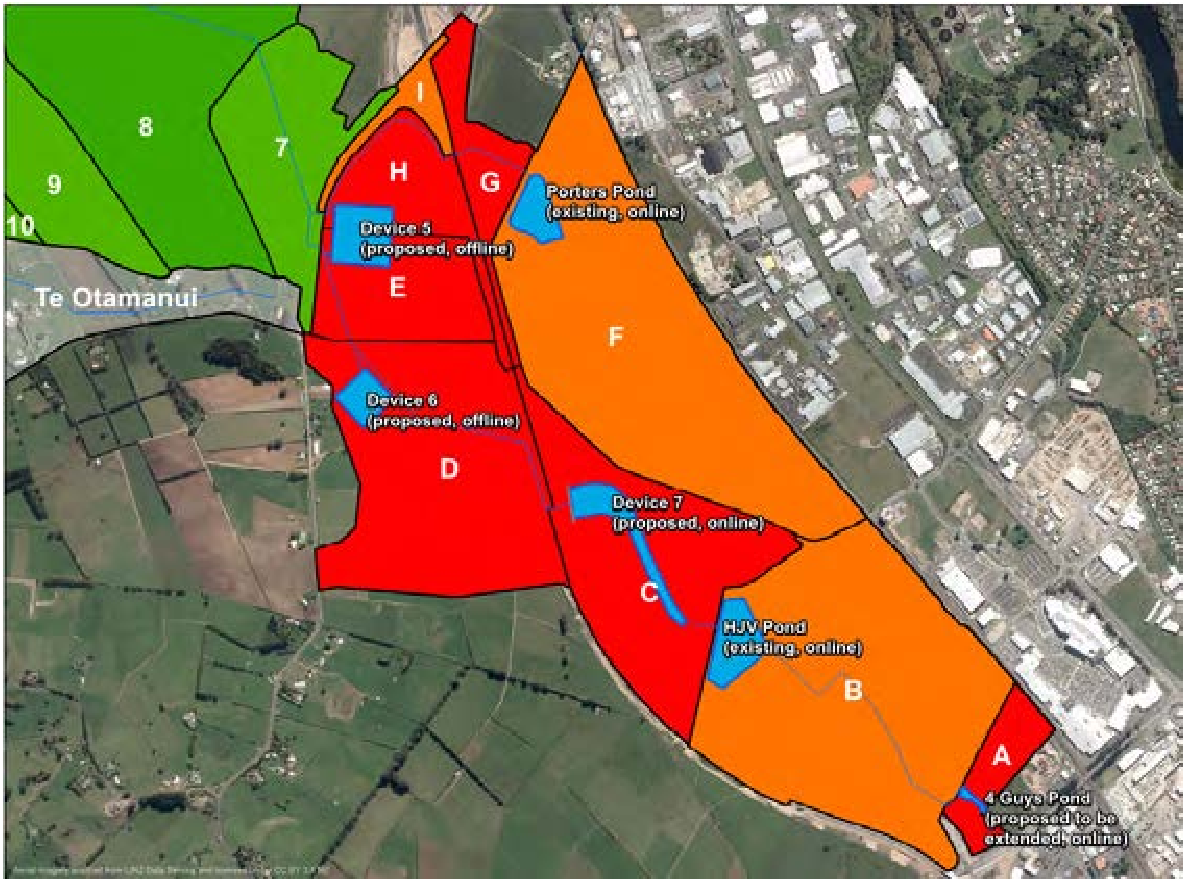


Figure 8: Proposed and Existing Device Locations

12 Further Work

It is possible that discharging stormwater into the Te Otamanui catchment from Mangaheka Stream will reduce or remove the attenuation requirements of MPD. A fatal flaw assessment has been carried out and it has been determined that there are not likely to be any fatal flaws to such discharge. The full assessment can be read in Beca, 2017. Investigations into this are being carried out separately.

13 Variations from HCC Modelling Specification

HEC-RAS has been used for 1-D modelling, instead of the recommended MIKE software. HEC-RAS has been used as it was seen as beneficial to adapt the existing Lysaghts model rather than developing a new model. This approach has been agreed with HCC and Morphum.

14 Peer Review

A peer review of this modelling report has been carried out by Morphum Ltd. Peer review comments and our responses can be found in Appendix I. A number of changes have been made to this report to reflex the peer review.

15 Assumptions and Exclusions

15.1 Assumptions

- Existing attenuation device dimensions, outlets and the channels within the existing developments have been taken from the various supplied modelling reports. Whilst these devices have been inspected on site, and it appeared that these were built as per the plans, the exact details were not measured and confirmed on site. It is therefore assumed that the as-built devices are as per the modelling reports supplied.
- Surveying has been carried out in areas where catchment boundaries were unclear from our site visit and to provide further definition of channel cross-sections. It has been assumed that the cross-section data is representative of the channel in locations between the surveyed cross-sections.
- The vast majority of the existing model cross-sections and elevations from the Lysaghts HEC-RAS model have been retained. It has been assumed that these are accurate and appropriate for this modelling. Some modifications have been made by way of adding cross-sections and adjusting levees and ineffective flow areas during our modelling.
- It has been assumed that the existing culvert and bridge deck levels and dimensions are accurate.
- The downstream boundary condition in the form of a fixed outlet level at the discharge point to the Waipa River has been used. These (100 year and 10 year levels) have been taken from the existing Lysaght model.
- Device initial water levels were set at the Extended Detention level in the 10 year event and empty in the 100 year events. This is similar to the modelling carried out by Aecom.
- A range of more minor assumptions have been made but not included here. These can be provided upon request.

15.2 Exclusions

- We have not determined drain down times for each of the proposed devices in terms of whether die-off of vegetation will occur. This should be assessed at detailed design. It is possible that wetland planting (which can handle extended periods of being wet) may be required if drain down times are longer than approximately 72 hours.
- No formal flood hazard assessment and mapping has been carried out. The attached flood maps are simply a flood extent laid over an aerial photograph. To carry out a flood hazard assessment and mapping exercise, a 2D model would be required.
- Plus exclusions noted in the IFS document dated 11/05/2016.

16 Future Actions

- Update model if LiDAR is flown in the future.

17 Glossary

ARI Average Recurrence Interval, or return period

ED Existing Development

MPD Maximum Probable Development

18 References

AECOM, 2013. Mangaheka Catchment Management Plan. 30 Aug 2013, Ref 60273984.

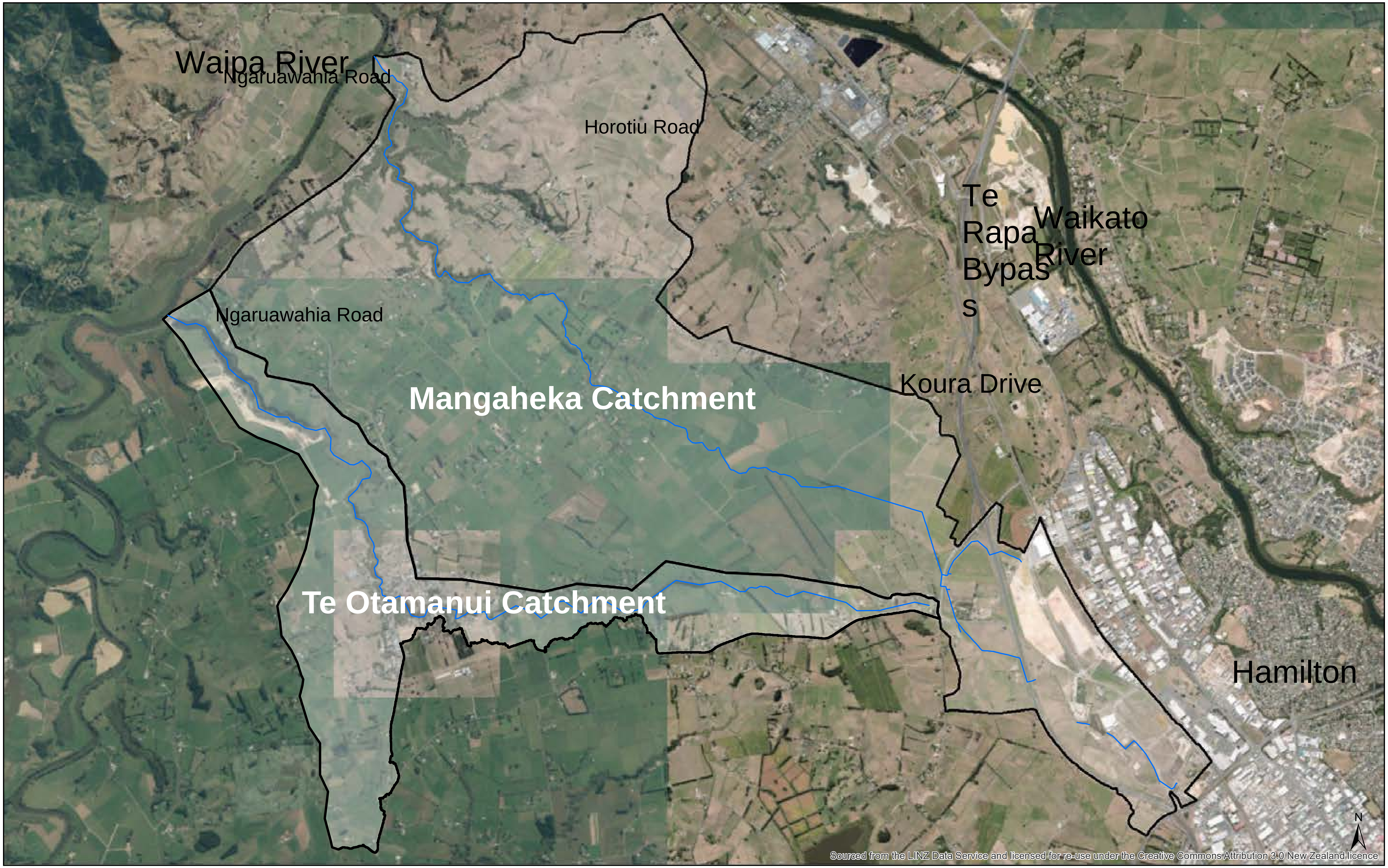
Beca, 2017. Te Otamanui Fatal Flaw Assessment, CH2M Beca Ltd. May 2017.

Hamilton City Council, 2013. Standard Stormwater Modelling Methodology. 1 May 2013, Ref D-974909.

Lysaght, 2012. Te Rapa North Industrial Development Stormwater Modelling – Discharge Consent. Lysaght Consultants Limited, 23 Nov 2012, Ref 112196.

Appendix A

Catchment Overview Plan



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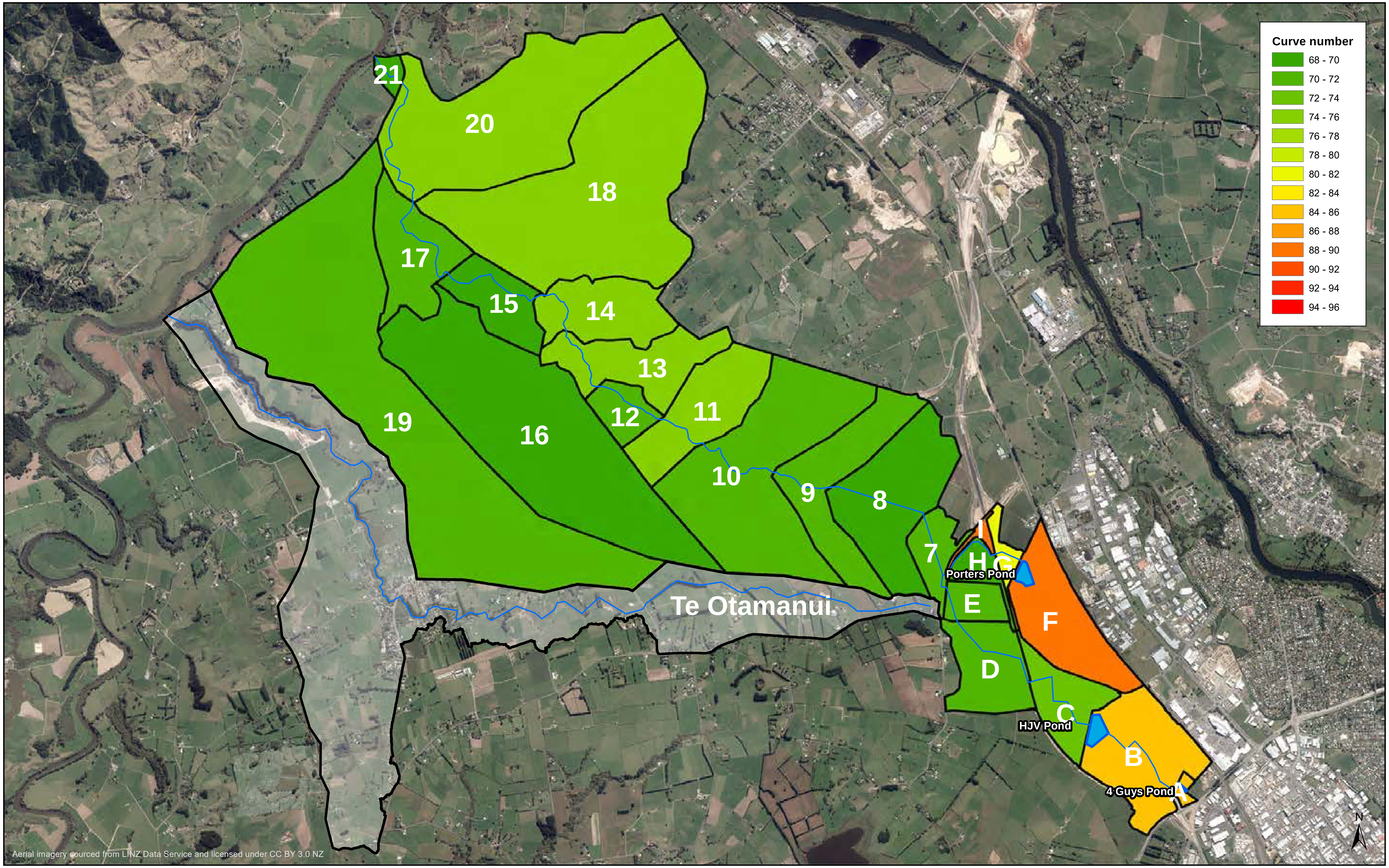
Appendix B

Catchment and Device Plans



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PROJECT TITLE

MANGAHEKA EXISTING* DEVELOPMENT CATCHMENT BOUNDARIES

*CURRENTLY CONSENTED

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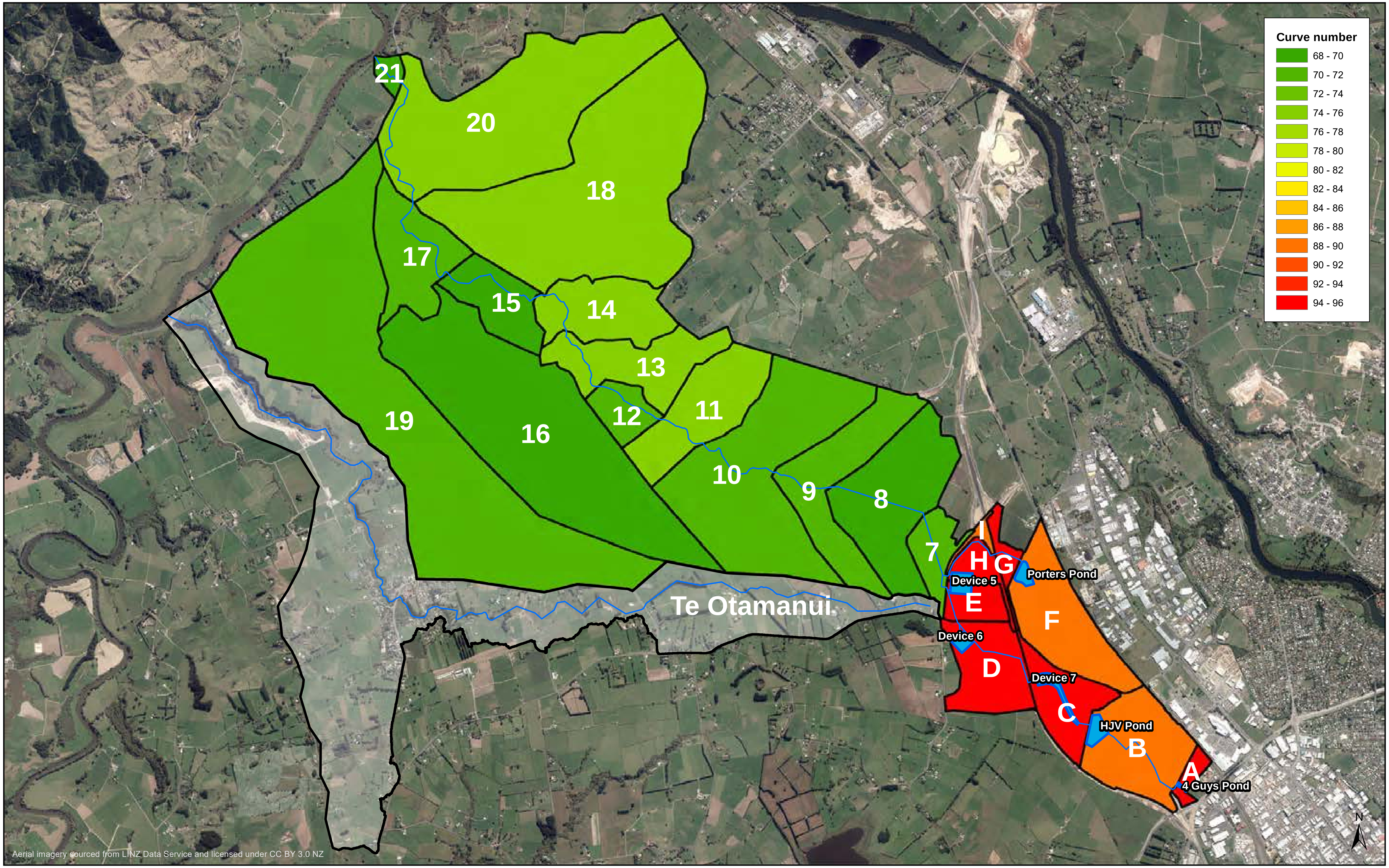

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PROJECT TITLE

MANGAHEKA MAXIMUM PROBABLE DEVELOPMENT CATCHMENT BOUNDARIES

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Appendix C

Catchment Characteristics

ED Catchment Characteristics

Catchment	Area (km^2)	Weighted SCS Curve Number	Percent Impervious	Time of Concentration
A	0.0325	87.4	63.3%	13
A0	0.0377	69.0	0.0%	41
B	0.7499	85.7	57.7%	87
C	0.3835	73.4	15.0%	61
D	0.4936	71.4	5.0%	61
E	0.1730	71.9	10.0%	48
F	0.6990	89.6	70.9%	67
G	0.0951	80.6	40.0%	34
H	0.1391	70.5	5.0%	65
I	0.0411	89.3	70.0%	25
7	0.2349	70.5	5.0%	98
8	0.9553	71.4	5.0%	92
9	0.7650	72.2	5.0%	90
10	1.7631	72.5	5.0%	80
11	0.6866	76.5	5.0%	64
12	0.2195	71.1	5.0%	99
13	0.6087	75.4	5.0%	74
14	0.5629	75.6	5.0%	61
15	0.4046	70.5	5.0%	142
16	2.5500	70.7	5.0%	136
17	0.5928	71.6	5.0%	66
18	2.6593	76.4	5.0%	160
19	4.0947	70.9	5.0%	278
20	2.0190	77.0	5.0%	90
21	0.0672	70.5	5.0%	53

MPD Catchment Characteristics

Catchment	Area (km^2)	Weighted Curve Number	Percent Impervious	Time of Concentration
A	0.0702	95.1	90.0%	22
B	0.6674	88.6	67.6%	81
C	0.3836	95.4	91.0%	53
D	0.4936	95.5	91.0%	47
E	0.1730	95.4	91.0%	36
F	0.6990	89.6	70.9%	67
G	0.0951	95.4	91.0%	34
H	0.1391	95.4	91.0%	49
I	0.0411	89.3	70.0%	25
7	0.2349	70.5	5.0%	98
8	0.9553	71.4	5.0%	92
9	0.7650	72.2	5.0%	90
10	1.7631	72.5	5.0%	80
11	0.6866	76.5	5.0%	64
12	0.2195	71.1	5.0%	99
13	0.6087	75.4	5.0%	74
14	0.5629	75.6	5.0%	61
15	0.4046	70.5	5.0%	142
16	2.5500	70.7	5.0%	136
17	0.5928	71.6	5.0%	66
18	2.6593	76.4	5.0%	160
19	4.0947	70.9	5.0%	278
20	2.0190	77.0	5.0%	90
21	0.0672	70.5	5.0%	53

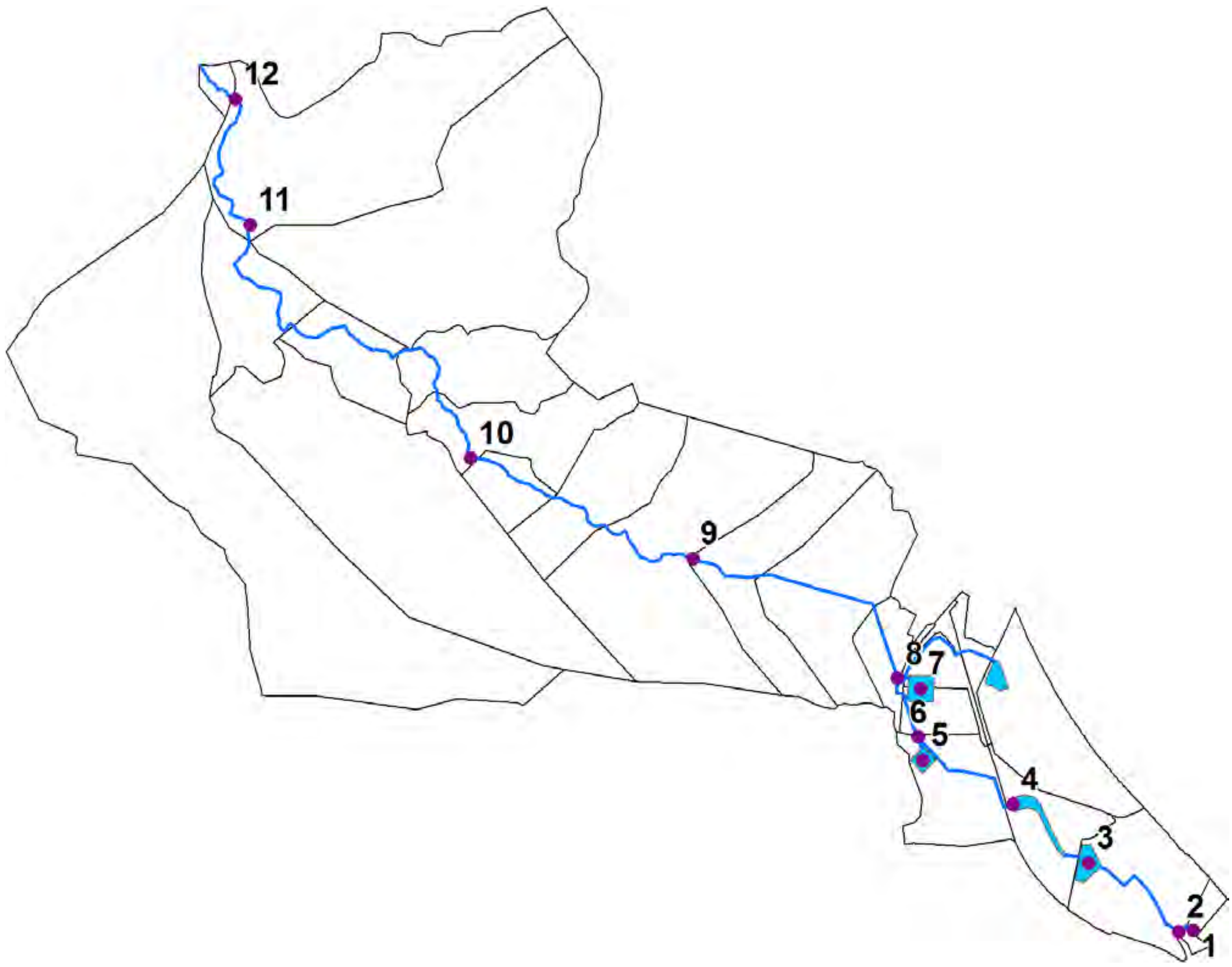
Appendix D

Reporting Locations

Reporting location descriptions

Location Label	Channel	Chainage	Description
1	n/a	n/a	4 Guys Pond (stage or outflow rate)
2	HJV Drain	11764	Immediately upstream of culvert under Arthur Porter Drive
3	n/a	n/a	HJV Pond (stage or outflow rate)
4	Mangaheka Stream	9963.79	Immediately downstream of Device 7 bund, but upstream of culvert under Waikato Expressway
5	n/a	n/a	Device 6 (stage or outflow rate)
6	Mangaheka Stream	9026.23	Immediately downstream of Device 6 outflow but upstream of culvert under Te Kowhai Road
7	n/a	n/a	Device 5 (stage or outflow rate)
8	Mangaheka Stream	8584	Immediately downstream of junction between Mangaheka Stream and Porters Drain
9	Mangaheka Stream	6662.78	Downstream end of catchment 9
10	Mangaheka Stream	4695.33	Immediately upstream of culvert under Horotiu Road
11	Mangaheka Stream	1524.27	Downstream of catchment 18 inflow hydrograph
12	Mangaheka Stream	373.54	Immediately upstream of culvert under Ngaruawahia Road

Reporting Locations



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PROJECT TITLE

MANGAHEKA MAXIMUM PROBABLE DEVELOPMENT CATCHMENT BOUNDARIES CLOSE UP

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CAD PROJECT FILE NUMBER

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Metres

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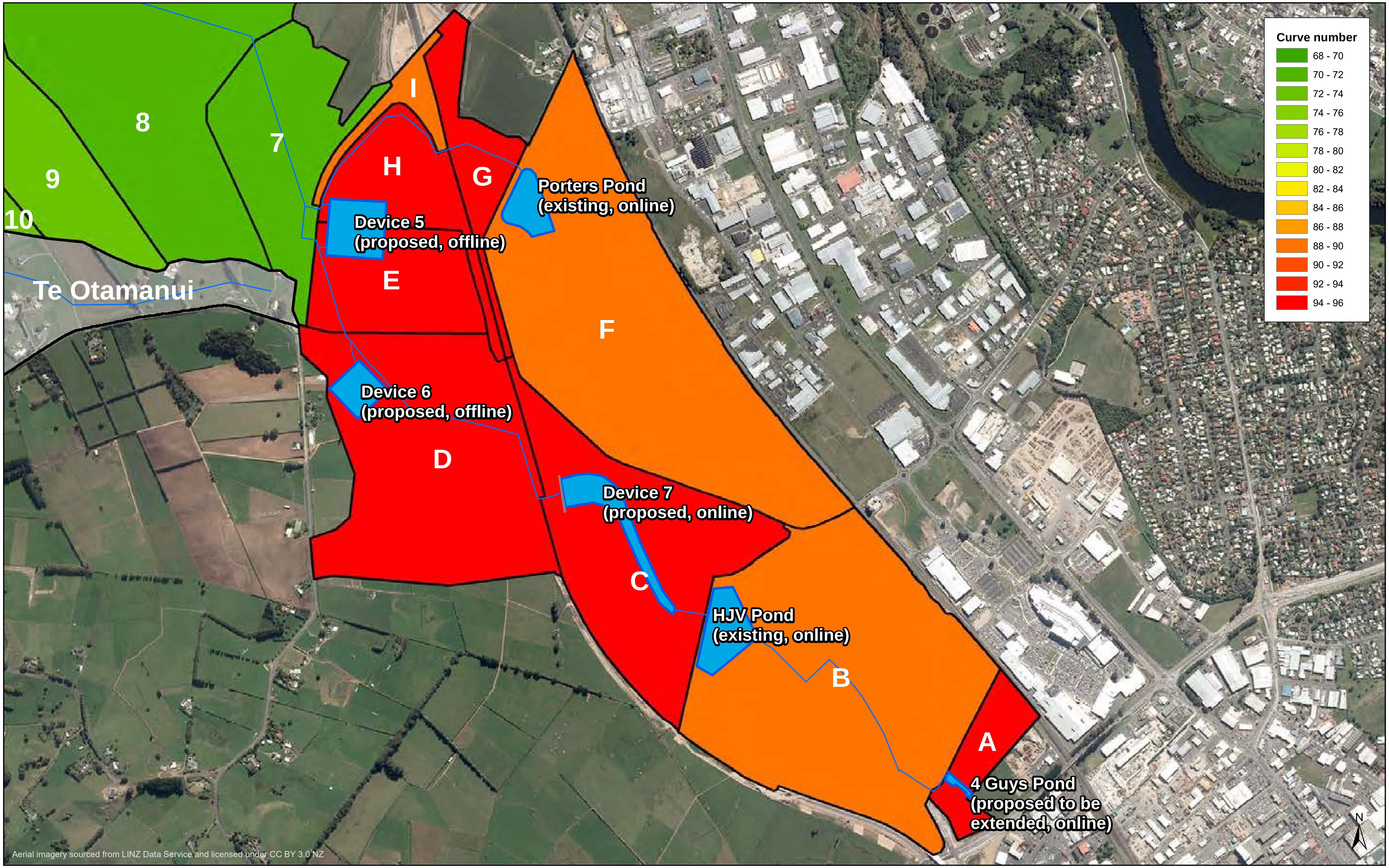
Appendix E

Proposed Mitigation Device Locations



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PROJECT TITLE
MANGAHEKA MAXIMUM PROBABLE DEVELOPMENT PROPOSED MITIGATION DEVICES

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Appendix F

Holdpoint email summarising pond configurations

Angela Pratt

From: Angela Pratt
Sent: Thursday, 6 October 2016 9:26 p.m.
To: 'Emily Reeves'
Cc: Reuben Ferguson; Melissa Slatter; Andrea Phillips; Cameron Oliver; Elliot Tuck
Subject: FW: Mangaheka 1D Modelling - MPD Holdpoint
Attachments: 10.2015.8149 - Engineering Design Plans & Reports - Z Energy - 77 Tasman... 21.pdf; Mangaheka revised catchment MPD.pdf; Device Locations MPD.pdf

Hi Emily,

We are hoping to get into the MPD modelling shortly, therefore in accordance with our IFS, below is the details of the proposed MPD modelling that requires your approval before we proceed. Are you able to confirm you are happy with this information? I am happy to discuss any of the details. I am out of the office tomorrow, but feel free to ring Cameron Oliver or Elliot Tuck if you have any questions (03 3663521).

Assumptions

- The Sharkfin area has been modelled in the Existing Development scenarios but this will discharge to the Rotokauri catchment when the area is developed. This has been discussed and agreed with Andrea Phillips.
- Catchment D has been included in ED modelling and will continue to in the MPD modelling however some of this area may discharge to Rotokauri when it is developed. We have included this area in our model to be conservative.

Runoff Characteristics (Imperviousness)

Catchment Summary

Catchment	Existing Development			Maximum Probable Development		
	Area ha	Imperviousness	Curve Number	Area ha	Imperviousness	Curve Number
A	3.3	63%	87.4	7.0	90%	95.1
B	78.8	55%	84.9	66.7	68%	88.6
C	38.4	15%	73.4	38.4	91%	95.4
D	49.4	2%	70.5	49.4	91%	95.5
E	17.3	10%	71.9	17.3	91%	95.4
F	69.9	71%	89.6	69.9	71%	89.6
G	9.5	40%	80.6	9.5	91%	95.4
H	13.9	3%	69.9	13.9	91%	95.4
I	4.1	70%	89.3	4.1	70%	89.3
7	23.5	5%	70.5	23.5	5%	70.5
8	95.5	0%	70.0	95.5	0%	70.0
9	76.5	0%	70.8	76.5	0%	70.8
10	176.3	0%	71.2	176.3	0%	71.2
11	68.7	0%	75.3	68.7	0%	75.3
12	22.0	3%	70.6	22.0	3%	70.6
13	60.9	2%	74.7	60.9	2%	74.7
14	56.3	0%	74.4	56.3	0%	74.4
15	40.5	0%	69.0	40.5	0%	69.0
16	255.0	1%	69.5	255.0	1%	69.5
17	59.3	0%	70.2	59.3	0%	70.2
18	265.9	1%	75.5	265.9	1%	75.5
19	409.5	3%	70.3	409.5	3%	70.3
20	201.9	0%	75.9	201.9	0%	75.9
21	6.7	0%	69.0	6.7	0%	69.0
Total	2102.8			2094.6		

- In terms of the main catchments to be developed at MPD (C,D,E,G, and H), we have used 91% Impervious. This assumes that 10% of the catchment is roads (95% Impervious)and 90% is Industrial (90% Impervious). As an average this is 90.5% Impervious (91% used).
- Note that catchment A and B are already partly developed so I have taken an average of the ED % impervious and the percentages stated above for the portion to be developed.

Catchment Boundaries

Attached is a plan with the MPD catchment boundaries. Of particular note is:

-the Giles block (north-east of 4 guys) is now in catchment A (rather than B)

-the sharkfin has been removed (as above)

-the area at the south end of Arthur Porter Drive goes into another system according the HCC GIS. The catchment boundary here has been changed for both MPD and ED.

Proposed Device Locations (See attached plan)

I have discussed this with Andrea, and subject to the MPD (without mitigation) modelling proving that mitigation is required, we propose to model the following attenuation systems: (Note that generally treatment would need to be onsite/at source and is not dealt with at all in this modelling)

Device 5 (Catchment E, H and possibly G) – This land has multiple owners. They would likely need to work together to build an attenuation system.

For the purposes of modelling, we propose one large offline attenuation pond just upstream of the two Koura Drive culverts. This would serve the three catchments but the triangle of land west of the stream (next to Koura Drive roundabout) and catchment G would not discharge into it ie it would over-attenuate catchments E and H.

Device 6 (Catchment D) - As this whole area of land is owned by a single owner, there are a few options for developing the site:

- An attenuation system on either side of the stream
- A combined attenuation system on one side only (SW) that attenuates the whole catchment i.e. larger to attenuate whole catchment but with only part of the catchment (SW part) draining to it. Plus, there would need to be separate treatment on both sides of the stream
- Move the stream north so that the whole catchment can be treated and attenuated in one system.

For the purposes of modelling, we have sized one large attenuation basin which serves the land on both sides of the stream.

Device 7 (Catchment C) – The area of land that this serves is owned by a variety of landowners. They would likely need to work together to build an attenuation system. It is also logical here to realign/naturalise the stream given the angular drain/stream alignment and create a low flow channel and higher/wider flood plain.

For the purposes of modelling, we will size one large online attenuation basin which serves the land on both sides of the stream. We will also test whether the existing culvert is enough of a throttle or if a formal outlet pipe/weir arrangement is required.

Device 8 (Catchment A) - This has already been sized to provide attenuation for the 4 Guys car yard, the Z energy petrol station and the piece of land north of the pond (Total area 3.5ha- See attached plan). This pond could be made larger to manage the Giles (ex Hooker) land to the north.

For the purposes of modelling, we will increase the size of the existing pond to manage the Giles land to the north. This area will therefore also shift from catchment B to catchment A.

Deviations from Modelling Specification

No new deviations from those approved for the ED modelling.

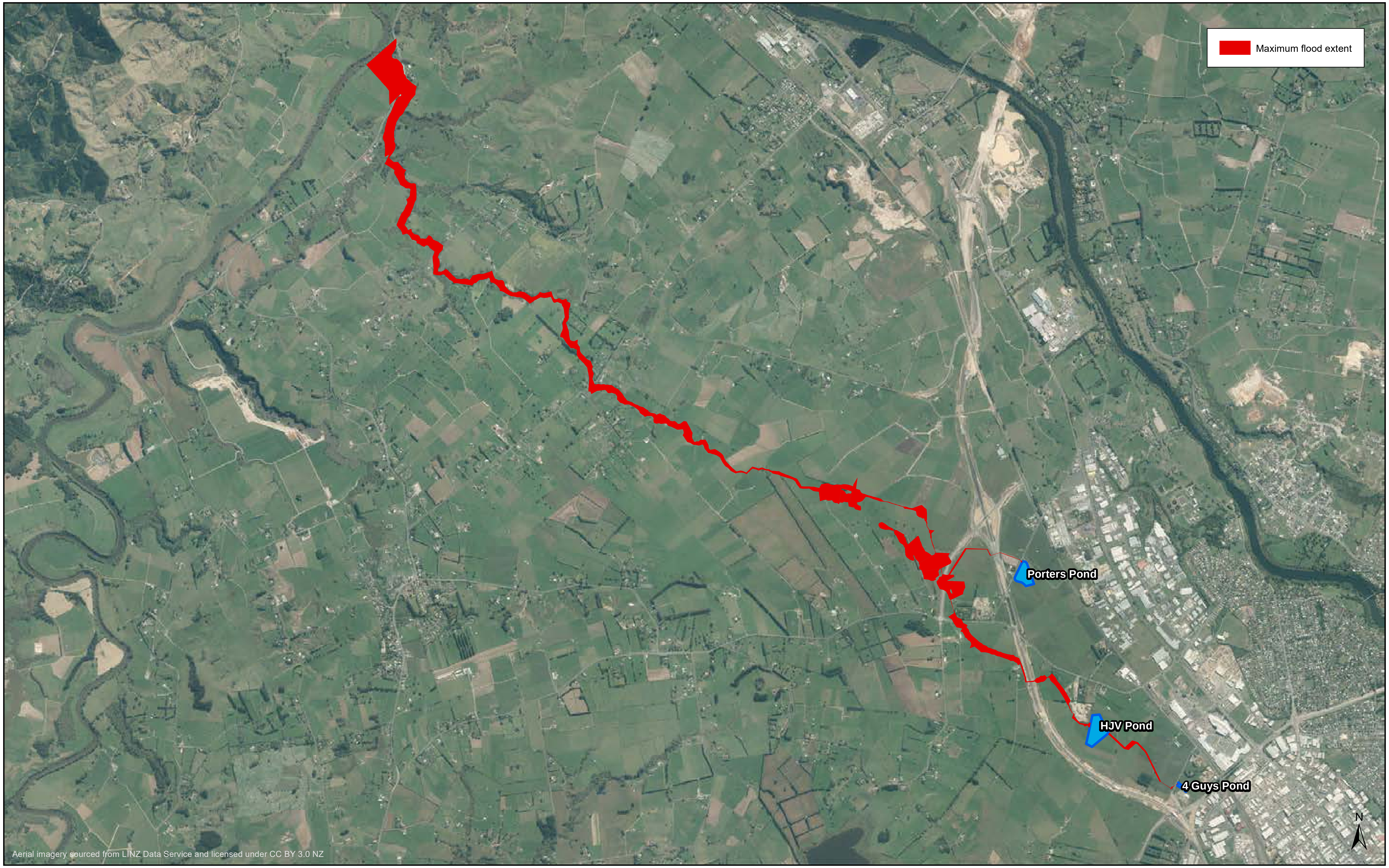
Angela Pratt
Senior Environmental Engineer
Beca

DDI +64 3 374 3197
angela.pratt@beca.com
www.beca.com

Note: My working hours are Monday, Wednesday and Friday 8.30am until 4pm.

Appendix G

Flood Maps – 100 year



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PROJECT TITLE

MANGAHEKA FLOOD EXTENT EXISTING DEVELOPMENT 100 YEAR ARI

DRAWING TITLE

FOR INFORMATION ONLY

CONTRACT NUMBER

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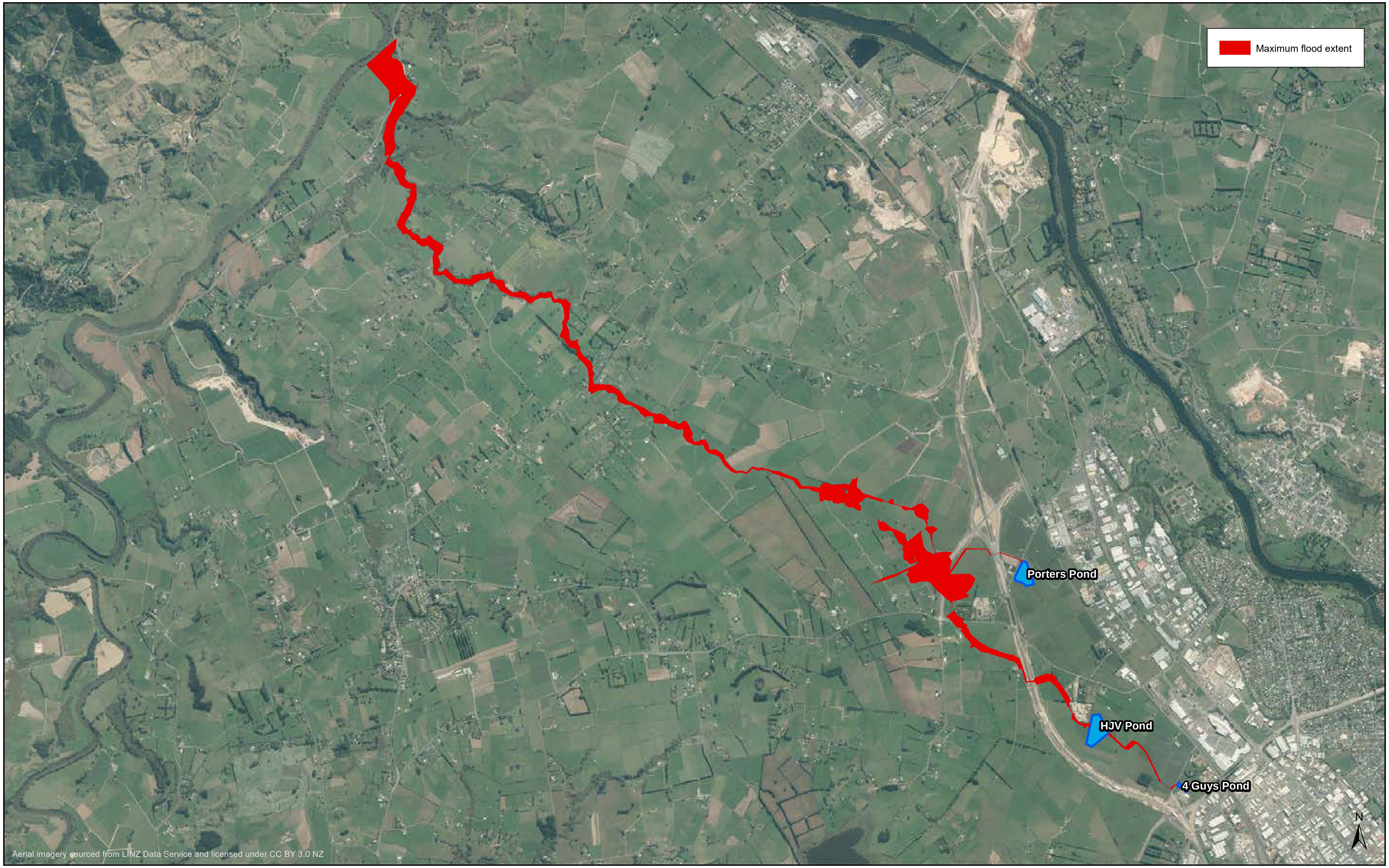

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PROJECT TITLE

MANGAHEKA FLOOD EXTENT EXISTING DEVELOPMENT 100 YEAR ARI CLIMATE CHANGE

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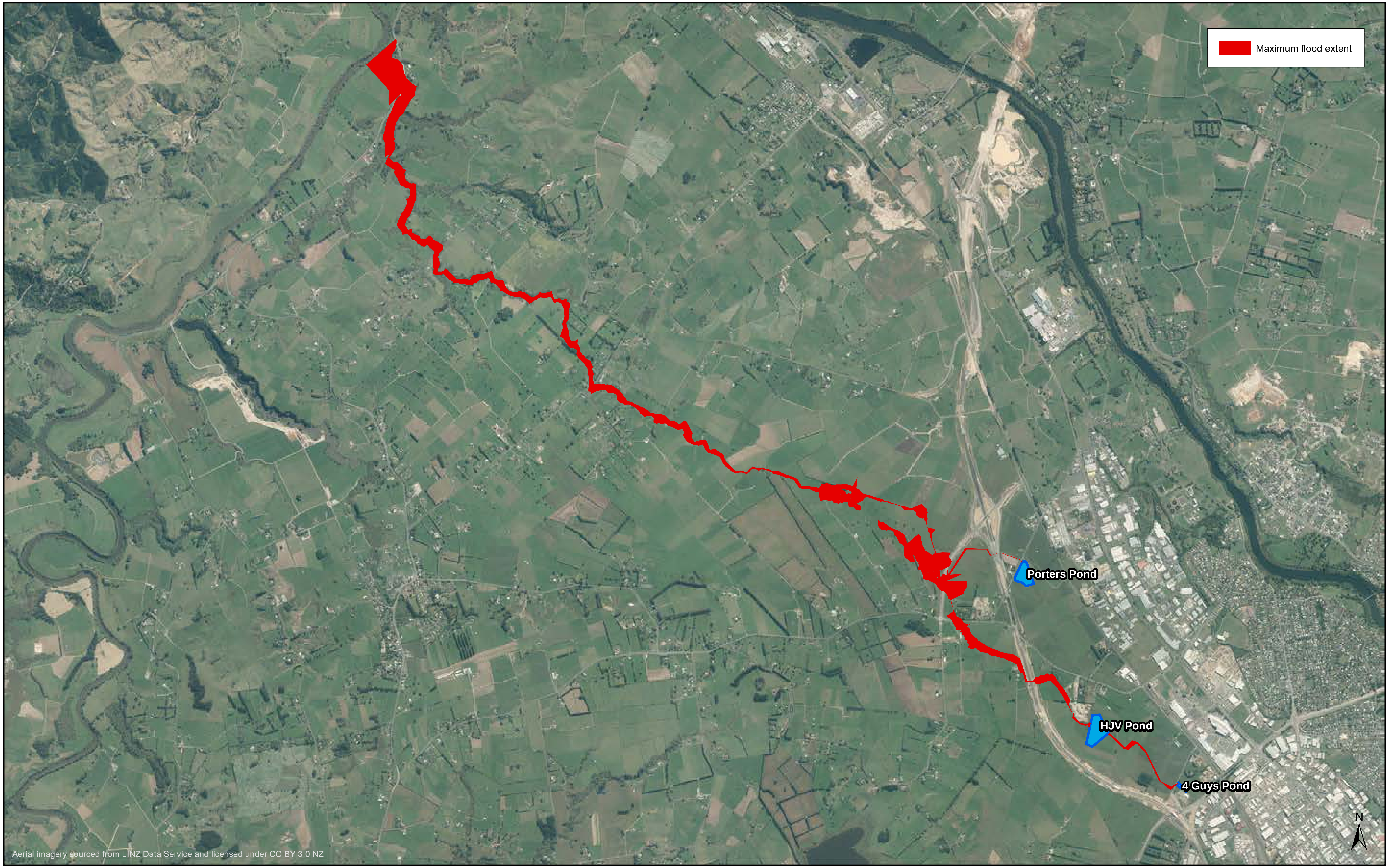

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DATE	SIGNED

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CONSULTANT FILE REF.

PROJECT TITLE

MANGAHEKA FLOOD EXTENT MAXIMUM PROBABLE DEVELOPMENT 100 YEAR ARI

DRAWING TITLE

FOR INFORMATION ONLY

CONTRACT NUMBER

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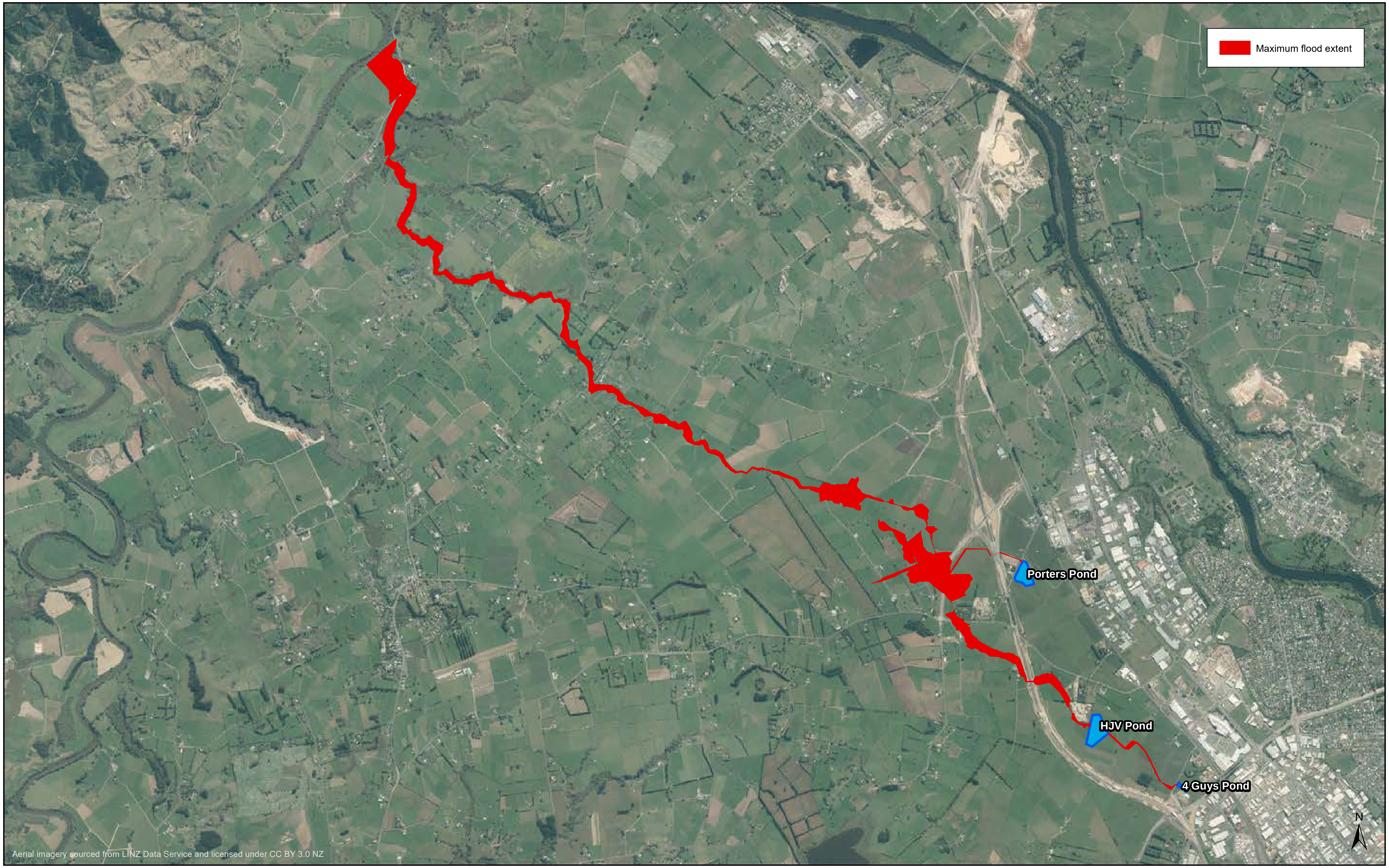

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PROJECT TITLE

MANGAHEKA FLOOD EXTENT MAXIMUM PROBABLE DEVELOPMENT 100 YEAR ARI CLIMATE CHANGE

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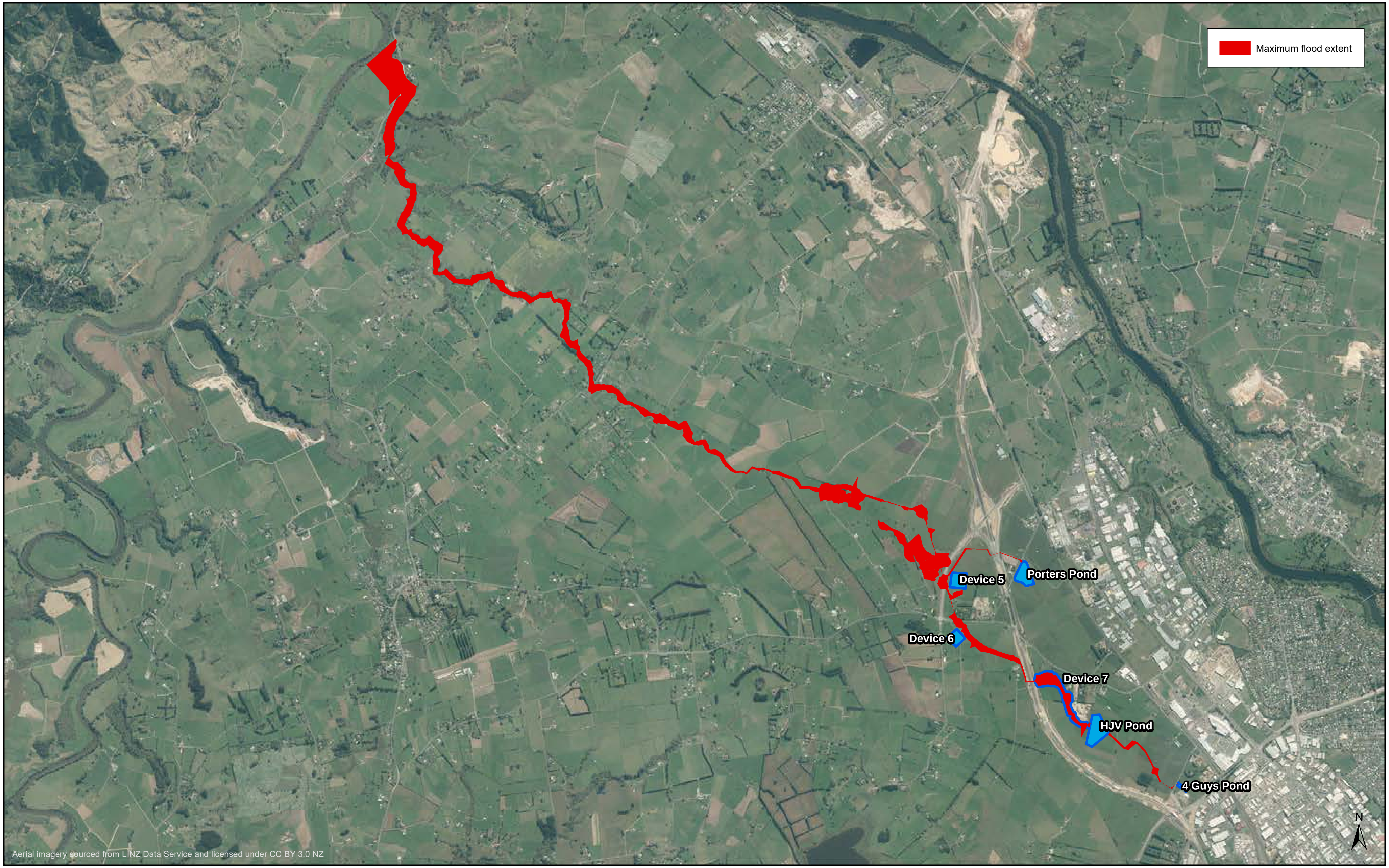

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PROJECT TITLE

MANGAHEKA FLOOD EXTENT
MPD 100 YEAR ARI CLIMATE CHANGE
WITH PROPOSED MITIGATION

DRAWING TITLE

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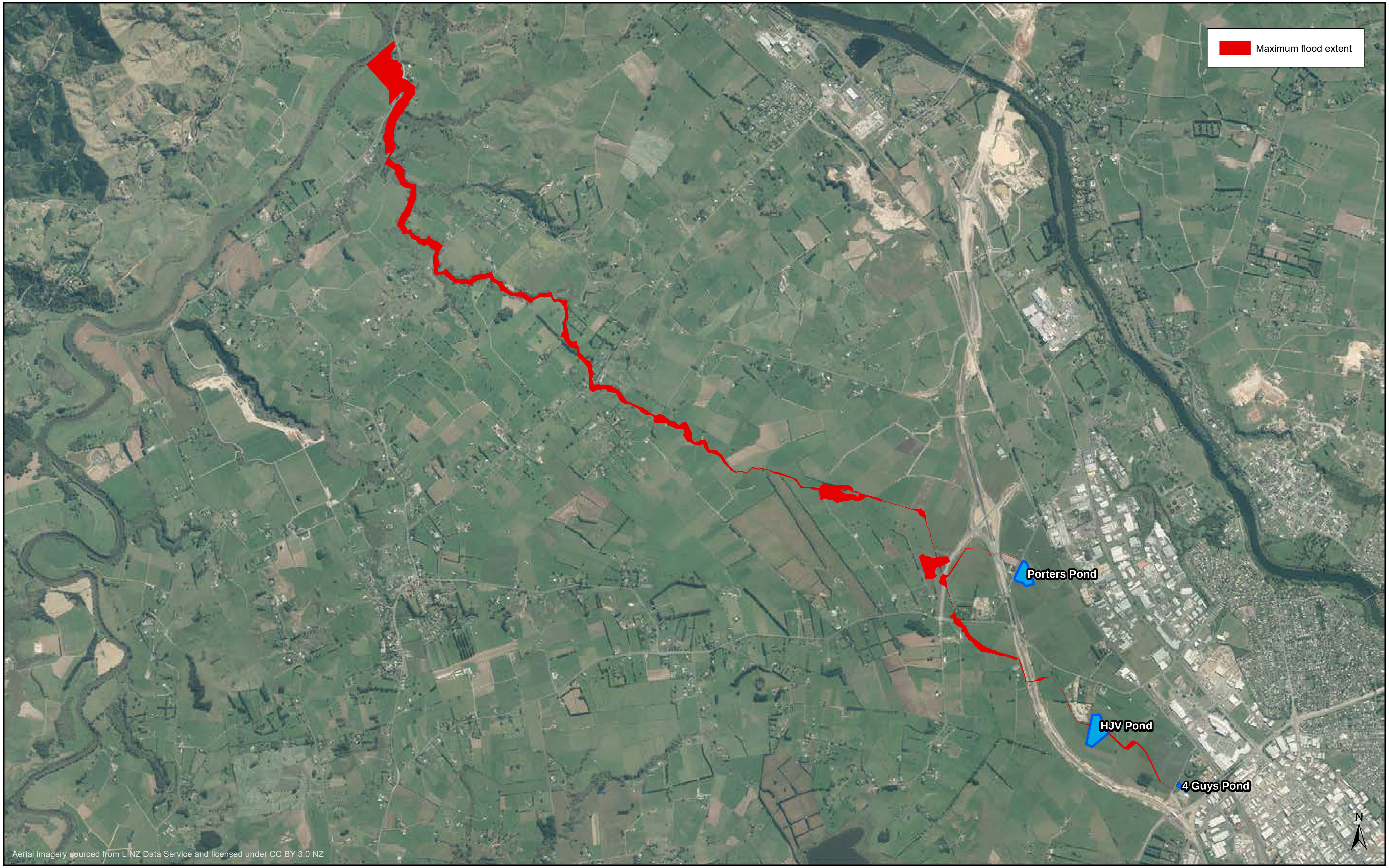
Appendix H

Flood Maps – 10 year



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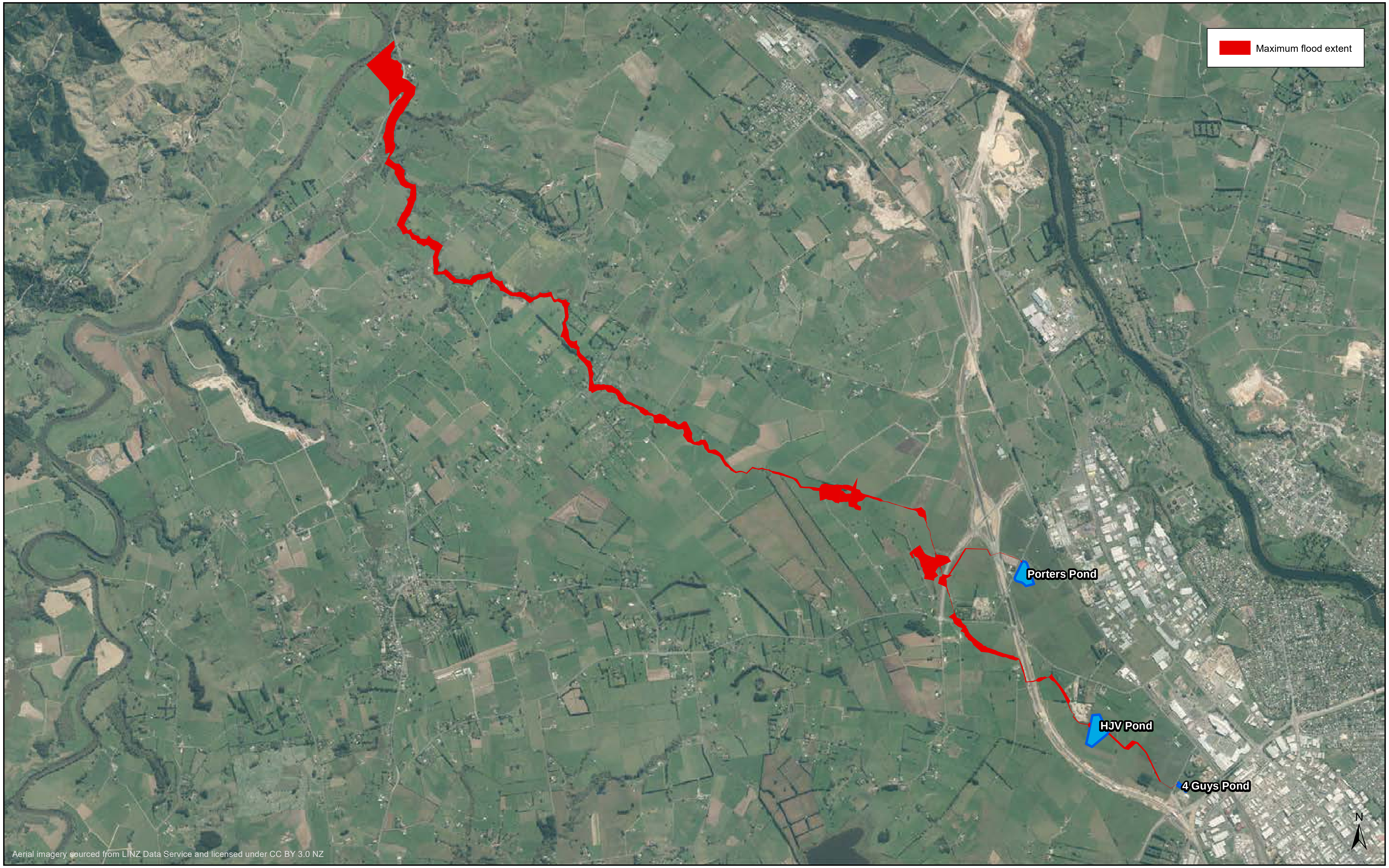

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PROJECT TITLE

MANGAHEKA FLOOD EXTENT EXISTING DEVELOPMENT 10 YEAR ARI CLIMATE CHANGE

DRAWING TITLE

FOR INFORMATION ONLY

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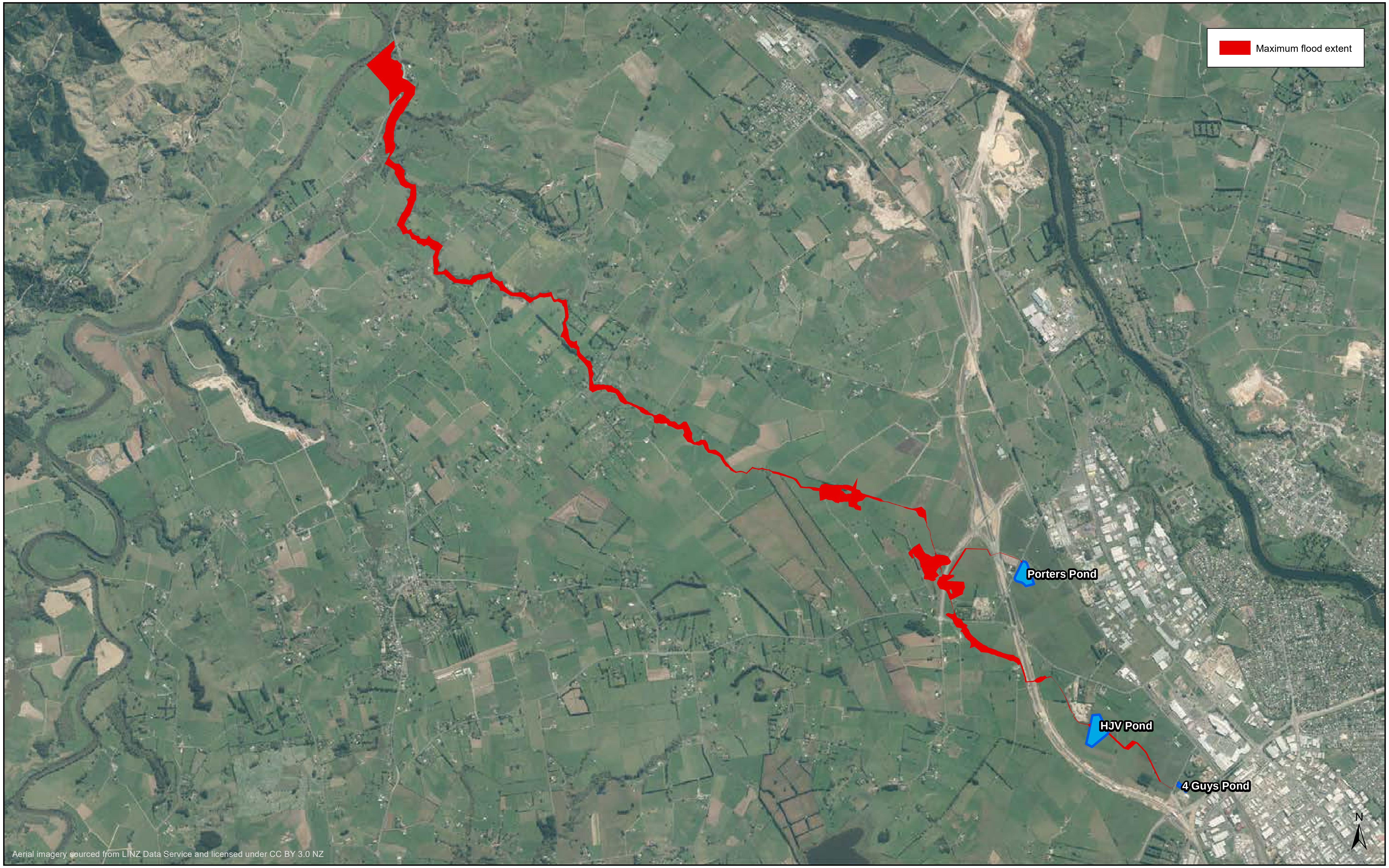

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MANGAHEKA FLOOD EXTENT MAXIMUM PROBABLE DEVELOPMENT 10 YEAR ARI

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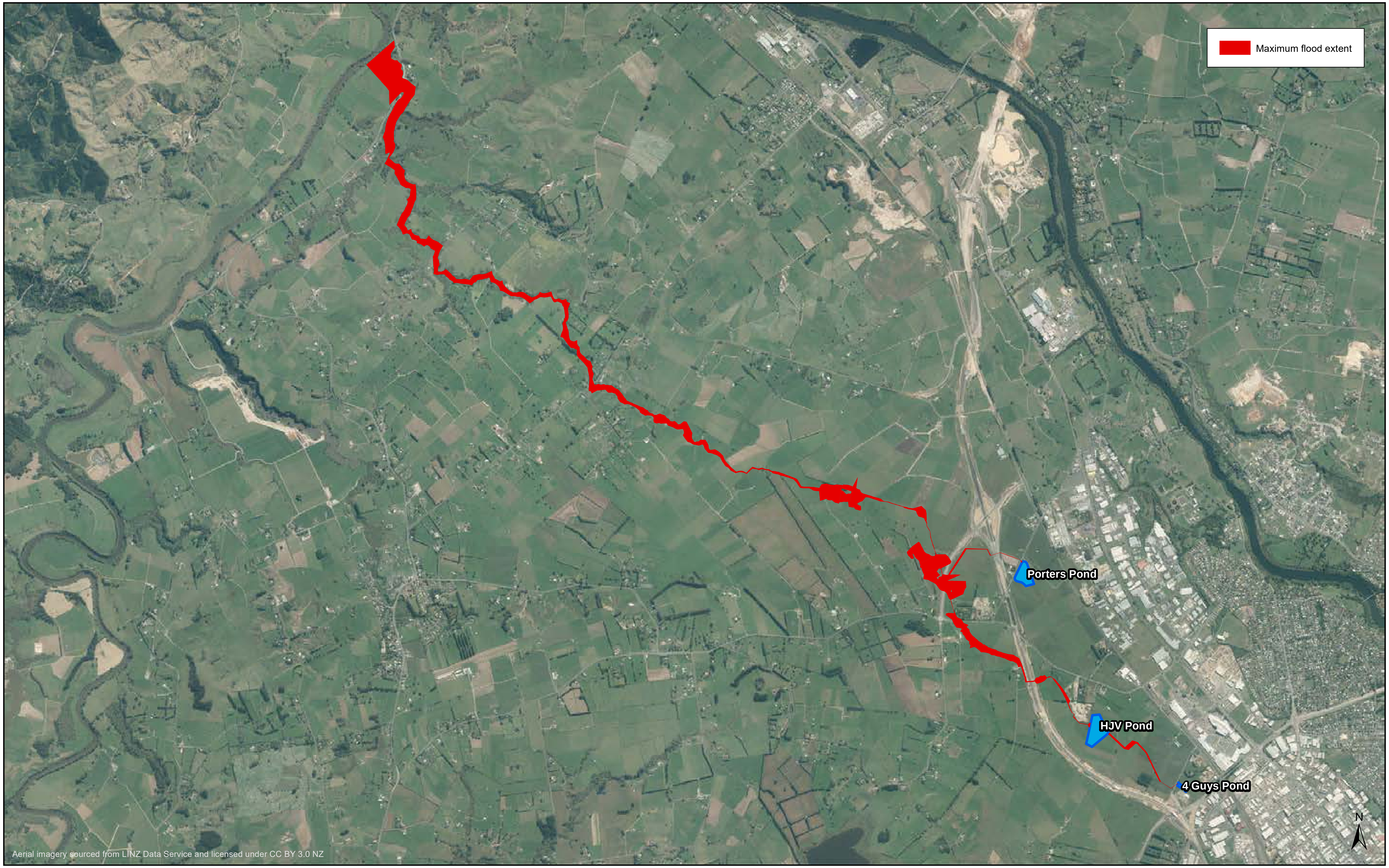

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PROJECT TITLE

MANGAHEKA FLOOD EXTENT
MAXIMUM PROBABLE DEVELOPMENT
10 YEAR ARI CLIMATE CHANGE

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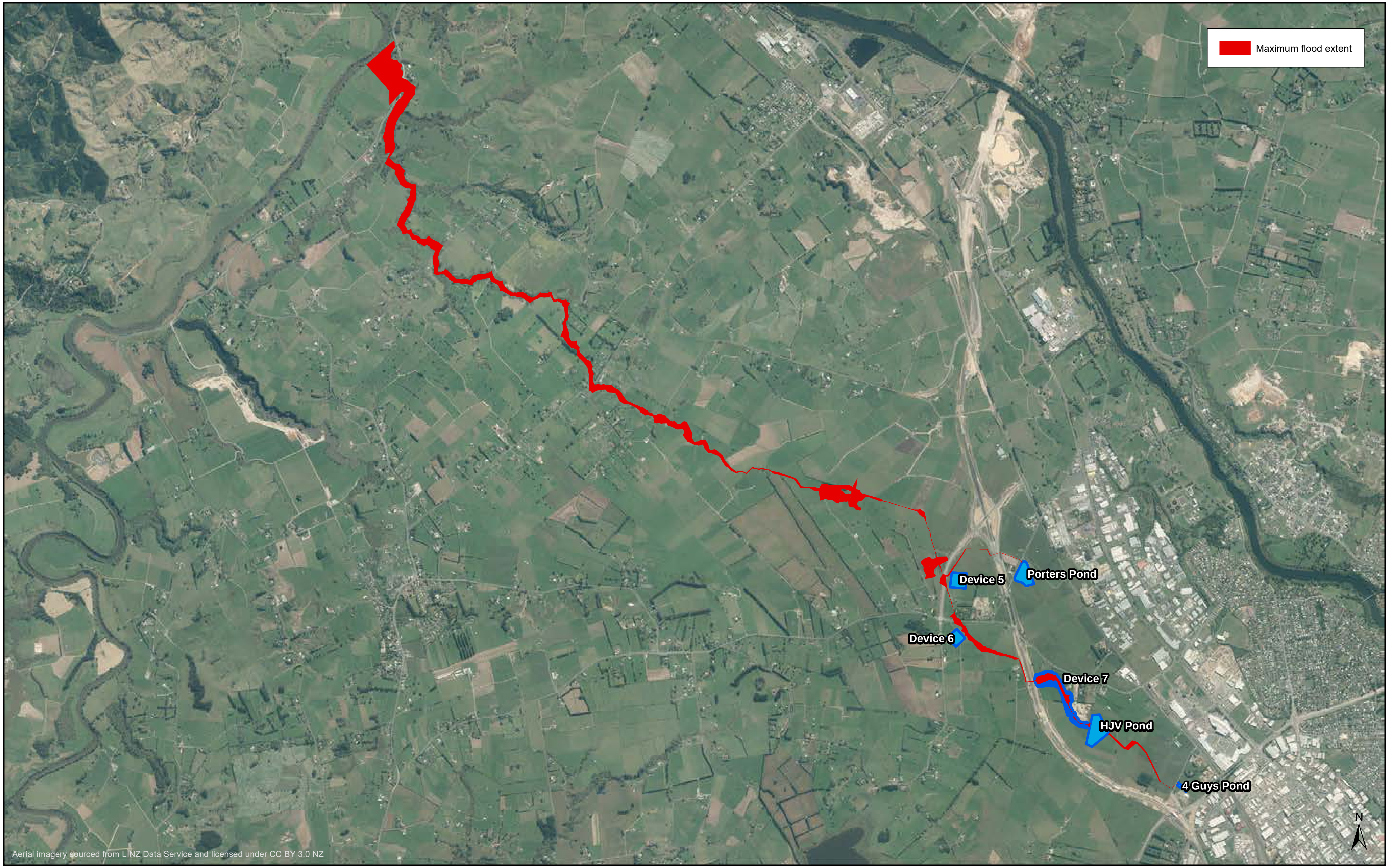

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PROJECT TITLE

MANGAHEKA FLOOD EXTENT MPD 10 YEAR ARI CLIMATE CHANGE WITH PROPOSED MITIGATION

DRAWING TITLE

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Appendix I

Peer Review Comments and Responses

Item	Reference	MEL comment	Beca comment	MEL response	Beca further response
1	General	Some background to the hydrological modelling underpinning the reported work would provide useful context, including specification of software used (understood to be HEC-HMS) and related assumptions. Similarly, further information on e.g. channel roughness values adopted, calculation of time of concentration, etc. would also provide useful context.	We agree that it would be useful to include this information.		Section 3.1, 3.4 and 3.7 of the report have been added to discuss the use of HEC-HMS and other inputs.
2	General	Mitigation targets were specified in the initial IFS as 80% of ED peak flows, and in the subsequent IFS as maintaining (i.e. 100%) existing water levels. It appears from Table 7 and Table 12 that the required flow reductions to meet the water level targets are in fact variable (and that water levels rather than peak flow rates are the parameter of interest). Could you please clarify the mitigation targets and reasoning behind them, e.g. why maintaining a particular peak flow does not result in maintaining the corresponding water level?	Section 2 states the overarching objectives of the modelling however more specifically, mitigation targets (provided in Table 7) are of three types: a) maximum pond levels to prevent overtopping, b) maximum 100-yr pond outflow rates equal to 70% of ED peak flows for the catchments being attenuated, and c) maximum water levels downstream of ponds, to ensure that water is no higher than in ED ie no additional flooding (extent or depth). Target b) is achieved for all devices. In general, b) would imply that c) is satisfied, however (with the exception of Device 6) this is not the case in the Mangaheka model. Flat gradients and coincidence of flows mean that achieving b) alone was not enough to mitigate effects. Additional attenuation wass requried to achieve target c). This results in peak flows less than 70% of ED. Therefore c) is the limiting factor for Devices 5 and 7 as well as 4 Guys pond upgrades. For Device 6, achieving target b) also resulting in target c) being met.		
3	General	The rationale for making detention devices either online or offline is not stated. While it is understood device positions have previously been agreed with HCC, some justification for the choice of different configurations would be welcome.	The rationale for deciding whether devices were offline or online was primarily based on land ownership. For devices servicing catchments which were generally one or two land owners, it was seen as easier to have one device as the developers could construct such devices themselves. For devices servicing multiple land owners, it was seen as better to have an online device which most lots could easily discharge to and would likely be constructed by Council. Development contributions would be charged to each landowner who develops. The online device (Device 7) also offers an opportunity to enhance/realign an existing waterway which is quite unnatural in alignment. Although note that for simplicity our modelling only utilises the existing landforms, with a modified (higher overflow level and smaller culvert size) existing culvert at the downstream end to control flows more appropriately. The alignment of the proposed basin could be modified to suit landowners at the time of development. If the existing landform were utilised, there is sufficient storage available within the existing flood plain, therefore not requiring major earthworks.		
4	General	The relative positions of the devices and reporting locations are not very clear on Figure 1. While it is acknowledged that the locations are described in Table 18, a large scale map (similar to Figure 9) would assist with interpreting the mitigation targets in Table 7 by showing the reporting locations in relation to each device. A map showing all the road names and other topographic features referred to in the text would also assist in understanding the modelling.	We agree, we will add a plan showing reporting locations to Appendix C. We will also add a "Catchment Overview" section which describes the catchments, roads and streams.		Section 3 has been added to include a catchment overview. Appendix A also provides a catchment overview plan showing road and river name labels. Appendix 3 provides a clearer plan of the reporting locations.
5	General	Do the reporting locations correspond to HEC-RAS cross-section locations or other model elements?	Reporting locations are first described in the first paragraph of Section 5. This paragraph refers to a table of HEC-RAS cross-section chainages in Appendix C. Text revised to make this clearer.		
6	Section 3.1 p2	Factoring in the Te Rapa four-laning was stated as an exclusion if not already present in the Lysaght model. Section 3.1 refers to 'minor adjustments' to account for the Te Rapa Bypass motorway. Does this mean the four-laning? A map to show the position of these roads would be useful to help reconcile report references with structures on the ground.	Yes we are referring to the 4 lane Te Rapa Bypass. The Lysaght Model was carried out pre construction of the motorway but had a catchment boundary along the alignment of the road. Now that this is constructed, we could better define which parts of the motorway discharge where, including the Koura Drive interchange, as part of our model. We have added a catchment plan which has an aerial photograph underneath to better see the alignment of the motorway.		
7	Table 1 p3	The IFS states that 8 scenarios will be modelled but Table 1 lists 10 scenarios, the additional ones being unmitigated MPD with non-CC rainfall for both return periods. While it is acknowledged that this provides additional information, that fact that there is no subsequent reference to the results of these scenarios means they could be omitted for simplicity.	After the IFS was agreed, it was realised that it would be necessary to also to include the additional scenarios for completeness i.e so that it would be possible to separate out the effects of MPD (as compared to ED), climate change, as well as the effect of the proposed mitigation. 'MPD 100 yr' appears in figures 3, 4 and 5, and appears in Table 11. 'MPD 10 yr' appears in Tables 4, 5 and 15 as well as, figures 6, 7 and 8.	Understood. The values are useful for comparison but the comment referred to the fact that there do not appear to be any textual references to them (I think), i.e. no interpretation of their significance or relationship to the values of other scenarios?	Comments added to discuss the significance of the additional scenario's.
8	Table 7 p7-8	States "Outflow from Device 6 (Location 5) must be ≤ 0.93 m^3/s … etc.". However, Location 5 has no flow reported in Table 3. If it is instead assumed to be Location 6 (as Catchment D flow), how is 0.93 m^3/s derived?	Table 3 only reports on scenarios that exclude mitigation (Section 6 is entitled "Model Results - Without Mitigation"). Device 6 and its corresponding Location 5 are only present in mitigation scenarios. 0.93m3/s represents 70% of the ED flows from the catchment, which was a conclusion in the Lysaghts model i.e reducing developed flows to 70% of existing will provide sufficient mitigation. This was the starting target for the MPD development, however it was realised that this alone would not mitigate water level increases resulting from MPD (+ CC)	Apologies, I mis-read that and got the tables mixed up.	
9	Table 7 p7-8	No reporting location is given for the outflow from Device 7 in Table 7 to check the mitigation result against. Presumably this is Location 4? It is unclear how the stated 5.70 m^3/s target (70% of ED) for Device 7 is related to the peak flow results in Table 10. Similarly for Devices 5 and 6.	Yes, Location 4. This has been added to text.	Still unclear on second part of comment, i.e. 5.70 m^3/s reported as being 70% of ED100y value. That would imply ED100y peak flow of 8.14 m^3/s which is not apparent in any tables.	Table 7 (8 in updated report) states that 5.7 m^3/s is "equivalent to 70% contribution… from catchment C". That is, only the component of the stream flow that originates from catchment C has been factored by 70%. The 5.7 m^3/s value is calculated by summing 100% of the HJV pond outflow rate with 70% of the catchment C runoff rate. Comment in Table 7(8) modified to make this clearer.

Item	Reference	MEL comment	Beca comment	MEL response	Beca further response
10	Table 7 p7-8	For Devices 5 and 6, mitigated maximum water levels are stated as 29.7 m and 31.2 m, respectively. How are these numbers derived (given that there are no ED equivalents)?	Device 6 text has been appended with "minimum ground elevation in nominal basin location". 29.7 m for device 5 represents a maximum water level of 300 mm lower than ground surface on the eastern side of this pond (as per cross-section elevation data). On the southern side this is 200 mm above immediately adjacent ground surface, but is equivalent to ground surface further upstream (from chainage 8811). This elevation has been chosen to allow for sufficient head difference during flood events.		
11	Table 7 p7-8	Mitigation targets are expressed in terms of the proposed devices rather than the sections of channel between devices which are of interest from a flooding perspective. For example, does Location 4 account for the water level in the channel between Devices 4 and 5?	We presume you mean between device 6 and 7. If so, yes location 4 represents the channel between devices 6 and 7. Table 7 provides a water level target within each device, and downstream of each device. . See last bullet point of each row.	Yes, sorry - I did mean between devices 6 and 7. I'd reiterate the value of a single large-scale map that shows the devices and reporting locations relative to each other (even though this information is provided in text form - just takes a bit more interpretation).	Appendix 3 now includes a clearer plan of reporting locations.
12	Table 9 p9	While it is explained why the mitigated 100-year water level at Location 8 slightly exceeds the ED level, no corresponding note accounts for the even greater exceedance at Location 3. Presumably the mitigated level is being compared to ED 100-year with CC in this case (as appears to be the case for the 100-year flows on p16). Please confirm this is the case.	Correct. Text amended to make this clear.		
13	Table 10 p12	Locations 9-12 show significant increases in peak flow between the ED and mitigated MPD scenarios. This increase is attributed to the effects of climate change (higher rainfall intensity) alone in the undeveloped catchments (as shown in Table 3). It seems rather a large increase - almost 50% in the case of Location 10 - especially given the low catchment imperviousness (much larger percentage differences than for the 10-year event). The corresponding water levels (Table 9) are not substantially higher (are these flows out of the channel?). Can you please confirm that the difference in flow rates between ED 100-year and ED 100-year CC (Table 3) are really that great for Locations 9-12?	For clarity, we have responded to each of the questions/statements separately below.		
13A		The corresponding water levels (Table 9) are not substantially higher.	As mentioned in the report, "Water levels at locations 11 and 12 are influenced by the water level boundary condition set at Waipa River of 16.07 for all 100-year ARI scenarios." The presence of this boundary condition and hence wider flooding extent means that an increase in flow at these cross sections does not change water level significantly. Locations 9 and 10 are immediately upstream of surcharged culverts, which have a similar effect to the downstream water level affecting locations 11 and 12.		
13B		Are these flows out of the channel?	Yes some of the flows are out of the channel. Note also that where flows in the MPD 100 year with CC and mitigation are out of the channel, they are also out of the channel in ED 100yr.		
13C		Can you please confirm that the difference in flow rates between ED 100-year and ED 100-year CC (Table 3) are really that great for Locations 9-12?	Yes these differences are correct and only due to the effect of climate change. The HEC-HMS model has been checked for representative catchment (13) and it was verified that the only variable changed was the selected nested storm. The HEC-RAS model was then checked to see that peak lateral inflows were the same for this catchment. The HEC-RAS peak modelled flows were checked at location 10 (RS 4695.33). The increase in catchment peak flows at MPD + CC are similar to the increase in rainfall depth that climate change produces. Whilst we have not interrogated the model to understand the timing of the peaks from each catchment, we consider that the large increases will likely be a result of coincidence of flows.		
14	Table 10 p12	The mitigated MPD peak flow at Location 1 is nearly twice that of ED but it is stated that the water level criterion is satisfied. This implies an increase in velocity which may lead to other issues. Please confirm the flow and water level values for Location 1.	Reported flow and water level are confirmed to be correct. The stream velocity in the MPD 100 yr with CC scenario at this location is almost three times that of ED 100 yr, but both are very small (significantly lower than 0.1 m/s) and therefore unlikely to lead to erosion. Froude number here is also much less than 1.	Okay. Is it worth reporting velocities alongside their corresponding flows in the report also?	Velocities have been added to Table 10 (now 12), as well as additional discussion on velocities.
15	Table 10 p12	Location 8 also shows a mitigated peak flow in excess of ED but the water level target is stated as being attained. Does this also imply an increase in velocity?	Yes, slightly. Channel velocity at this location is 0.35 m/s for ED 100 yr and 0.41 m/s for MPD 100 yr CC. It is not expected that additional erosion would occur at these velocities.	Okay. Might be worth stating that in the report (as above).	Table 10 is now Table 12. This table now shows that the velocity is lower at MPD after a error was fixed.
16		It would be useful to have a table that directly compares the mitigated MPD flow rates (or water levels) for each reporting location with the particular ED value they are to be compared to, i.e. ED 100-year or ED 100-year with CC. This would enable easier checking of mitigation targets being achieved so that the reader does not have to refer to different tables.	This information is in Table 10.	Specifically I meant the scenario name (i.e. ED100y or ED100yCC) rather than the actual value. e.g. for Location 3, a glance at Table 10 gives the impression that the target is not met, until you read the note at the bottom that says the target was the ED100yCC value rather than the ED100y value. It was just a thought that occurred to me while initially comparing the various ED and mitigated MPD values and having to flick between tables.	Table 8 modified and Table 13 added to explan the attenuation targets better.
17	Figure 4 p11	Long-section shows mitigated MPD water level to be above all other scenarios between the HJV pond and the Waikato Expressway. Does this represent the maximum water level in Device 7 (approx. 700 m long)?	Yes this is the location of Device 7 therefore it is expected that the water level will be higher than ED given that attenuation is occurring in this area. This is seen in the long section as the device is online.		
18	Section 8.1.1 p12	Porters Drain flows are stated as being mitigated by Device 5. Figure 9 appears to show the Porters Drain flows discharging to the Mangaheka channel downstream of Device 5. Could you please confirm the hydraulic relationships between the channels and device, and that Device 5 receives all flows from Catchments E, G and H.	Yes you are correct, Porters Drain does enter Mangaheka Stream downstream of Device 5. Device 5 over-attenuates flows from catchment E and H (As stated in Table 6) thus also providing mitigation for catchment G. This was done because the developable area (parts not within the Te Rapa Bypass designation) of catchment G is small and the stream runs through the centre of the developable area. This mean that it would likely be difficult to configure a device in this location. The text has been amended to make this clearer.		

Item	Reference	MEL comment	Beca comment	MEL response	Beca further response
19	Section 8.1.3 p12	"Drain down time" appears to refer to the duration of overbank spilling (but not necessarily draining from the floodplain) rather than emptying of the detention devices following the particular design event. Or does it refer to overtopping of low flow channels within the detention basins? If it does not refer to the emptying of the devices themselves, this would be useful information to have. While perhaps out of scope, the duration of sustained high flow from the device outlets is important from an ecological perspective.	We have defined drain down time as the length of time water is outside of the stream bank and in the floodplain. As mentioned in section 2, Objective 5, it is important to farmers and Waikato Regional Council that farmland is not flooded for longer than 72 hours, hence it was the "farmable" ie floodplain land that we were assessing in terms of length of flooding. That said, a similar definition of drain down time has been used in the upper reaches which are not farmed. We agree that it would be useful to know how long it takes to empty the devices but this was not one of the objectives of the modelling. We have run the models for 72 hours therefore they would need to be rerun the model to assess the device drain down times.		
20		There are several mis-referenced tables and comments, e.g. Section 8.2.1, 8.2.2 and 10.0. It would assist with general readability to fix these.	Could you provide more specific information on where in the document these incorrect references are given? Page 7 of the PDF we sent contains a reference to Section 8.2.1, but this is the correct location. We can't find any references to Sections 8.2.2 or 10.0.	Sorry, I meant references *in* those sections, rather than *to* them. 8.2.1: says "Table 13 refers to MPD 100 yr with CC … etc." when it in fact refers to MPD 10 yr with CC. 8.2.2: says "Table 14 lists maximum flow rates for the MPD 100 yr with CC … etc." when it refers to MPD 10 yr (Table 14 captions also refers to 100 yr). 10.0: A reference to Table 16 appears to actually mean Table 17 (device specs). There are also references to "Attachment" when it appears to mean "Appendix". It's obvious enough what's intended but I had initially gone looking for an attachment. References to "Attachment A" (p2) and "Appendix A" (p8) appear to mean the same thing.	Referencing has been fixed.
21	Table 12 p13	Why difference between catchment outflow and device outflow?	"Peak discharge from catchment" refers to the runoff only from the catchment area that the device was designed to serve ie the outflow from the device. "Peak flow downstream of device" refers to the total flow rate in the channel downstream of the device, and therefore includes the effect of other upstream (and downstream) mitigation devices.		
22	Table 16 p19	Please confirm that the last column in Table 16 is the mitigated MPD peak flow, as a percentage of ED, that results in the water levels reported in Table 9.	Correct.		
23	Figure 9 p20	The placement of Devices 6 and 7 appear to show that not all parts of the contributing catchments are able to reach the devices, i.e. the devices are not located at the downstream extent of the catchments. Do the devices receive flows from all parts of the catchment attributed to them? Do the runoff calculations assume that all parts of each catchment are contributing flow to the respective devices? Are the devices sized for all flows generated by the catchments or just the portion of catchment upstream of the device as shown?	Device locations are indicative. It is assumed that all parts of the catchment can drain to the device, other than Devices 5 and 6 which over attenuate for parts of catchments or other catchments which will not be able to drain to the device. Runoff calculations reflect this ie runoff from catchment G goes into Porters Drain rather than Device 5.		
24	Section 13.1 p21	Existing culvert levels and dimensions have been assumed to be correct. Were the culvert inverts defined as part of the surveying in accordance with discussion in earlier correspondence (emails of 13/4/16)?	The survey only included the culverts that were seen as critical to the modelling and information on size and levels were not known or available . The following culverts were modelled: 2x culverts under Koura Drive, culvert under TRB servicing the Shark Fin (south part of catchment B which is only in model in ED scenario) and Porters drain culvert under TRB. Culverts downstream of the developable area were assumed to be correct from the Lysaghts modelling. They were however checked to make sure the levels in the model looked realistic.		
25	Appendix B p28-29	In accordance with the recommendations of Hold Point 2, all minimum imperviousness values for rural areas (for ED and MPD) were changed to 5% (from 0%). It is noted that Catchment A0 in ED remains at 0%. While this is unlikely to have any more than a negligible effect on model results, for consistency it would be good to set to 5%.	This was a mistake. Changing catchment A0 to 5% imperviousness would increase the ED 100 year flow from 0.420 m3/s to 0.435 m3/s, i.e. by 3.6%. In ED models catchment A0 is routed into the stream passing 4 Guys pond. Because location 1 flows are measured immediately at the outflow point of 4 Guys pond, peak flow rates at this location would be unaffected by such a change. Given the size of the A0 catchment compared to the total catchment at location 2 or anywhere else in the model, and given the very small increase in flows, we consider that this would not likely make a material difference to the conclusions made. We therefore have not rerun the model to reoutput the results.		
26	Appendix B p28-29	The time of concentration for Catchment A is longer for MPD than ED (22 mins vs 13 mins). It is assumed that this has something to do with the way Catchment A has been divided up, given the ED reference to Catchment A0. There is also no Catchment A0 reported in the MPD table or on the maps. Should this be the case?	Yes, ToC differences for catchment A are to do with the way this catchment has been divided up. A0 needed to be separated as in the existing scenario this would likely have drained to the channel alongside 4 Guys pond, however at MPD it has been assumed that it would drain directly into the pond. MPD catchment A = ED catchments A + A0. We have corrected the ED map in Attachment A to plot catchment A0.		

Appendix C

Water Quality Assessments

CH2M Beca

www.ch2mbeca.com

Report

Mangaheka Water Quality Assessment

Prepared for Hamilton City Council

Prepared by CH2M Beca Ltd

15 February 2018

Revision History

Revision Nº	Prepared By	Description	Date
1	**Angela Pratt**	Draft for Client Review	8/6/2017
2	**Angela Pratt**	Final Report including Pollution Plan Template	19/9/17
3	**Angela Pratt**	Update of Final Report	12/1/18
4	**Angela Pratt**	Update of Final Report (Update Section 12 following client discussion)	15/2/18

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Angela Pratt**		15/2/18
Reviewed by	**Graham Levy/Dan Evans**		15/2/18
Approved by	**Kristina Hermens**		15/2/18
on behalf of	CH2M Beca Ltd		

Contents

Appendices

Table of Figures

Table of Tables

1 Introduction

This report has been prepared to document a range of water quality related aspects of the draft Mangaheka Integrated Catchment Management Plan. This work has been carried out in a number of stages, with additional scope being added after each stage.

The purpose of this report includes:

- To confirm whether the devices have been designed to adequately treat the contaminants likely to be generated after Maximum Probable Development (MPD) has occurred
- To detail how the current requirements for on-lot treatment and Pollution Control Plans could be improved to provide better water quality outcomes

2 Scope

The following tasks were requested to be carried out by HCC:

Stage 1a

Review the design reports and consent applications for each of the three existing devices to determine:

- What design standard should the devices have met (likely Auckland Regional Council's Stormwater Management Devices: Design Guidelines Manual, Technical Publication 10 (TP10))?
- Have the devices been designed to this standard?
- Have they been constructed in accordance with the consents and the standards?
- Any other concerns with the current device designs in relation to their water quality performance?
- If the devices are designed and constructed in accordance with the plans, what treatment performance would the devices likely achieve? This would involve a literature/guideline review (TP10 + others) to identify the types of contaminants that the devices will remove and the expected removal performance

The above tasks have been documented in **Section 6**.

Stage 1b

Based on the proposed MPD industrial development (some existing and some still to be developed) contributing to each device and the fact that any lots with high risk industrial activities will trigger the Waikato Regional Council (WRC) Rules or HCC bylaws and will be required to provide an onsite management plan:

- What are the likely residual contaminants being generated (performance and types)? i.e. what types of activity does the industrial zone in the District Plan allow developers to carry out and what are the likely contaminants from such industries? **See section 9**
- Therefore are the existing devices likely to be sufficient to provide appropriate treatment, or is additional on-lot treatment likely to be required? **See section 8**
- Review any monitoring data that the WRC may have in terms of whether the performance of the devices is appropriate. This is a difficult task as treatment performance should be considered over a long time period rather than based on a few discrete events which may have been sampled. Timing of samples, as well as incoming water quality, also have an impact on device performance. It is therefore likely that this task may be of little real benefit but still worth having copies or any records help. **See Section 6.4 and Section 4.3**

Note that no monitoring data has been collected during this study and we have not been able to find any other monitoring data for the devices by WRC, HCC or others.

Stage 2

The following tasks have been carried out as part of Stage 2.

- Provision of a brief list of device improvements that could be implemented to increase the treatment efficiency of the existing devices – **See section 6.5**
- Review the list of industrial activities contained in the Draft Waikato Stormwater Management Guideline and provide some recommendations on which industrial activities will need to prepare Pollution Control Plans (PCPs). This included a discussion with the HCC staff in order to understand any issues with the proposed list. **See section 9**
- Provision of a list of requirements/expectations for what would be contained within a PCP e.g. a description of the site practices where there is potential for contaminant export into the stormwater system. This would not only help developers but also HCC staff assessing the plans. This would link in with the Waikato Stormwater Management Guidelines**. See section 10**
- Brief discussion on / qualitative justification for providing PCPs as well as more detailed information in PCPs. This would likely be based on existing policy approaches elsewhere. It is expected that some developers will need to provide a plan now when previously it would not have been necessary so it is important that they understand why this is now required. Note that this task could be quite involved depending on the level of detail required. **See Section 9.4**

Since preparing the PSP for HCC, the following have also been requested as scope items:

- Review the existing HCC Pollution Control Plan template and advise whether this is appropriate or whether additions/modifications should be made. **See section 10.2**
- Provide an assessment of the options for managing water quantity and quality for future devices including pros and cons of offline versus online flood mitigation and high flow bypass options**. See section 11.1**
- The 1D Modelling report (Beca, 2017) provides the sizes of flood mitigation devices required in order to mitigate the effects of Maximum Probable Development. If these devices were enlarged to also provide treatment, determine how large the proposed devices would need to be to provide treatment as well as flood mitigation. **See section 11.2.4**

In addition to this scope, to provide context to the content of the report, we have also provided the following:

- Background information in terms of the current legislation that the Mangaheka ICMP is operating under and the objectives of the ICMP. **See Section 3.2**
- A summary of the existing water quality in the Mangaheka Catchment. This forms the baseline for assessment of the future effects of development. **See Section 5**

2.1 Exclusions

- Note that this report does not consider effects of stormwater discharges on groundwater or the interaction of devices with groundwater. Such effects would need to be carried out during detailed design of developments. It should be noted however that there are no known (based on Waikato Regional Council GIS system) drinking water supply bores within 2 km down-gradient from the industrial area
- This report considers treatment performance during the MPD operational phase – construction effects are dealt with separately in the ICMP and are generally short term in nature

3 Background

3.1 Overview

The Mangaheka Stream catchment is located on the north-west side of Hamilton City. In the upper catchment, there is a 280 ha area of industrially-zoned land that is progressively being developed. Currently there are three stormwater treatment and attenuation devices serving parts of this area. These devices each have their own stormwater discharge consent (currently held by the developers), however these devices will be vested in HCC (ownership transferred to HCC) at some time in the future.

The three existing stormwater devices are shown on Figure 3-1. These devices are:

- Porters Properties Pond (hereafter referred to as “Porters Pond”): This is an online “wetland pond”
- Hamilton Joint Venture Pond (hereafter referred to as “HJV Pond”): This is an online “wetland pond”
- 4 Guys Car Yard Pond (hereafter referred to as “4 Guys Pond”): This pond only provides stormwater attenuation and has not been specifically designed to provide treatment. The downstream HJV Pond has been designed to provide treatment for the catchment of the 4 Guys Pond

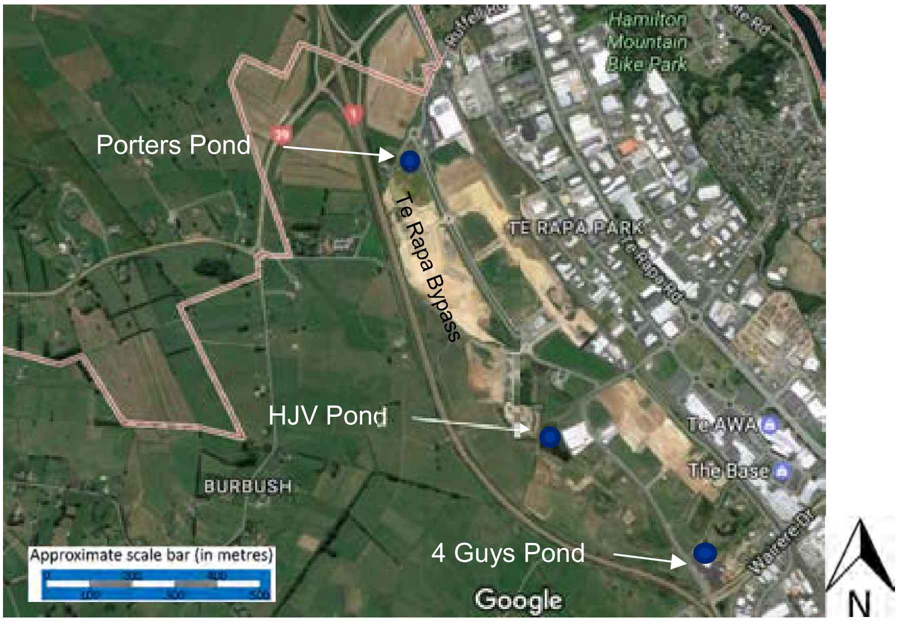

Figure 3-1: Existing Device Locations (Adapted from Google Maps, 2017)

In the future, the remainder of the industrially zoned land will likely be developed. The proposed Mangaheka ICMP will therefore set out the requirements for design of future development, as well as any undeveloped lots with the area served by the existing devices.

3.2 Current Legislation and Guidelines

3.2.1 Overview

When a developer wants to develop land within an Industrial Zone, they may need to do the following:

- Apply for a Building Consent for construction of buildings
- Apply for a land use consent if all the relevant rules for the zone area not met
- Apply for a connection to the HCC stormwater network from their site

There are a number regulatory documents governing such activities. These are detailed below.

3.2.2 Operative HCC District Plan

The District Plan sets out activities that can occur within certain zones e.g. Industrial zone. Some activities are permitted and some require a consent to be applied for. In terms of the Mangaheka Industrial Zone, it is the Industrial Zone chapter which applies, and in some cases, also the Hazardous Facilities Chapter.

The current Industrial Zone chapter in the Partially Operative HCC District Plan (2016) provides restrictions in terms of how industries that can develop including requiring a maximum of 90% impermeable surface area across each site. In addition, the Hazardous Facilities chapter contains restrictions on:

- Site design
- Site drainage to avoid discharge of hazardous substances
- Wash-down areas to avoid contaminated washwater from discharging into the stormwater drainage network or contaminating any water body
- Spill containment systems
- Storage of hazardous substances
- Tanks for storage of petroleum products

3.2.3 HCC Stormwater Bylaw

In 2015, HCC introduced a stormwater bylaw which governs and protects both private and public stormwater systems, along with watercourses within the HCC boundary. One of the bylaw's purposes is to manage the input of contaminants into the stormwater system. The bylaw states that in order to not breach the bylaw, sites on the WRC High Risk Facilities register need individual site measures to control discharges of contaminants to the environment. This is discussed further in Section 3.2.4 below.

3.2.4 Waikato Regional Council High Risk Facilities Register

The High Risk Facilities Register is a section of the Waikato Regional Plan, referenced in the HCC stormwater bylaw. The register lists the types of sites/facilities seen as having a high risk of spillages of hazardous substances or contaminants which, if not controlled appropriately, pose a further risk of discharging into the environment. Under the HCC bylaw, such sites "must install and maintain an appropriate private stormwater interception system to eliminate, as far as practicable and otherwise minimise, the risk of prohibited materials entering the public stormwater system" (Source: HCC Stormwater Bylaw, 2015). Any owner or occupier of a high risk facility must also prepare and comply with a Pollution Control Plan. A copy of this register is attached as Appendix A.

3.2.5 Waikato Regional Plan

Discharges of stormwater (and other activities) are controlled by Regional Plans, normally through discharge consents. Hamilton City Council currently hold a comprehensive discharge consent for discharges from its stormwater network. This consent requires that they need to control inputs from land within the city which discharge to their network.

3.2.6 HSNO Act

The *Hazardous Substances and New Organisms Act 1996* relates to the management of hazardous substances and new organisms. The Act defines what is considers a hazardous substance or new organism as well as thresholds and controls to manage these things. Where hazardous substances or new organisms are going to be used, stored or manufactured within the Industrial Zone, the HSNO Act regulates the activity in addition to any local Council regulations.

3.2.7 Other Documents

Auckland Unitary Plan - Industrial and Trade Activities

The Industrial and Trade Activities section of the Unitary Plan assigns an activity status (permitted, discretionary, controlled etc.) using a risk based approach. Depending on size and type of activity, sites are classified as low, medium or high risk in terms of stormwater contamination. Under this plan controlled activities must provide treatment devices and restricted discretionary activities must also provide a Spill Control Plan and Environmental Management Plan. The Unitary Plan forms a framework for managing such sites and could be referred to in Hamilton as part of the management of Industrial sites. A copy of this list is attached as Appendix B.

WRC Draft Waikato Stormwater Management Guideline

Waikato Regional Council has recently prepared a Draft Waikato Stormwater Management Guideline (not publically released yet) which provides site/stormwater design guidance particularly for industrial developments (Table 11.1). A copy of this table is provided as Appendix C.

Additional Development Restrictions

In addition to the above legislation and guidelines, developers in the Mangaheka Industrial area will also need to meet the requirements of the Te Rapa Gateway "development guidelines" which include the following requirements:

- Individual lot Low Impact Design (LID) measures
- The use of unpainted Zincalume® roofing materials is not permitted

4 Water Quality Targets and Objectives

4.1 Water Quality Targets

The draft Mangaheka ICMP document contains a number of water quality targets which will apply to all discharges to the Mangaheka Stream. These are provided in the Design Parameters table in the ICMP document, provided in section 6.4

In terms of TSS, for which the ICMP target is 75% removal (typical industry value), it is important to consider (when developing monitoring programmes) that TP10 standards for TSS removal are intended to indicate performance on a long-term average basis rather than on an individual storm basis. In addition, inherent in the definition of performance, both the input and output from a stormwater treatment device would need to be monitored. Timing of sampling within a storm will lead to large variance in the reported performance of a device. This will be dependent on temporal differences in both inputs of sediments delivered to the device and the treatment capacity of the system and this variation should be considered when both designing a water quality monitoring program to obtain ‘representative samples’ and when analysing any water quality monitoring data.

This report deals only with the operational phase targets and effects. Construction phase targets will also be important, but will be dealt with through other statutory mechanisms and short term treatment approaches.

4.2 Draft ICMP Operational Objectives

In addition to the targets section 6.4, the Draft ICMP document also sets out an operational objective to “maintain or enhance Mangaheka Stream quality”. This objective should be referred to when assessing performance of treatment and the quality of discharges. This could be done by comparing baseline water quality conditions (see Section 5) with samples taken in the future.

4.3 Water Quality Target Locations and Timing

The design parameters outlined in the ICMP document and mentioned above include the proposed location where these water quality targets should apply. In the Mangaheka catchment at MPD, there is likely to be a range of on-lot treatment devices and larger centralised devices, so definition of the point(s) of compliance is essential. The following two locations are referred to in the Design Parameters table:

- Where there is a centralised device: target should be met at the discharge point of the device
- Where there is on-lot treatment, with no downstream centralised device, target should be met at the discharge point from the on-lot treatment system

In addition, some of the parameters will need to be measured “after reasonable mixing downstream of a discharge point” with “reasonable mixing” being defined in the Regional Plan.

Section 6.4 of the Draft ICMP provides the Draft Design Parameters Table which identifies which parameters should be achieved and where.

Currently HCC consents require annual monitoring and that a monitoring plan be prepared by a suitably qualified professional..

The WRC consents for each development as well as HCC's Comprehensive consent have been reviewed in terms of monitoring requirements. These require that "The consent holder shall retain suitably qualified and experienced persons to prepare a Stormwater Monitoring Programme. The objective of this monitoring programme shall be to monitor the effectiveness of the wetland treatment pond for water quality and water quantity purposes post wetland construction. The monitoring programme shall be to a standard acceptable to the Waikato Regional Council and shall be submitted to the Waikato Regional Council for written approval acting in a technical certification capacity, prior to commencement of the activities authorised by this resource consent."

It would be expected that this monitoring would require:

- Checking of overall system state including vegetation, presence of erosion etc.
- Sampling of the discharge to determine effectiveness in terms of removing contaminants of concern in the catchment. Samples would need to be taken prior to treatment and downstream of the device

Whilst HCC normally requires annual monitoring, we recommend that more frequent sampling occur initially after development has occurred and then annually if results are appropriate. One annual sample is often not enough to assess effectiveness of treatment systems on a long term average basis. Monitoring during rainfall events of varying sizes as well as between events can give a better indication of performance.

5 Existing Water Quality

5.1 Overview

In order for the effect of future discharges to be assessed against the ICMP targets and objectives, it is important to understand baseline Mangaheka Stream water quality conditions.

Boffa Miskell's 2016 ecological assessment details the existing water quality in the Mangaheka catchment. For key stormwater contaminants, the assessment compared the existing water quality against the ANZECC 2000 guidelines (Trigger values for aquatic ecosystem protection at 90% protection of species, based on a high disturbed environment) and MfE guidelines and suggested that:

- Arsenic, cadmium, chromium, lead and nickel were generally below ANZECC guidelines
- Aluminium (total and dissolved) exceeded the ANZECC guidelines
- Iron levels were elevated (note there are no ANZECC guideline values for iron).
- Nutrient (nitrogen and phosphorus) levels exceeded Ministry for the Environment (MfE) water quality guidelines for limiting algal growth
- Turbidity was elevated in comparison to NZ slightly modified Aquatic Ecosystem ANZECC Guidelines (5.6 NTU)
- Faecal coliform levels exceeded ANZECC guidelines for livestock watering and MfE guidelines for human contact

Boffa Miskell (2016) also noted that thermal pollution i.e. elevated water temperatures, is likely to be an issue for watercourses receiving urban drainage. Temperature measurements taken as part of sampling indicated existing temperatures ranging between 11.4 and 15.7 degrees Celsius. Values at the time of sampling were all lower than the ICMP target of 23 degrees however it is likely that with industrial development occurring, that temperature will be higher, especially during summer.

In summary, Boffa Miskell (2016) states that the existing water quality in the catchment is poor to moderate, but similar to most Hamilton waterways.

5.2 Typical Contaminants of Concern for Industrial Development

Whilst rural drainage and groundwater discharge accounts for a large proportion of the above issues, industrial development has the potential to reduce water quality further, especially once MPD has occurred. Of particular concern in regard to the industrial development are the parameters and existing concentration ranges listed in Table 5-1 which were noted in BML (2016) as exceeding the ANZECC 2000 guideline values for 90% protection. These values are from sampling carried out by Boffa Miskell and reported in BML (2016). The range represents values from a number of sites through the catchment. Literature also provides information on generation rates and treatment device removal efficiencies for these contaminants.

Table 5-1: Existing Contaminant Concentrations (Source: Boffa, 2016)

Contaminant	Existing Concentration Range (all g/m³)
TSS	5 – 13
Total nitrogen	0.44 – 4.6
Total phosphorus	0.035 – 0.106
Total zinc	0.0175 – 0.069
Total copper	0.0022 – 0.0028

There are also a range of other contaminants that are likely to be generated by industrial developments, such as:

- Hydrocarbons
- Metals: lead, cadmium, aluminium, chromium, arsenic, iron
- Pathogens
- Biochemical Oxygen Demand (BOD)
- Coarse debris such as litter

As there is not sufficient literature on generation rates of these additional contaminants, this assessment has only focussed on those contaminants in Table 5-1 as indicators of treatment performance and down-gradient environmental conditions.

6 Existing Devices

6.1 Porters Pond

6.1.1 Overview

The Porters Development is located in the northern part of the Mangaheka Industrial area. It comprises a land area of approximately 69 hectares (ha). Figure 6-1 below shows the area of the site.

The Porters Development is serviced by the following stormwater management system, designed by Lysaght Consultants Ltd:

- Individual lot water quality management including requirements to paint any galvanised roofs, on-site treatment for high contaminant generating sites, LID measures (permeable paving, rain tanks, sand filters, re-use and soakage)
- Conventional kerb and channels, sumps and pipes discharging to:
  - Vegetated swales (treatment and conveyance)
  - A wetland/pond

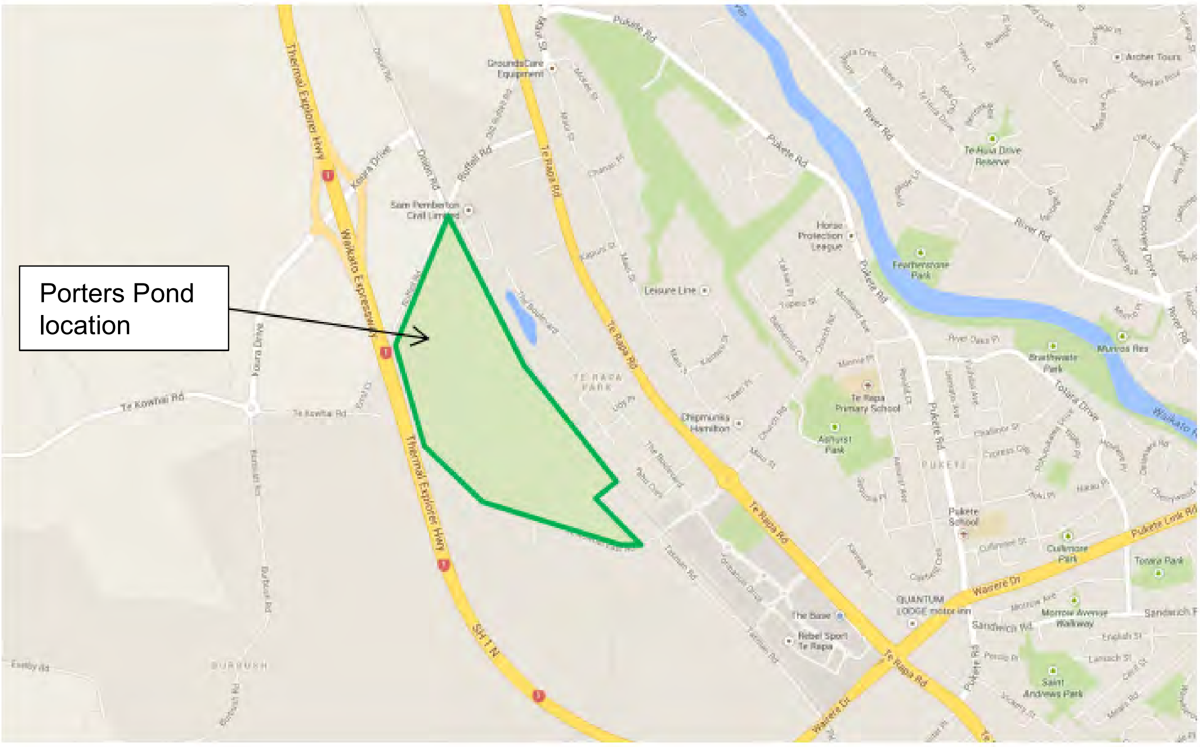

Figure 6-1: Porters Development (Source: Lysaght, 2013a)

The wetland/pond is located in the north-western part of the site and discharges via culverts under Ruffell Road and into Porters Drain.

The Porters Pond has been designed and constructed to suit a staged approach to the development. A smaller wetland pond is currently constructed, serving Stage 1 of the development. It will later be enlarged to service the whole site. We note that the Stage 1 pond size and area served has not been confirmed in Lysaght (2013a).

6.1.2 Design Standards

Lysaght (2013b) states that Porters Pond has been designed in accordance with TP10 which requires 75% removal of TSS. To achieve this standard, Lysaghts concluded that the wetland/pond needed to be designed to treat a water quality volume (WQV) of 1/3rd of a 2-year 24-hour storm volume.

The pond has also been designed to provide extended detention and peak flow attenuation of up to the 100-year storm.

The Porters development swales have residence times between 17 minutes and 100 minutes. TP10 requires a minimum residence time of 9 minutes, therefore it is expected that treatment will be equal to or better than the standard.

Given the importance of the WQV to the performance of the pond, we have sought to verify that this factor was calculated correctly. In reviewing the design report (Lysaght, 2013), it is noted that whilst there is an Appendix C which states that it contains calculations, it does not appear that any calculations have been provided. Rather, only model results and device stage/volume tables/graphs have been included. It is therefore unclear whether the wetland/pond has been designed to treat the WQV. The report does however state that the forebay is 1,700 m^3, which is 15% of the Water Quality Volume (WQV). From this the WQV should be 11,333 m^3.

To confirm if the volume is approximately correct, we have undertaken a basic Rational Method calculation of the WQV. Based on a runoff coefficient of 0.81 (curve number of 89.7), this gives a WQV of 12,100 m^3, which is appropriate compared to the estimated pond volume based on the forebay volume stated. It is normal that TP108 (which would have been used by Lysaghts to calculate the WQV) would give a slightly different volume than the Rational Method, therefore based on the above, it is concluded that the volume is likely to be correct but this requires further verification.

6.1.3 Treatment Performance

Lysaght (2013a) refers to the treatment performances in NZTA (2010) and the formula in the same reference for calculating a combined efficiency based on using swales and wetland/ponds in series. Below is the treatment performance stated in Lysaght (2013a).

Table 6-1: Combined Treatment Efficiency (Source: Lysaght, 2013a)

Practice	TSS	Nitrogen	Phosphorus	Zinc	Copper
Swales	70%	20%	30%	75%	60%
Wetland/Pond	90%	40%	50%	80%	80%
Combined	**97%**	**52%**	**65%**	**95%**	**92%**

The treatment efficacy for TSS is within the performance target defined in Section 4.1. However, as described later, we have reservations about the reliability of the combined treatment efficacy, which tends to overstate the likely performance.

6.1.4 Site Visit Findings

During the CH2M Beca site visit on 8 June 2016, the following was noted:

- Swales had been constructed and planted in accordance with the plans (see Figure 6-2)
- The pond is being used as an erosion and sediment control pond as:
  - It hadn't been finished to the standard expected of a permanent treatment pond
  - The outlet was fitted with T-bar decant structures as required for erosion and sediment control ponds, but not normally used for permanent ponds
  - Baffles made of silt fence material were being used. These appeared temporary in nature. Figure 6-3 and Figure 6-4, shows these baffles

In addition:

- No forebay had been constructed
- There was minimal planting/grassing within the wetland or on the banks
- There was quite a lot of erosion of the banks of the pond, especially the south side
- It did not appear that the bunds defining the flow path within the wetland/pond (as shown on the construction drawings) had been constructed. These were to be higher than the extended detention depth so should have been obvious if they were in place, given it did not seem to have rained recently (ground was dry throughout and devices were not discharging)
- The overall area of the pond appeared to match the plans

Figure 6-2: Central swale along the main road through the Porters development (looking south)

Figure 6-3: Porters Pond looking west

Figure 6-4: Aerial photo of Porters Pond (Source: Google Earth)

6.1.5 Concerns with the Existing Devices

Whilst it appeared that the overall area of the pond was in accordance with the design, its use as an erosion and sediment control pond in the longer term is not recommended. Whilst WRC has confirmed (Brian Richmond, *pers. comm.*, 29 May 2017) that the pond is not yet operational in terms of the wetland features, it is only considered appropriate to use the device in this way whilst the bulk earthworks and road construction of the initial stages of the development are constructed. Using it in this way long term, whilst individual sites are being developed, is not recommended. These sites should employ their own individual on-site erosion and sediment control practices. The use of the pond in this way could potentially have the following effects:

- Lower standard of treatment for stormwater discharges from completed parts of the site
- High levels of sediment inflow can reduce the volume of the pond and hence the attenuation abilities
- Lack of planting will have an impact on the water temperature. Planting acts to shade the water and to reduce temperature of the pond. Plants would also perform a sediment trapping role in their root structure and provide uptake / assimilation potential for bio-available components of contaminants of concern such as metals and nutrients

In terms of this project and the overall performance of the system, it is unclear as to what the final "pond" system function is. Lysaghts (2013a) discusses the fact that it is a wetland/pond but also suggests that it will act like a large swale, although the treatment function of a swale is supposed to involve slow flow through a thick grass sward, which is not what happens here. Compared to a standard TP10 wetland, this pond has a low flow channel rather than a series of bunds across the wetland with deeper pools between (banded bathymetry). The bunds would normally spread the flow over the full pond width, hence slowing flows. Whilst the report suggests that this occurs, this wetland does not have the same form as a TP10 wetland. A TP10 wetland has a number of benefits via promoting a range of chemical and biological reactions for contaminant removal that do not occur in a wet pond. Whilst the current form of the wetland/pond will undoubtedly provide treatment, when it comes to the stated removal efficiency of the system (see Section 6.1.3), it is our opinion that this system would not achieve the rates of removal of a TP10 wetland. It is likely it would be more like a TP10 wet pond in terms of treatment efficiency.

Whilst it may not have been possible and it is not expected in TP10, separation of treatment from attenuation (i.e. two systems in parallel) is recommended. This is likely to improve treatment performance as a result of high peak flows not causing turbulence and resuspension within a treatment system. This will also reduce the treatment efficiency. It is recommended that this is considered for future device designs.

In addition, the pond outlet design does not have a method for excluding hydrocarbons from the discharge e.g. downturned elbow, upwards sloping pipe. It is likely that volatilisation would occur from the large pond surface however it is possible that any hydrocarbons that are not removed in the swale or pond, could discharge to the Mangaheka Stream.

In addition, faecal coliforms can increase as a result of ponds/wetlands becoming bird habitats. This is a normal occurrence and given the other benefits of this sort of system, it is generally not considered to be a major issue given there are no known contact recreation sites in the vicinity of the devices or drinking water takes from the stream. Given the expected loads of nutrients assessed in section 7, there is also potential for algal growth which may need ongoing management.

6.1.6 Overall Performance

Based on our review of Lysaght (2013b) and our site visit, we conclude the following:

- When properly converted to a normal wetland/pond, performance is likely to improve.
- The wetland/pond is not likely to be performing as well as a TP10 wetland due to the form (as per design) being different
- The swales are likely to be providing treatment performance in the high end of the range due to the much longer retention times achieved

Overall, it is considered that the treatment performance for the swales will be at the high end of normal ranges and the wetland/pond performance would be more in line with that expected for a wet pond.

6.2 Hamilton Joint Venture (HJV) Pond

6.2.1 Overview

The HJV development is located in the southern part of the Mangaheka industrial area, south of the Porters Development. The development itself is 70 ha in size, however the stormwater system manages flows from an additional 11.1 ha of rural land (the “Shark Fin” block) and 14.1 ha of the Giles Block.

At MPD, stormwater flows from the Shark Fin will discharge into the Rotokauri catchment, rather than discharging through the culvert under Te Rapa Bypass at the south end of the development. The Giles block will likely be developed as industrial land and discharge to the HJV pond via the 4 Guys pond. Note that the 4 Guys Pond only provides flood storage and has not been designed to provide treatment. This has not been included in the Water Quality Volume Calculations.

The HJV development is serviced by the following stormwater management system, designed by Lysaght Consultants Ltd and reported in Lysaght (2013b):

- Individual lot water quality management including requirements to paint any galvanised roofs, on-site treatment for high contaminant generating sites, LID measures (permeable paving, rain tanks, sand filters, re-use and soakage
- Conventional kerb and channels, sumps and pipes discharging to:
  - Swales (treatment and conveyance)
  - A wetland/pond

Figure 6-5 and 6-6 show a plan location and aerial photo of the HJV pond.

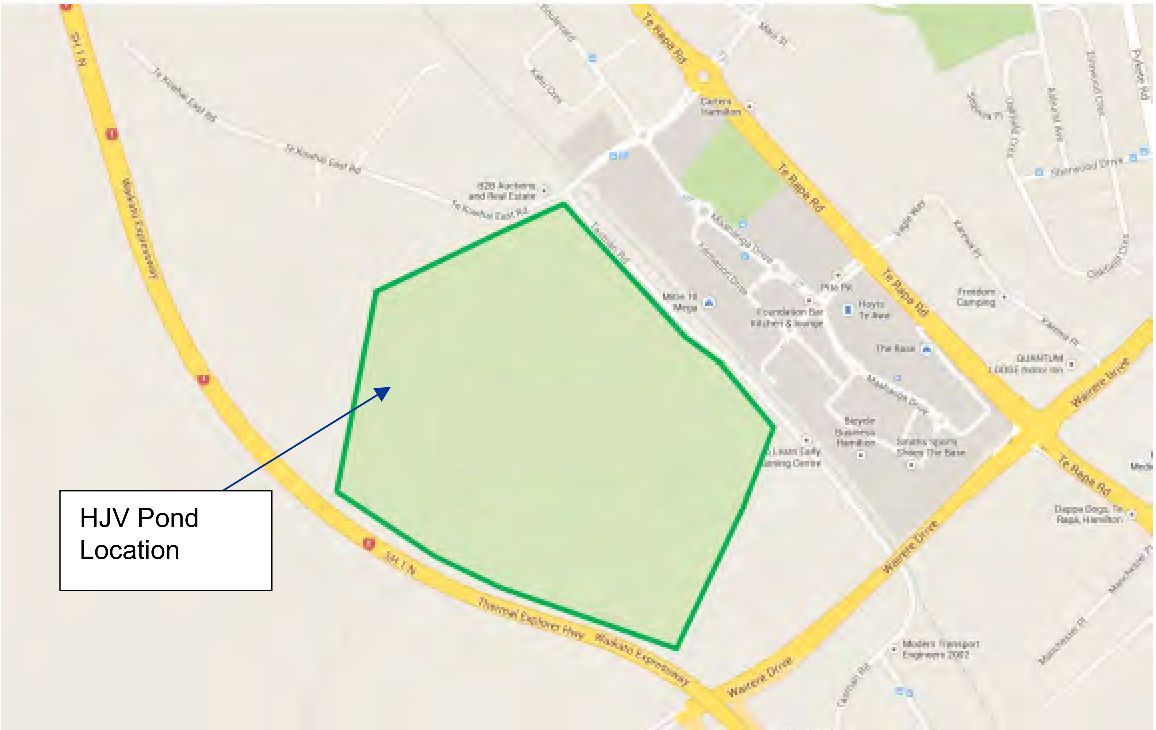

Figure 6-5: HJV Pond Location

Figure 6-6: Aerial photo of HJB Pond (Source: Google Maps)

6.2.2 Design Standards

Lysaght (2013b) states that the HJV pond has been designed in accordance with TP10, which requires 75% removal of TSS. To achieve this standard, Lysaghts concluded that the wetland/pond needed to be designed to treat a water quality volume of 1/3rd of a 2-year 24-hour storm volume.

The HJV pond has also been designed to provide extended detention and attenuation of up to the 100-year storm.

Similar to Lysaght (2013a), the HJV design report (Lysaght, 2013b) does not appear to contain any calculations of the WQV. It also doesn't state a forebay volume to enable a check of the volume. It is therefore unclear whether the wetland/pond has been designed to treat an appropriate volume. This should be checked, however for the purposes of this report, we have assumed that it has been.

The Porters development swales have residence times between approximately 3 minutes and 2 hours (total for swales in series), with shorter residence times being for sections of swale just upstream of where these discharge into the wetland/pond. Overall, the average residence time is well in excess of the TP10 minimum residence time of 9 minutes. It is therefore it is expected that, on average, treatment will be better than standard, although there will be some swales where that is not the case It is the overall performance that is considered important for compliance.

6.2.3 Treatment Performance

Similar to Lysaght (2013a), Lysaght (2013b) also refers to the treatment performances in NZTA (2010). See Table 6-1 for the reported treatment efficiency of the combined swale/wetland pond treatment performance.

6.2.4 Site Visit Findings

During the CH2M Beca site visit on 8 June 2016, the following was observed:

- The bunds required for the Stage 1 pond had been constructed (see Figure 6-7)
- The outlet manhole slot (extended detention outlet) was submerged, although water did not seem to be flowing at all through the system. An area of ponded water was also present downstream of the outlet (see Figure 6-8). The cause of this could not be ascertained during the visit, however it is noted in Lysaght (2013a) (Section 4.5.4) that there was a requirement to lower the upper end of the downstream channel by 300 to 500 mm to match the invert of the basin. It is possible that this lowering has not occurred to a distance far enough downstream as to provide sufficient gradient on the drain. This issue does however appear to suggest that the dead storage of the pond is higher than expected, which reduces the flood storage/attenuation volume provided
- The wetland planting indicated in Lysaght (2013b) did not appear to have been fully completed. Some grasses appeared to have grown or been planted within the pond and grassing of the banks had been completed but the vegetation is not as extensive as shown in the design plans
- The swales appeared planted in accordance with the design plans

Figure 6-7: HJV Pond looking from the north

Figure 6-8: Downstream of HJV Pond Outlet

Figure 6-9: HJV Pond Outlet

Figure 6-10: Swale C (along Arthur Porter Drive looking south)

6.2.5 Concerns with Existing Device

- Like the Porters Pond, the HJV wetland/pond does not have the banded bathymetry required of a TP10 wetland, therefore it is expected that there will be a lower standard of treatment than that stated in Lysaghts (2013b)
- The lack of planting is likely to have an impact on the water temperature. Planting acts to shade the water and to reduce temperature of the pond. Plants would also perform a sediment trapping role in their root structure and provide uptake / assimilation potential for bio-available components of contaminants of concern such as metals and nutrients
- Whilst it may not have been possible and it is not expected in TP10, separation of treatment from attenuation (i.e. two systems in parallel) is recommended in that this is likely to improve treatment performance as a result of high peak flows not causing turbulence (resulting in less effective sedimentation) within a treatment system
- Like the Porters Pond, the HJV Pond outlet design does not have a method for excluding hydrocarbons from the discharge e.g. downturned elbow, upwards sloping pipe. It is likely that volatilisation would occur from the large pond surface however it is possible that any hydrocarbons that are not removed in the swale or pond, could discharge to the Mangaheka Stream
- Faecal coliforms can increase as a result of ponds/wetlands becoming bird habitats. Given the expected loads of nutrients calculated in Section 8.4, there is also potential for algae growth and ongoing management may be required
- 100 year spillway is lower (30.45 ha) than the manhole weir level (30.5 ha). A 100 year spillway should be used as a last resort, with flow going over the top of the outlet manhole first

6.2.6 Overall Performance

Based on our review of Lysaght (2013b) and our site visit, we conclude the following:

- The wetland/pond is not likely to be performing as well as a TP10 wetland due to the form being different
- The swales are likely to be providing adequate treatment on average

Overall, it is considered that the treatment performance for the swales will be at the high end of normal ranges and the wetland/pond performance would be more in line with that expected for a wet pond.

6.3 4 Guys Pond

6.3.1 Device Description

The 4 Guys Pond is located at the southern end of the industrial development within the Mangaheka catchment. The pond serves the 4 Guys car yard, a Z Energy petrol station and some existing rural land referred to as the "Giles block" (part of labelled Proposed Future Development on Figure 6-11 plus the block to the north of that). The 4 Guys Pond has been designed to only provide attenuation of flows rather than treatment, with treatment for the contributing catchment being provided in the downstream swales and HJV Pond (see Section 6.2).

This device has been designed by CKL Ltd.

Currently, flows from the land labelled "Proposed Future Development" on Figure 6-11 are diverted via a drain around the pond.

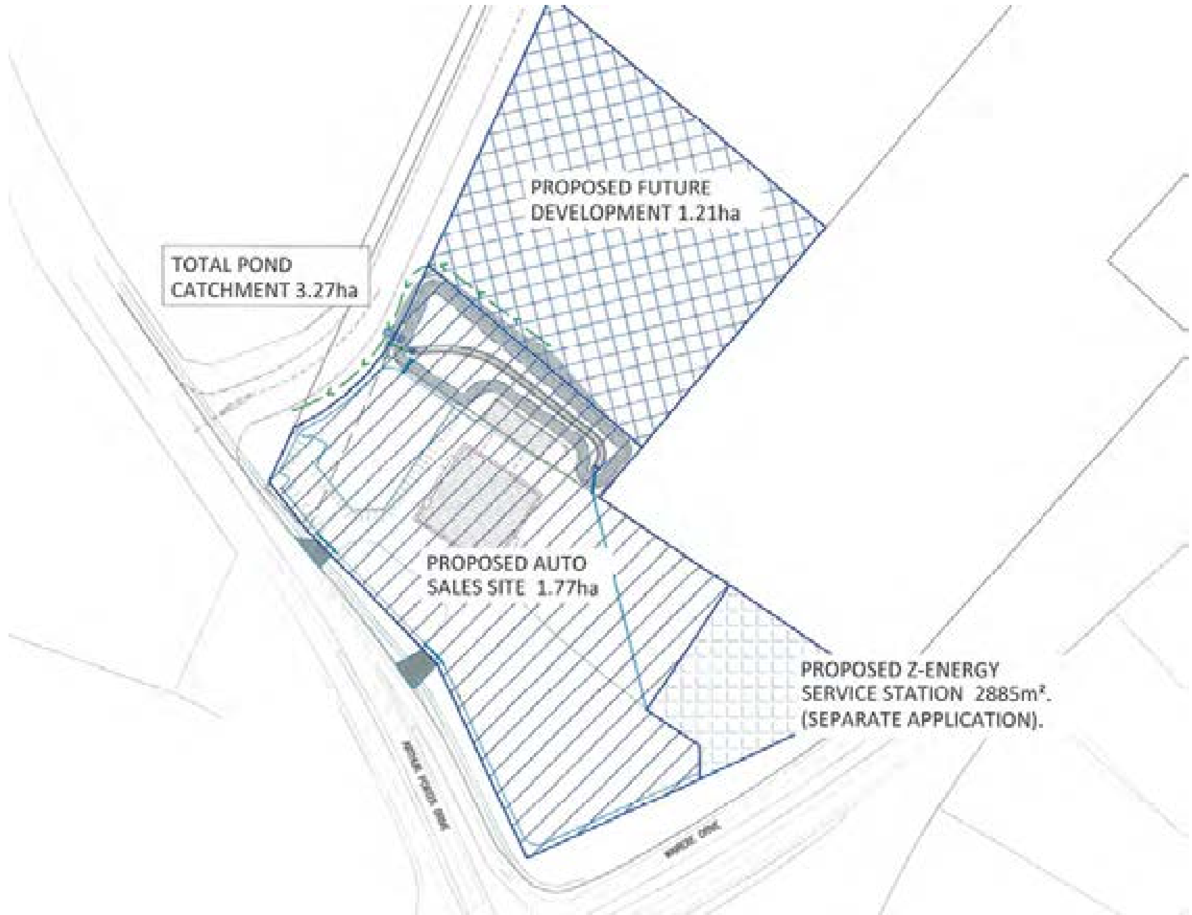

Figure 6-11: 4 Guys Pond Catchment

The existing car yard (which contains a car wash facility) and petrol station are sites considered to be at high risk of spillages of contaminants; classified as “High Risk Facilities” by the WRC. In order to achieve the requirements of the HCC bylaw for such facilities, the following on-lot measures have been implemented:

- A rainwater tank system collecting roof water for car washing. The tank overflows to the pond.
- An oil and grit interceptor serving the car wash slab
- A Fox valve for flow diversion to the wastewater system during car-washing. This discharges to the stormwater pond when car-washing is not occurring

It is unknown what measures the Z Energy service station has installed however it is likely that an oil interceptor would also have been required at this site.

At MPD, it is proposed that this pond be enlarged to be able to provide attenuation for an additional 3.8 ha of future development (currently rural land). Flows from this land are currently diverted around the 4 Guys Pond. This will either be carried out by HCC or the land owner/developer.

6.3.2 Design Standards

As noted above, this pond has not been designed to provide treatment, relying on the downstream HJV pond for the necessary treatment. That said, it is likely that some removal of contaminants would be occurring in the pond via settlement and other processes.

The pond has the following characteristics as provided in CKL (2015):

- Extended detention volume: 900 m^3
- Outlet diameter of 80 mm allowing release over 24 hours

These appear appropriate for the contributing catchment.

6.3.3 Site Visit Findings

A site visit to the pond was carried out by CH2M Beca on the 8 June 2016. The pond appeared to be constructed in accordance with the plans. The following points were noted:

- Erosion at the southern inlet to the pond (See Figure 6-12). This appeared to be due to high flows down the relatively steep inlet channel. Scour protection has been provided but this appears inadequate for the flows involved. This issue is likely to generate sediment (from erosion) in higher amounts than the downstream system is designed for, if it does not settle out before leaving the 4 Guys Pond and could also lead to undermining and loss of integrity of surrounding infrastructure
- There is minimal planting on upper batter slopes and in parts of the pond invert, particularly in the northern part of the pond. See Figure 6-12 and Figure 6-14

Figure 6-12: 4 Guys Pond Inlet

Figure 6-13: 4 Guys Pond (looking east from outlet)

Figure 6-14: 4 Guys Pond (looking west)

6.3.4 Issues with the Pond

The pond appears to be constructed in accordance with the plans. The most significant issue was in relation to the erosion of the inlet shown in Figure 6-12. In addition, but generally not of major concern was:

- Lack of planting in invert – this would help with shading to reduce temperature of the pond water and any discharge from it
- Pathogens - faecal coliforms can increase as a result of ponds/wetlands becoming bird habitats. As there are no down-gradient water users for drinking water purposes and there is likely to be a far higher input from downstream farming practices, it is therefore not considered necessary to modify the system to improve this situation

6.4 Monitoring Data

WRC have been contacted to determine if they have carried out any sampling of the discharges from the HJV and Porters devices. They have indicated that this has not been done, therefore this aspect of the scope has not been carried out. Refer also section 4 which provides some recommendations on monitoring.

6.5 Device Improvements

Based on our observations during site visits, the following amendments could be implemented to improve the performance of the existing treatment devices in the Mangaheka Catchment.

- The existing device outlets could be fitted with mechanisms for preventing the release of floatables/hydrocarbons – Refer to Section 9.5.6.5, page 167 including Figure 9.30 of the Draft WRC Waikato Stormwater Management Guideline
- Install appropriate wetland planting as this will enhance metals and nutrient removal efficacy

- Install submerged outlets on all existing road sumps. These help to prevent floatables and hydrocarbons from being discharged downstream. Additional maintenance is however required to remove these contaminants from the sumps intermittently e.g. 6 monthly
- When the Porters Pond is converted from an erosion control pond to a wetland, the layout of the device could be modified to introduce the banded bathymetry detailed in ARC's TP10, rather than the current meandering low flow channel. Banded bathymetry forces the flows through bands of dense wetland planting, hence improving sediment trapping and contaminant uptake by plants, as well as slowing water velocities, leading to increased settlement

Whilst some of the above items may be harder to implement, as none of the existing devices are currently vested in Council, there is an opportunity for HCC to require the developer to implement these improvement measures prior to vesting with HCC.

It is also recommended that the above measures are provided in larger treatment devices in other parts of the catchment when they are developed. In addition, it is recommended that flood flows bypass the treatment systems such that the more contaminated initial flows are treated appropriately are not diluted and discharged faster by later high flow rate flood flows.

7 Expected Contaminant Generation

The following are the key stormwater contaminants that can be found in urban stormwater. Such contaminants are generally generated by roofs, carparks, roads and pervious surfaces.

- Suspended sediment
- Hydrocarbons
- Nutrients (nitrogen and phosphorus)
- Metals with the primary focus being on zinc and copper as indicators for other metal contamination such as lead, cadmium, aluminium, chromium, arsenic and iron
- Pathogens
- Biochemical Oxygen Demand (B.O.D)
- Coarse debris such as litter

Roads and paved areas are expected to generate additional sediment, metals and hydrocarbon loads.

In terms of pathogens, it is often found that bird life within wetlands, vegetated swales and ponds are the main generator of contamination. This is difficult to treat, but there are practical ways bird populations can be managed, as is normally required for any ponds close to airports due to the risk of birds striking aeroplanes.

It is expected that sites within the Mangaheka industrial zone will produce all of the above contaminants to some extent. In addition, a range of other contaminants could be generated depending on the type of industry and the site controls in place. The likely contaminants are noted in the Draft Waikato Stormwater Guideline, Table 11.1.

A literature review has been carried out to determine the expected rates for generation of contaminants within the Mangaheka industrial area. As there is little available industry specific data (i.e. for individual industries) more generic generation rates have been referred to.

For comparison, generation rates for the undeveloped “rural” land use have also been provided in order to identify where development of the industrial area will result in contaminant generation will be higher than existing and thus potentially degrading the existing water quality.

Three main sources of information have been used to compile generation rates from. These are:

- Auckland Council’s TP10 document
- Auckland Council’s Contaminant Load Model
- Contaminant loads and impacts on the Waikato River (NIWA, 2001)

Table 7-2 below compares the contaminant loads relevant to the Mangaheka catchment, provided in each of these sources. It should be noted that the AC CLM only provides sediment, zinc copper and hydrocarbon loadings. Whilst these are likely to be some of the main contaminants, a range of others are also likely in this location. In terms of the Mangaheka industrial area, roofs, roads and industrial paved surfaces are the most applicable here.

Table 7-1: Expected Contaminant Loadings g/m²/year

Contaminant	Rural (TP10)	Farmed Pasture (ARC's CLM)	Roads ARC TP10	Commercial ARC TP10	Roofs ARC CLM	Roads (ARC CLM) <1000 VPD	Paved Surfaces other than roads (ARC CLM)	Industrial area (NIWA 2001)
TSS	10.3-58.3	152.0	28.1-72.3	24.2-136.9	5.0	21.3	32.0	133
TP	0.001-0.025	N/A	0.059-0.15	0.069-0.91	-	-	-	0.331
TN	0.12-0.71	-	0.13-0.35	0.16-0.88	-	-	-	0.85
Zn	0.002-0.017	0.0053	0.018-0.045	0.17-0.49	0.020	0.004	0.590	0.576
Cu	0.002-0.004	0.0011	0.003-0.009	0.011-0.032	0.002	0.001	0.107	0.0214

In selecting the rates above, the following should also be noted:

- The NIWA, 2001 figures are 16 years old and are from an area of older development. This means they are likely to be high compared to the newer development being assessed. The newer development design has had a higher level of focus on environmental protection, which is likely to drive site practices. It is therefore expected that the NIWA values are at the high end of the range
- Roads in the ARC CLM have different values depending on the traffic numbers. The stated values are for less than 1,000 vehicles per day. TP10 does not distinguish vehicle numbers therefore the lower end of range is appropriate

Based on the source values in Table 7-2, it is considered that the values shown in Table 7-2 and Table 7-3 are likely to be representative of the Mangaheka site, both for existing rural development and Industrial future development. Each table also provides justification as to how the value has been selected from the values in Table 7-1.

Table 7-2: Selected Contaminant Loadings g/m²/year - Rural

Contaminant	Selected Value	Justification
TSS	73.5	Average of source values
Total phosphorus	0.013	Average of source values
Total nitrogen	0.415	Average of source values
Total zinc	0.0081	Average of source values
Total copper	0.0024	Average of source values

Table 7-3: Selected Contaminant Loadings g/m²/year - Industrial

Contaminant	Selected Value	Justification
TSS	32	TSS will mostly be sourced from paved surfaces. Selected value fits in the range also.
Total phosphorus	0.15	Average of source values
Total nitrogen	0.35	Average of source values
Total zinc	0.49	Zinc is often sourced from paved areas where vehicles turn (due to tyre wear) and also from galvanised roofs. Roofs are not to be bare galvanised in this development. "Commercial" value selected as this is lower than paved surfaces and roof generated stormwater will likely provide dilution.
Total copper	0.11	Copper is often sourced from brakes i.e. road and paved areas.

The rates in Table 7-2 and Table 7-3 have been applied to the whole site, and hence represent a high level indicator of effects assuming homogenous contaminant generation. The project scope did not provide for a detailed load assessment to quantify sub-plot level contaminant generation into more detail in terms of individual land uses and specific rates for each site.

8 Expected Device Performance

8.1 Stated Performance

Lysaght (2103a) and Lysaght (2013b) provided information on the expected performance of the Porters and HJV wetland pond/swale treatment systems. Values stated were based on removal rates stated in NZTA (2010). Both reports also used a calculation method shown in NZTA (2010) for determining the combined performance for treatment systems in series (swales and wetland/ponds).

Table 6-1 provides the combined swale and wetland pond system for both systems, from Lysaght (2103a) and Lysaght (2013b).

8.2 Performance of TP10 Devices

If the devices were both designed in accordance with the TP10 guidelines and then constructed in accordance with the design plans, it would be expected that the devices would achieve the level of performance stated in TP10 on a long term average basis. However we note that given the expected future nutrient and sediment loads and erosion noted at some sites, there is also potential for the export of contaminants and the growth of algae.

Table 8-1: TP10 treatment system contaminant removal rates (%)

Contaminant	Wetland Removal Rate	Wet pond Removal Rate	Swale Removal Rate
TSS	45	50-90 (70)	85
Total phosphorus	No value stated	55	No value stated
Total nitrogen	33	45	No value stated
Total zinc	86	60 (30-90)	62-73 but up to 80
Total copper	79	50 (20-80)	60

8.3 Comparison to Other Literature

In addition to TP10 removal efficiencies, a literature review has also been carried out to determine what the expected performance of the devices would be. Whilst TP10 is the design standard used for the Porters and HJV ponds, other design guidelines require similar sizing of devices and hence reported removal efficiencies are likely to apply.

Table 8-2 below compares removal rates for wet ponds from various literature. “Rate Used” values are those used to determine device performance (see Section 8.4).

Table 8-2: Wet Pond Contaminant Removal Rates

Contaminant	Reduction rate TP10	AC CLM	Reduction rate NZTA	Average Reduction rate CCC (range in brackets)	Rate Used
TSS	50-90 (70)	75	75	70 (60-80)	75
Total phosphorus	55		40	60 (40-80)	50
Total nitrogen	45		25	50 (40-60)	40
Total zinc	60 (30-90)	30	50	60 (40-80)	50
Total copper	50 (20-80)	30	40	60 (40-80)	45

Table 8-3 below compares removal rates for wetlands from various literature.

Table 8-3: Wetland Contaminant Removal Rates

Contaminant	Reduction rate TP10	Reduction rate NZTA	Average Reduction rate CCC (range in brackets)	ARC CLM	Rate Used
TSS	45	90	70 (60-80)	75	70
Total phosphorus		50	60 (40-80)		55
Total nitrogen	33	40	40 (20-60)		35
Total zinc	86	80	60 (40-80)	30	65
Total copper	79	80	60 (40-80)	40	65

Table 8-4 below compares removal rates for swales from various literature.

Table 8-4: Swale Contaminant Removal Rates

Contaminant	Reduction rate TP10	ARC CLM	Reduction rate NZTA	Average Reduction rate CCC (range in brackets)	Rate Used
TSS	85 (73-94)	75	75	40 (20-60)	65
Total phosphorus			30	30 (20-40)	30
Total nitrogen			20	30 (20-40)	30
Total zinc	62-73 but up to 80	40	75	40 (20-60)	60
Total copper	60	50	60	40 (20-60)	50

8.4 Expected Performance

Based on our site observations and reading of the design reports, we are of the opinion that because the wetland/ponds do not have the form of a TP10 wetland, that the treatment performance is not expected to be as high as suggested. The swale performance is however likely to be higher than expected due to the increased residence times. Based on this, we have reassessed the removal efficiencies and have determined a combined removal efficiency based on the use of swales and wet ponds in series on a long term average basis using the NZTA method as used in Lysaght (2103a) and Lysaght (2013b). Our reassessed efficiencies are shown in Table 8-5.

However, as outlined later, we have reservations about the reliability of the combined treatment performance, which tends to overstate the likely performance.

Table 8-5: Reassessed Treatment System Contaminant Removal Efficiency (%)

Contaminant	Lysaght reported Rate	Rate Used
TSS	97	91
Total phosphorus	65	65
Total nitrogen	52	58
Total zinc	95	80
Total copper	92	78

To assess the effects of the developments' treatment systems, an overall contaminant load for the two developments (Porters and HJV) has been calculated and is shown in Table 8-6: Calculated Contaminant Loads and Concentrations – Existing Rural . This has been compared to a calculated existing rural contaminant load for the same land area. For the developed land contaminant load, a pre-treatment and a post-treatment load. For the developed landuse, a pre-treatment contaminant load, as well as a post treatment contaminant load is provided in Table 8-7 below. The calculated contaminant loads have also been converted to an average concentration in order that it can be compared to the ANZECC Guideline Values and MfE guideline values the ICMP targets and objectives.

The following values have been used as part of this assessment

- Annual rainfall depth – 1400 mm (Source: WRC website)
- Runoff coefficient Rural – 0.45 (pervious value for rural area's from 1D modelling report- Beca, 2017)
- Runoff coefficient Industrial – 0.75 (average value from 1D modelling - Beca, 2017)
- Land area – 143.7 ha (Porters and HJV development areas, not including the Shark Fin area)

More detailed calculations are provided in Appendix D.

Table 8-6: Calculated Contaminant Loads and Concentrations – Existing Rural

Contaminant	Contaminant load generated ($g/m^2/year$)	Average concentration (g/m^3)	Guideline g/m^3
TSS	73.5	116.7	No value
Total phosphorus	0.013	0.021	0.015-0.3[a]
Total nitrogen	0.415	0.659	0.04-0.1[a]
Total zinc	0.0081	0.013	0.015[b]
Total copper	0.0024	0.004	0.0018[b]

Note (a): MfE, 2001, (b): ANZECC, 2000. 90% species protection limit based on disturbed environment.

From Table 8.6, it can be seen that the existing rural land use would likely have been generating contaminants at rates higher than the guideline limits for total phosphorus, total nitrogen and total copper (indicated in red).

Table 8-7: Calculated Contaminant Loads and Concentrations - Industrial

Contaminant	Contaminant load generated (g/m²/year)	Removal efficiency %	Contaminant load post treatment (g/m²/year)	Average concentration g/m³	Guideline g/m³
TSS	32	91	2.8	2.7	None
Total phosphorus	0.15	70	0.525	0.050	0.015-0.3
Total nitrogen	0.35	58	1.47	0.14	0.04-0.1
Total zinc	0.49	80	0.098	0.093	0.015
Total copper	0.11	78	0.024	0.022	0.0018

From Table 8.6, it can be seen that the existing rural landuse would likely have been generating contaminants at rates higher than the guideline limits for total phosphorus, total nitrogen and total copper (indicated in red).

Table 8-7 above indicates that even with treatment, it is likely that the guideline values would not be met for metals and nutrients (indicated in red). Table 8-8 below also compares the developed industrial figures against the existing rural values.

Table 8-8: Comparison of Existing Rural with Future Industrial Concentrations

Contaminant	Existing Rural Calculated Concentration (g/m³)	Calculated Industrial Concentration (g/m³)
TSS	111.4	2.7
Total phosphorus	0.021	0.050
Total nitrogen	0.659	0.14
Total zinc	0.013	0.093
Total copper	0.004	0.023

Table 8-8 above indicates even after treatment, discharges of total phosphorus, total copper and total zinc are likely to be higher than existing (red). It is therefore likely that even with the existing treatment (Porters and HJV ponds), it is likely that the ICMP targets of maintaining or enhancing the existing water quality may not be met and will need to be supported by additional on-lot stormwater quality measures.

The residual nutrient concentrations may also contribute to algae growth in locations where there may be slow moving water downstream and also within the wetland/ponds. Given that all flows pass through the treatment devices, it is possible that particulate contaminants (e.g. sediment, metals and nutrients) may re-suspend during high flows and may result in the export from the treatment devices, thus resulting in lower overall treatment performance of the devices.

8.5 Discussion

Whilst the NZTA method results documented above are also used in other reference literature (e.g. Auckland Council's Contaminant Load Model), it is our opinion that this method is not particularly appropriate or effective at estimating overall treatment train treatment efficiencies. This is because it assumes the second device in the treatment train achieves the full removal performance on the residual contaminant flowing to it, when in practice the second device will not achieve full performance. Further, any bypass or incomplete capture of flow in larger storms will still occur in both devices.

This opinion is based on relatively simple sedimentation theory. Whilst other processes occur in treatment devices, especially for nutrients, a large amount of the contaminant removal occurs due to sedimentation, including for TSS and metals, for which the particulate component generally attaches to sediment particles. According to theory, the removal efficiency of sediment relates to the range of sizes of the particles and hence how long they take to drop through the water column.

If, for example, 75% of TSS (standard TP10 device) is removed down to a certain size particle, the remainder of the sediment present after treatment is likely to be very small. When the stormwater enters the next device, this sediment becomes "stirred up" and has to settle through the full water column of the next device. Assuming the retention time and depth of the second device being similar to the first, it is unlikely that these smaller particles will settle out to the same degree as the first device, hence it is not logical that a second device (standard TP10 device) would be able to remove 75% of the sediment which is delivered from the first device. It would likely be much less than this. If the size of the sediment are particularly small to start with e.g. silty and clayey soils in the catchment, the removal will be much less again, often requiring flocculation.

Based on this, it is expected that the values presented in Table 8.5, although lower than the Lysaght's values, these are likely to still be optimistic. This said, without carrying out a detailed assessment, which doesn't form part of this report's scope, the NZTA method still provides a high level (if optimistic) gauge as to performance. The values from Table 8.5 have therefore still been used to carry out the above assessment of the effects of the devices.

9 On-lot Pollution Prevention Regulations

9.1 Introduction

The above sections have identified that the existing treatment systems are not likely to provide high enough levels of treatment to meet the ICMP targets, specifically for nutrients and metals. It is also likely that even with the best practicable option treatment based on current good practice, this is still not likely to be possible. This means that additional measures are required to mitigate the effects of development.

Conventional stormwater treatment systems remove a range of contaminants including those noted in section 7 and 8. Industrial activities are also likely to generate these contaminants. However, these can sometimes be at far higher rates, and non-conventional contaminants may also be generated depending on the nature of industry. Some of these contaminants will be removed by a conventional treatment system e.g. the existing HJV and Porters ponds, but some may not. WRC's Draft Stormwater Management Guideline (WRC, 2017) provides a comprehensive list of industrial activities in Table 11.1. This table lists contaminants of concern associated with each activity as well as a "risk of release rating".]

The most effective way to provide additional mitigation is on-lot via source control, i.e. stopping the contaminants entering the stormwater system in the first place. If source control is not appropriate or practical, additional on-lot treatment measures would need to be implemented. Another advantage of on-lot treatment is that contaminants are more readily removed when the flow and dilution are low (i.e. at source) than when they are mixed with other runoff at larger devices.

Currently, on-lot source control and treatment is required for industries which are listed on the WRC High Risk Facilities Register (HRFR). These industries are also required to prepare a Pollution Control Plan as part of their development, which outlines how the site will be managed to prevent contaminants being entrained and discharged into the stormwater system. The current focus for HCC are "high-risk" industries i.e. those which are likely to produce contaminants which are at high risk of being released into the environment.

The issue then is whether requiring high risk sites to have on-lot treatment be enough to meet the targets. Part of this is whether the current list of high risk sites is appropriate. Given that rates of contaminant generation are likely to be industry specific and highly influenced by site practices, it is difficult to quantify this. As a result it is unclear as to whether medium and low risk sites also need some treatment. On the basis that this ICMP provides design parameters which will govern the design of future centralised and on-lot devices (for sites where no centralised device is provided), it would be reasonable to assume that the future devices will provide a slightly (i.e. wetland efficiency versus wet pond) higher level of treatment than the existing HJV and Porters Devices. Treatment efficiencies of the HJV and Porters devices could also be improved if the recommendations in section 6.5 were implemented. This said, it is not expected that the guideline values will be achieved with such treatment and will therefore need to be supported by additional on-lot treatment measures.

We therefore have the following options as to how to manage this:

- Require all sites which are likely to generate nutrients and metals to prepare a PCP. To determine which industries this may apply to. We have highlighted in red in Appendix E all the medium and low risk industries that would likely generate nutrients or metals. Based on this, the bulk of the list is affected.
- Rely on the trade waste consent process to pick up any industries that are not high-risk but may be generating nutrients or metals. Currently during review of trade waste discharge consents, HCC staff flag to the stormwater engineering team when applications are lodged that may require additional stormwater management measures.

We recommend that the first option is taken as this means that developers know what they need to do by looking at the ICMP early in their design process, rather than later when it is more difficult to incorporate any requirement for on-lot treatment.

9.2 Current Requirements for On-Lot Treatment and Controls

Currently, the main way of HCC controlling on-lot source control and treatment is via requiring developers to prepare a Pollution Control Plan as part of the building consent process when a site is developed. The existing HCC Stormwater Bylaw currently only requires this for activities on the WRC High- Risk Facilities Register (HRFR). As this register is quite limited in nature (as demonstrated in Section 9.3), it is possible that on-lot controls and treatment are not being provided as frequently as required to mitigate effects.

9.3 Review of the WRC High Risk Facilities Register

The current HRFR list of applicable industries is relatively short, therefore this has been compared to the WRC Stormwater Management Guideline list (Table 11.1) and Auckland Councils list of Industrial and Trade Activities to identify gaps that, if filled, would provide a more comprehensive set of industries requiring on-lot treatment and pollution control. This will further help to achieve the ICMP targets.

In comparing the AC and WRC documents, it is recommended that the Stormwater bylaw refer to both the HRFR and the WRC Guideline as this will provide a comprehensive list. There are however gaps i.e. industries listed in the AC list that are not on the other two documents. The ICMP should clearly identify these, or the relevant reference documents should be updated.

Appendix E, provides a list of high risk industries from the AC list which are currently not on the HRFR or on the WRC Stormwater Management Guideline List. It is possible that the bylaw could be changed to only refer to the WRC guideline. If this occurs, Appendix E also provides a list of activities on the HRFR but not in the other two documents i.e. activities that would need to be added to the Guideline list.

During the course of this work, we have also identified that the risk rating of some industries is different across the different documents. Appendix E also provides a list of industries where the rating is different. The reasons for these differences have not been investigated in detail however this should be done if the documents are updated.

Appendix F provides list of recommended updates to the WRC Guideline Industrial Activities list in terms of missing items, and recommended changes to risk ratings.

9.4 Justification

The following statements have been prepared to provide some justification for requiring PCPs and on-lot measures more frequently, and to explain why the regulations need to be made more onerous i.e. more sites required to prepare PCPs and that the plans provide more detailed information.

“The existing Mangaheka industrial area has three treatment and attenuation devices. Future development of greenfields land within the catchment will also need to provide treatment and attenuation. The treatment devices will need to be/have been designed in accordance with ARC’s TP10 plus HCC’s ITS or the new WRC guideline, however such devices are generally only designed to treat typical contaminants and at standard loadings. Depending on the individual lot site practices, it is expected that industries may develop that generate contaminants at higher loadings or containing different contaminants than these standards are intended to apply to. If this is the case, HCC will need to know how these contaminants are managed on the site, prior to discharge to the HCC stormwater network (after it is vested in Council) such that discharges of contaminants are avoided or minimised to typical industry standards.”

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10 Pollution Control Plans

10.1 Overview

The original scope of this work was to provide a template for a Pollution Control Plan. Subsequent to this, HCC has identified that they already have an existing document. This section therefore details a review carried out of this document, against the template previously provided. This HCC template is provided as Appendix H. For reference, our previous template is provided as Appendix I.

10.2 Review of the Existing HCC Pollution Control Plan Template

The existing PCP Plan Template provides a detailed description of what a PCP is and why it is important. It also lays out a template of what is expected in such a plan. This has been compared to our previous template and it is felt that this template is appropriate for the purpose. We do however suggest that the following is added to the existing template:

- References to guideline documents which provide information that would be useful in preparing the plan
- A section describing who has prepared the plan. Refer section 10.3 below
- There are some examples in the table of the template but there needs to be guidance provided on what sorts of controls are required to prevent stormwater contamination and when these are required. This needs to take a risk based approach based on:
  - The size of the site
  - The likely contaminants generated at the site
  - The amount of the contaminant present at the site/likely to be generated by the site
  - How the site operates i.e. likelihood of these being entrained in stormwater
  - How easily contaminants can be removed on-site. This relates to the types of contaminant
  - When additional on-lot treatment is required. For some sites, source control is the only way to reduce contamination as the contaminants are hard to remove once entrained in stormwater. For others, treatment may be an appropriate solution
  - The baseline condition and sensitivity of the receiving environment

In addition we also note that it is not compulsory for sites to submit their PCP to HCC. It is recommended that this is submitted as part of the building consent or discharge consenting process for the site.

The Draft WRC Stormwater Management Guideline also provides details of how to prepare a site plan (section 11.2) and general Industrial site management guidance and should be referred to when developing an Industrial site, whether a PCP is required or not. Table 11.1 also indicates what sort of treatment would be appropriate for the various contaminants generated by industry.

10.3 Who Should Be Preparing the Pollution Control Plan?

It is recommended that a suitably qualified and experienced practitioner will need to prepare PCPs. It is recommended that the person preparing the PCP provides a statement including the following information:

- Name of person who has prepared the plan
- Qualifications of person who has prepared the plan
- A statement of experience which provides information justifying why they are appropriate to prepare such a Pollution Control Plan

It is possible that the owner or developer of the site is the most appropriate person to prepare a PCP, however requiring the above information will give HCC confidence that that person is suitable.

11 Proposed New Devices

11.1 Options Assessment

11.1.1 Introduction

The Mangaheka ICMP will set out requirements for managing water quantity and water quality (amongst other things) for future land development within the catchment. As part of this ICMP, future centralised devices have been identified and sized in order to determine requirements for mitigating effects of future development within the HCC city limits. Sizing of these devices in terms of flood mitigation is provided as part of the 1D Modelling report (Beca, 2017). The below information discusses the options that were considered in terms of both water quantity (flooding) and water quality mitigation. Whilst this report discusses water quality, water quantity is also discussed below as it is possible that combined devices will be constructed in some locations and it is useful to detail the background to this here.

11.1.2 Flood Storage (On-line or off-line)

It is possible to provide both on-line or offline flood storage in a development area.

- By on-line, this means that the flood storage mechanism, sits in the stream or watercourse and the stream flow (both from the development area and from upstream catchments) passes through the device in all events including low flow
- An off-line flood storage device would collect water from a specific sub-catchment or development area and attenuate the peaks prior to discharging to a stream or watercourse

Either of these options can achieve the required outcomes, although fish passage considerations would be important (and can usually be addressed) with the on-line system.

The current Porters and HJV devices are both considered on-line according to the above definitions.

11.1.3 Treatment Bypass options.

The following are options for configuring treatment devices:

- Water quality treatment is provided within a device and higher flows are **bypassed**. Bypass could occur in all events greater than the water quality storm, or greater than the 10 or 100 year event for example, depending on the implications of the larger flows in damaging or affecting performance of a particular device
- All flows are passed through the device, with **no bypass**

The water quality treatment device can be located within the margins of the flood attenuation ponding, but still be off-line from the main stream channel that it discharges to, as in the devices proposed for Mangaheka.

It is recommended that flows higher than the water quality storm are bypassed for the following reasons:

- High flows can cause scouring within the treatment device resulting in sediment generation and potentially stability issues of the slopes of the device (pond/wetland type devices)
- High flows can cause disturbance/dislodging of vegetation within the treatment device, thus requiring maintenance or replanting
- High flows can cause resuspension of sediment and contaminants which have settled on the invert of the device. This can result in export of contaminants from the device.
- Flood water can quickly displace the water quality volume and discharge it after a much shorter detention time

If bypassing all events larger than the water quality storm, it is also possible to configure this in two ways:

- Bypassing the entire device , so bypass flows receive no treatment
- Bypassing after the forebay, where the bulk of larger contaminants settle out

11.1.4 Centralised versus decentralised (on-lot)

Where devices are to be vested in Council, larger centralised devices are generally preferred in order to minimise ongoing operational and maintenance costs. It may also be appropriate in some cases to provide a small treatment device for a particular site or part of a site in order to target a particular contaminant source. This could be done to minimise the size of the device especially where most of a site is not likely to be generating contaminants.

11.1.5 Treatment Types

In terms of treatment, there are a number of types of devices for treating stormwater. These are described in detail in AC's TP10 and WRC's Stormwater Management Guideline. In terms of choosing an appropriate device, this should always be done based on the types of contaminants expected. However HCC also has a list of preferred devices in the Infrastructure Technical Specifications. Based on this, HCC prefer the use of wetlands and raingardens as they generally provide a higher level of treatment for standard contaminants. The HCC Infrastructure Technical Specifications (ITS) should also be referred to for other design guidance and considerations.

11.2 Device Description and Sizing

11.2.1 Introduction

The below sections describe the proposed water quantity mitigation devices proposed as part of Beca, 2017. They also describe the options for how water quality mitigation could be provided in each catchment as well as the water quality volume needing to be stored for each contributing catchment.

Appendix G provides a plan with locations of these devices and the contributing catchments.

11.2.2 Device 5 (Catchment E, G and H))

Device 5 is located and sized to serve several catchments with several land owners. A larger device serving these multiple catchments is proposed. Catchments E and H will be able to drain to the device but catchment G will not due to its location on the east side of the Te Rapa Bypass. Device 5 therefore over attenuates in order to offset the un-attenuated flows from catchment G as well. In order to provide treatment, three devices would likely be required, one to serve catchments E1 and H and separate devices for within catchment G and E2.

11.2.3 Device 6 (Catchment D)

Device 6 (as proposed in Beca, 2017) serves an area of land owned by singled owner. Device 6 is an offline device sized to provide flood mitigation for the areas of land on both sides of the stream (off-set mitigation). Other options that may be considered here are two off-line devices, one on each side of the existing stream, or to realign the stream northwards so that the whole catchment can drain to a single device.

If the watercourse is retained in its current position, treatment for the south-western section of the catchment could be combined in conjunction with the flood mitigation system, for the section of the development on the north side of the stream. Device 7 (Catchment C).

Device 7 is an online flood mitigation device. This proposed device is online due to the location of the stream through the centre of catchment, resulting in it being difficult to have an offline device without realigning the stream. The proposed device relies on flood storage within the existing watercourse flood plain.

In this catchment, there are a large number of lots draining to the device and a large number of different land owners. It is therefore likely to be hard to get all land owners to work together in order to construct a single off-line treatment device. Such a device would also likely require a realignment of the existing watercourse due to its location in the middle of the catchment. Based on this it is recommended that treatment occur offline and then discharge to an online flood storage device which utilises the existing topography.

11.2.4 Water Quality Volumes

In order to provide treatment as well as flood storage with the devices proposed in Beca, 2017, additional storage volume and area will be required as well as specific design of device hydraulics in order to manage the full range of storm events. In order to provide treatment, the water quality volume needs to be stored. This has been calculated and is presented below. As HCC's treatment type preference is for wetlands, we have referred to the Draft WRC Guideline for sizing guidance (see below).

Water Quality Volume calculations are based on a runoff coefficient of 0.75 and a water quality rainfall depth of 22.4 mm. This is 1/3rd of a 2 year 24 hour storm. For clarity, the water quality volumes for each catchment contributing to each device are provided. This has been done as in some locations treatment needs to be provided separately for each catchment due to catchments being physically separated by a stream or other feature, catchments, e.g. Catchment G

- The standard surface area of 3% of the contributing catchment from WRC (2017)
- As an allowance for maintenance (5 m all around)
- Depth has been assumed to be 1 m deep with a normal operating depth of 0.6 m (average- will vary with banded bathymetry) i.e. 0.2m freeboard

Table 11.1 - Device Water Quality Volumes

Device	Catchment	Area requiring treatment (ha) [a]	Water Quality Volume (m^3)	Required Surface Area (m^2)
5[a]	E and H	27.21	4571	14300
	G	3.29	553	2475
6 [b]	D – west side of stream	35.78	6010	18200
	D- east side of stream c	9.27	1557	5600
7[b]	C - west side of stream	11.68	1961	6750
	C- east side of stream	17.53	2945	9600

Note (a) These areas do not include the area of the Te Rapa bypass which has its own separate treatment system (swales). (b) Treatment for this catchment needs to be via two devices, one combined with flood storage device 6 and the other for the catchment on the east side of the stream.

12 Conclusions and Recommendations

Based on our review of the design reports for each of the devices and their treatment performance, as well as literature, we make the following conclusions:

- Existing swales are likely to be providing treatment of an appropriate (or better) standard of treatment due to longer residence times (other than some of the shorter HJV pond swales)
- The wetlands/ponds are considered to be functioning more like wet ponds than wetlands due to their form, therefore treatment is not likely to be as high as for a TP10 wetland,
- Based on our assessment, with the current treatment, it is likely that total nitrogen and total copper levels would be higher than existing and that nutrients (total phosphorus and total nitrogen) and metals (such as total zinc and total copper) would also be higher than ANZECC guidelines. It is therefore possible that the treatment will not meet the ICMP targets and objectives to maintain or enhance the existing water quality in Mangaheka Stream. Overall, it is considered that the existing devices are not likely to be providing appropriate levels of treatment in order to achieve the ICMP targets
- It is likely that there could be high risk industries that develop in the area which would not be required to provide on-lot treatment due to not being included in the WRC High-Risk Facilities register. If such industries develop, it is therefore possible that treatment would not be provided or that it will not be appropriate to achieve the ICMP targets/objectives

Based on our assessment, we make the following recommendations for future actions:

- HCC should consider referring to the Auckland Unitary Plan as part of their management of industrial sites.
- HCC should seek further information in regard to sizing of the Porters and HJV ponds in terms of water quality volume, at the engineering approval stage.
- HCC should investigate the feasibility of implementing the suggested changes to existing devices such that treatment is improved.
- HCC should recommend to WRC that they either :
  - 1. review and update the High Risk Facilities register to include all high risk activities (including those in the WRC Guideline and those in Appendix F that are missing from the WRC Guideline) or:
  - 2. Refer to the WRC SW Guideline list as well as those that are missing or are noted as likely to need a change of rating (Appendix F)
- HCC should review the SW bylaw to also refer to high risk activities on the WRC Stormwater Guideline Industrial Activities list.
- HCC should require all “high risk” industries to prepare a PCP and provide on-lot treatment as well as any industries that are likely to generate nutrients or metals
- HCC should refer developers to the Draft WRC Stormwater Management Guideline in terms of what sorts of on-lot treatment would be appropriate for their activity.
- HCC should update their existing PCP template to include the recommendations suggested in section 10.2.
- HCC should always require developers (who need to) to submit their PCP as part of the building consent/resource consent process. The HCC Stormwater Bylaw wording would need to be updated to do this.

13 References

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Appendix A

WRC High Risk Facilities Register

Activity	Reason for High Risk Classification
1. Mechanical workshops and service stations.	These sites use and handle large volumes of oils and other petroleum products. Spillages of these substances are not uncommon, hence the greater risk of stormwater discharges to the environment.
2. Printers.	Relatively large quantities of dyes and paints are handled at these sites. The risk of spillages is relatively high.
3. Spray painting facilities.	Paints can not only be spilt at these sites but can enter stormwater as a consequence of drift from spray painting operations.
4. Meat, fish and shellfish processing industries.	Wastes from these industries can typically have a high BOD. This can cause significant adverse effects.
5. Dairy products processing.	Wastes from these industries can typically have a high BOD. This can cause significant adverse effects.
6. Waste management sites (transfer stations, compost sites, landfills etc.).	Litter, hazardous substances and high BOD wastes can all enter stormwater systems from these sites.
7. Truck wash facilities	The activity of truck washing can was hazardous contaminants of trucks as well as sediments and wastes from spillages on site.
8. Unenclosed manufacturing and bulk storage of fertiliser.	Fertilisers can give rise to high levels of nutrient in stormwater discharges. Where fertilisers are manufactured or stored in such a way that fertilisers can enter stormwater the risk of adverse effects is unacceptably high.
9. Textile fibre and textile processing industries where dying and washing of fabric occurs.	Large quantities of dye and high BOD wastes (from wool scourers for instance) are handled on these site. The risk of spillages that could enter stormwater is high.
10. Tanneries and leather finishing.	Large quantities of dye and high BOD wastes are handled on these sites. The risk of spillages that could enter stormwater is high.
11. Footwear manufacture.	Large quantities of dye and high BOD wastes are handled on these sites. The risk of spillages that could enter stormwater is higher.
12. Manufacture of paper and paper products.	Hazardous substances such as chlorine based bleaches and dyes are regularly handled on these sites. The risk of spillages etc. entering stormwater can be high.
13. Manufacture or processing of chemicals, and of petroleum, coal, rubber and plastic products.	The risk of spillages associated with hazardous substances used in these industries can be high.
14. Manufacture of clay, glass, plaster, masonry, asbestos and related mineral products.	The risk of spillages associated with hazardous substances used in these industries can be high.
15. Manufacture of fabricated metal products, machinery and equipment.	The risk of spillages associated with hazardous substances used in these industries can be high.
16. Electroplaters, Foundries, galvanizers and metal surfacing.	The risk of spillages associated with hazardous substances used in these industries can be high.
17. Concrete batching plants and, asphalt manufacturing plants.	The risk of spillages associated with hazardous substances used in these industries can be high.
18. Stock saleyards.	High BOD run-off can be associated with these sites.
19. Bakeries.	Outside washing of trays, dishes and pans can result in high BOD, fats, greases and detergents entering stormwater systems.
20. Car wash and valet services.	High oil, solvent and solid discharges can occur from these activities.
21. Commercial laundries (excluding self-service laundrettes and Laundromats).	The risk of spillages associated with detergents, alkalis and salts used in this industry can be high.
22. Furniture/wood manufacturing and refinishing industries.	Some of these industries work outside extensively, usually with no stormwater treatment, Contaminants such as sawdust, glues and alkali stripper solution in the stormwater coming of these sites can include high solids, BOD and high pH.
23. Timber preservation, treatment and storage sites where chemically treated timber is sorted.	A range of hazardous substances are used on these sites (e.g. Copper Chrome, Arsenic, Boron and copper-quinoline compounds). In addition, timber treatment chemicals have been shown to be able to leach from treated wood in storage.

Appendix B

Auckland Unitary Plan – Industrial and Trade Activities

E33. Industrial and trade activities

E33.1. Background

Industrial and trade activities involve the use, handling and storage of environmentally hazardous substances as part of their production and operation. Unless these activities are appropriately managed, hazardous substances can be discharged from the site, as contaminants, onto land or into rivers and streams, groundwater systems and coastal waters. Appropriate management includes:

- disposal as trade waste to the wastewater network;
- collection for disposal or recycling to an appropriate facility;
- treatment onsite prior to discharge to the receiving environment; and
- adoption of appropriate industry standards, site practices, operating procedures and plans.

It is the overriding purpose of the land use provisions to avoid the discharge of contaminants in the first instance. Where the avoidance of discharges cannot be achieved, good onsite management practices remain the primary method of minimising the discharge of environmentally hazardous substances

E33.2. Objective [rcp/rp]

(1) Industrial and trade activities are managed to avoid adverse effects on land and water from environmentally hazardous substances and discharge of contaminants, or to minimise adverse effects where it is not reasonably practicable to avoid them.

E33.3. Policies [rcp/rp]

(1) Manage the use of land for industrial or trade activities to prevent or minimise any adverse effects of storage, use or disposal of environmentally hazardous substances.

(2) Require industrial or trade activities to have, where reasonably practicable, onsite management systems, processes, containment, treatment, or disposal by lawful means.

(3) Require measures to be implemented, where contaminants cannot be disposed as trade waste to the wastewater network or contained on site, to minimise adverse effects on land and water including:

(a) reducing contaminant volumes and concentrations as far as practicable; and

(b) applying measures, including treatment, management procedures, monitoring, controls, or offsite disposal, having regard to the nature of the discharge and the sensitivity of the receiving environment.

E33.4. Activity table

Table E33.4.1 specifies the activity status of use of land for industrial or trade activities pursuant to section 9(2) of the Resource Management Act 1991.

The industrial or trade activity land use and discharge rules address stormwater quality aspects of the discharge of contaminants from an industrial or trade activity area. The rules should be read in conjunction with E31 Hazardous substances, E8 Stormwater – Discharge and diversion and relevant zone rules.

For the purposes of this section ‘existing’ means existing at the date of notification of the Proposed Auckland Unitary Plan, being 30 September 2013.

Table E33.4.1 Activity Table – Use of land for an industrial or trade activity

Activity		Activity status
Consented industrial or trade activities		
(A1)	Use of land for an industrial or trade activity that is authorised by a resource consent to discharge contaminants	P
(A2)	Use of land for an industrial or trade activity that is listed in Appendix 22 Consented existing high risk industrial or trade activities and for which the specified consent(s) has not expired or may be exercised under section 124(1) and (3) of the Resource Management Act 1991	P
Unlisted industrial or trade activities		
(A3)	Use of land for an existing or new industrial or trade activity not listed in Table E33.4.3	P
Low risk industrial or trade activities		
(A4)	Use of land for an existing or new industrial or trade activity listed as low risk in Table E33.4.3	P
Moderate risk industrial or trade activities		
(A5)	Use of land for an Existing or new industrial or trade activity listed as moderate in Table E33.4.3	P
High risk industrial or trade activities		
Existing sites		
(A6)	Use of land for an existing industrial or trade activity listed as high risk in Table E33.4.3 (before the Table E33.4.3 timeframe expires)	P
(A7)	Use of land for an existing industrial or trade activity listed as high risk in Table E33.4.3 (after the Table E33.4.3 timeframe expires)	C
New sites		
(A8)	Use of land for a new industrial or trade activity listed as high risk in Table E33.4.3	C

Unlisted, low, moderate and high risk industrial or trade activities that do not meet the relevant land use standards		
(A9)	Any activity in this table that does not meet the relevant permitted or controlled land use standards	D

Table E33.4.2 Activity table – Discharge of contaminants from an industrial or trade activity area

Table E33.4.2 specifies the activity status of discharges of contaminants from industrial or trade activity areas pursuant to section 15 section of the Resource Management Act 1991.

The industrial or trade activity land use and discharge rules address stormwater quality aspects of the discharge of contaminants from an industrial or trade activity area. The rules should be read in conjunction with E31 Hazardous substances, E8 Stormwater – Discharge and diversion and relevant zone rules.

For the purposes of this section 'existing' means existing at the date of notification of the Proposed Auckland Unitary Plan, being 30 September 2013.

Activity		**Activity status**
Consented industrial or trade activities		
(A10)	The discharge of contaminants from an industrial or trade activity that is authorised by a resource consent to discharge contaminants.	P
Unlisted industrial or trade activity areas		
(A11)	Discharge of contaminants from an existing or new industrial or trade activity area not listed in Table E33.4.3	P
(A12)	Discharge of contaminants from an existing or new industrial or trade activity area not listed in Table E33.4.3 where the permitted discharge standards are not met	C
(A13)	Discharge of contaminants from an existing or new industrial or trade activity area not listed in Table E33.4.3 where the controlled discharge standards are not met	D
Low risk industrial or trade activity areas		
(A14)	Discharge of contaminants from an existing or new industrial or trade activity area listed as low risk in Table E33.4.3	P
(A15)	Discharge of contaminants from an existing or new industrial or trade activity area listed as low risk in Table E33.4.3 where the permitted discharge standards are not met	C
(A16)	Discharge of contaminants from an existing or new industrial or trade activity area listed as low risk in Table E33.4.3 where the controlled discharge standards are not met	D
Moderate risk industrial or trade activity areas		

(A17)	Discharge of contaminants from an existing or new industrial or trade activity area listed as moderate risk in Table E33.4.3	P
(A18)	Discharge of contaminants from an existing or new industrial or trade activity area listed as moderate risk in Table E33.4.3 where the permitted discharge standards are not met	C
(A19)	Discharge of contaminants from an existing or new industrial or trade activity area listed as moderate risk in Table E33.4.3 where the controlled discharge standards are not met	D
High risk industrial or trade activity areas		
Existing sites		
(A20)	Discharge of contaminants from an existing industrial or trade activity area listed as high risk in Table E33.4.3 (before the Table E33.4.3 timeframe expires)	P
(A21)	Discharge of contaminants from an existing industrial or trade activity area listed as high risk in Table E33.4.3 (before the Table E33.4.3 timeframe expires) where the permitted discharge standards are not met	C
(A22)	Discharge of contaminants from an existing industrial or trade activity area listed as high risk in Table E33.4.3 (before the Table E33.4.3 timeframe expires) where the controlled discharge standards are not met	D
(A23)	Discharge of contaminants from an existing industrial or trade activity area listed as high risk in Table E33.4.3 (after the Table E33.4.3 timeframe expires)	D
New sites		
(A24)	Discharge of contaminants from a new industrial or trade activity area listed as high risk in Table E33.4.3	D

Table E33.4.3 Activity table – Industrial or trade activity risk criteria

Table E33.4.3 contains a list of industrial or trade activity risk criteria to assist in application of Table E33.4.1 and Table E33.4.2.

The industrial or trade activity land use and discharge rules address stormwater quality aspects of the discharge of contaminants from an industrial or trade activity area. The rules should be read in conjunction with E31 Hazardous substances, E8 Stormwater – Discharge and diversion and relevant zone rules.

For the purposes of this section 'existing' means existing at the date of notification of the Proposed Auckland Unitary Plan, being 30 September 2013.

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
Agricultural support industries	Inorganic fertiliser manufacture, storage or handling	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
Animal feedstuffs	Stock food manufacture storage or handling	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Pet food manufacture	Less than 1000m^2	1,000m^2 to 5000m^2	More than 5,000m^2	12
Chemical and associated product manufacturing	Batteries	Activity is never low risk	No activity area	Any activity area	12
	Cosmetics, toiletry, soap and other detergents	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Explosives and pyrotechnics	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Fungicides, herbicides, pesticides, timber preservatives and related products	Activity is never low risk	No activity area	Any activity area	12
	Industrial Gas	Activity is never low risk	Less than 5,000m^2	More than 5,000m^2	12
	Medicinal, pharmaceutical or veterinary products	Less than 1000m2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Paint, pigment, inks and dyes	Less than 1000m2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Polishes, adhesives or sealants	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m2	12
	Solvents	Less than 1000m^2	1,000m2 to 5,000m2	More than 5,000m2	12
	Synthetic resins	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Acids, alkalis or heavy metals	Activity is never low	No activity area	Any activity area	12
	Other chemical products (e.g. plastic manufacturing)	Less than 1000m^2	1,000m^2 to 5000m^2	More than 5,000m^2	12
Commercial livestock	Slaughter	Less than 1000m^2	1,000m^2 to 5000m^2	More than 5,000m^2	12

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
processing industries	Manufacture, store or handle products derived from animal slaughter (e.g. gelatin, fertiliser or meat products)	Less than 1000m^2	1,000m^2 to 5000m^2	More than 5,000m^2	12
	Scouring or carbonising greasy wool or fleeces	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Tanneries or Fellmongeries	Activity is never low risk	No activity area	Any activity area	12
	Rendering or fat extraction	Activity is never low risk	No activity area	Any activity area	12
Electronics	Circuit board manufacturing (excluding assembly only)	Activity is never low risk	No activity area	Any activity area	12
Food or beverage manufacturing or handling	Bakery product manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Bakery product handling	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A
	Beverages or malt product manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Beverages or malt product handling	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A
	Flour mill or cereal foods	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Meat and meat product manufacture (including fish)	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Meat product handling (including fish)	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A
	Oil or fat product manufacturing or handling	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Processed dairy foods manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Processed dairy foods handling	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
	Vineyards or wine manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Other foodstuffs manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Other foodstuffs handling	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A
Research or defence	Research establishments	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A
	Naval and Air Force defence activities	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	0
Machinery or equipment manufacturing	Industrial machinery or equipment	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Motor vehicles or parts	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Other machinery or equipment	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
Metal product manufacturing	Sheet and structural metal products	Less than 1000m^2	More than 1,000m^2	Activity is never high risk	N/A
Motor vehicle services facilities	Existing or new service stations that comply with the Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand, Ministry for the Environment, December 1998	Activity is never low risk	Activity is always moderate risk	Activity is never high risk	N/A
	All other service stations	Activity is never low risk	Activity is never moderate risk	Activity is always high risk	12
	Mechanical servicing of motor vehicles	Activity is never low risk	Activity is always moderate risk	Activity is never high risk	N/A

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
Non-metallic mineral product manufacturing	Cement, lime, plaster and concrete products	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Concrete batching plants - ready mixed concrete	Activity is never low risk	No activity area	Any activity area	12
	Glass	Activity is never low risk	Less than 5,000m^2	More than 5,000m^2	12
Metal processing, metallurgical works or metal finishing	Metal plating, anodising or polishing	Activity is never low risk	No activity area	Any activity area	0
	Metal blasting or coating, excluding spray painting	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Refinement of ores	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Processing of metals e.g. smelting, casting	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
Petroleum or coal product manufacturing	Bitumen/asphalt premix or hot mix	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Coal products	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Petroleum refining	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Petroleum hydrocarbon, oil or grease manufacturing	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
Power	Electricity generation	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
Product storage or handling centres	Bulk chemicals	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Bulk hydrocarbons - non-service station	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
Recycling, recovery, reuse or	Automotive dismantling	Activity is never low risk	No activity area	Any activity area	12

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
disposal	Batteries	Activity is never low risk	No activity area	Any activity area	12
	Chemicals	Activity is never low risk	No activity area	Any activity area	12
	Crushing, grinding or separation works other than sand, gravel, rock or mineral e.g. slag, road base, demolition material	Activity is never low risk	Less than 5,000m^2	More than 5,000m^2	12
	Hazardous materials storage or treatment	Activity is never low risk	No activity area	Any activity area	12
	Landfills	Activity is never low risk	No activity area	Any activity area	12
	Metals - crushing, grinding, sorting or storage	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	0
	Non-metal recycling e.g. composting, glass, paper or paper board	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Oil, petroleum hydrocarbon wastes	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Chemical containers cleaning reconditioning, or recycling	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Sewage solids treatment or storage facilities	Activity is never low risk	No activity area	Any activity area	12
	Tyres	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
	Waste transfer stations	Activity is never low risk	No activity area	Any activity area	12
Rubber industries	Tyre manufacturing or retreading	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
	Synthetic rubber manufacturing	Less than $1000m^2$	$1,000m^2$ to $5,000m^2$	More than $5,000m^2$	12
Transport and related activities	Boat or ship construction, repair or maintenance	Less than $1000m^2$	$1,000m^2$ to $5,000m^2$	More than $5,000m^2$	0
	Bus depots	Activity is never low risk	Less than $5,000m^2$	More than $5,000m^2$	12
	Commercial airports other than Auckland International Airport Limited	Activity is never low risk	Less than $1,000m^2$	More than $1,000m^2$	12
	Auckland International Airport Limited activities contained within the secure area as declared from time to time by the Director of Civil Aviation under section 84 of the Civil Aviation Act 1990 provided that the stormwater runoff from that secure Area complies with Stormwater Management Devices: Design Guidelines Manual second edition, May 2003, Technical Publication 10	Activity is never low risk	Activity is always moderate risk	Activity is never high risk	N/A
	Heliports other than Auckland International Airport Limited	Activity is never low risk	Less than $1,000m^2$	More than $1,000m^2$	12
	Road freight transport depot (non-chemical) with mechanical servicing	Less than $1000m^2$	More than $1,000m^2$	Activity is never high risk	N/A
	Road freight transport depot (bulk chemical)	Activity is never low risk	Less than $1,000m^2$	More than $1,000m^2$	12
	Railway workshops or refuelling depots	Less than $1000m^2$	$1,000m^2$ to $5,000m^2$	More than $5,000m^2$	12
	Shipping container reconditioning (not located at port areas)	Less than $1000m^2$	More than $1,000m^2$	Activity is never high risk	N/A

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
	Commercial ports (including the Ports of Auckland Limited), shipping container reconditioning, and shipping loading/unloading	Activity is never low risk	Less than 5,000m^2	More than 5,000m^2	12
	Existing or new truck refuelling facilities (non-service stations) that comply with the Environmental Guidelines for Water Discharges from Petroleum Industry Sites in New Zealand, Ministry for the Environment, December 1998	Activity is never low risk	Less than 1,000m^2	More than 1,000m^2	12
Wood or paper product storage, manufacturing or fabrication	Log storage yards outside forested areas	Activity is never low risk	Less than 5,000m^2	More than 5,000m^2	12
	Plywood or veneer manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Particle board or other wood panel manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Pulp, paper or paper board manufacturing	Less than 1000m^2	1,000m^2 to 5,000m^2	More than 5,000m^2	12
	Timber treatment	Activity is never low risk	Activity is never moderate risk	Any activity area	0
	Treated timber storage	Activity is never low risk	Less than 5,000m^2	More than 5,000m^2	12
Sewage treatment and handling	Environmentally hazardous substances storage or use (excluding sewage)	Activity is never low risk	No activity area	Any activity area	12

Description of Industrial or trade activity		Low risk	Moderate risk	High risk	Time-frame (mths)
(excluding any part of a sewage conveyance network as that network does not form an industrial or trade activity for the purposes of the industrial or trade activity rules	Sewage solids storage.	Less than $1000m^2$	$1,000m^2$ to $5,000m^2$	More than $5,000m^2$	12

Note 1

The risk is based on the size of the industrial or trade activity area. The level of risk e.g. low, moderate or high, determines the type of authorisation required for the activity. Thereafter compliance or otherwise with the provisions of the industrial or trade activity rules, or changes to the size of the industrial or trade activity area, dictate the site's status and therefore the site's risk status can change over time.

Note 2

Some activities are categorised as moderate risk even if they have no industrial or trade activity area.

Note 3

Timeframes should be interpreted as the number of months after this chapter of the Auckland Unitary Plan becomes operative.

Note 4

If the timeframe is 0, this means the timeframe expires the date the provisions becomes operative.

Note 5

The timeframes apply to high risk activities only.

Note 6

The owners or operators of high-risk industrial or trade activity whose permitted activity status expiry dates are approaching should commence the preparation of an Environmental Management Plan for the activity.

Note 7

Electrical substations that contain 1,000 litres or less of oil, are not considered an industrial or trade activity for the purposes of the plan.

E33.5. Notification

(1) An application for resource consent for a controlled activity listed in Table E33.4.1, Table E33.4.2 and Table E33.4.3 will be considered without public or limited notification or the need to obtain written approval from affected parties unless the Council decides that special circumstances exist under section 95A(4) of the Resource Management Act 1991.

(2) Any application for resource consent for an activity listed in Table E33.4.1, Table E33.4.2 and Table E33.4.3 and which is not listed in E33.5(1) will be subject to the normal tests for notification under the relevant sections of the Resource Management Act 1991.

(3) When deciding who is an affected person in relation to any activity for the purposes of section 95E of the Resource Management Act 1991 the Council will give specific consideration to those persons listed in Rule C1.13(4).

E33.6. Standards

E33.6.1. Permitted activities

Activities listed as a permitted activity in Table E33.4.1, Table E33.4.2 and Table E33.4.3 must comply with the following permitted activity standards except activities (A1) and (A2) from Table E33.4.1 and Activity (A10) from Table E33.4.2 do not have to comply with the permitted activity standards.

E33.6.1.1. Use of land for an industrial or trade activity

Activities listed as a permitted activity in Table E33.4.1 must comply with Standards E33.6.1.1(1) to E33.6.1.1(12). In addition, activities (A17) and (A20) in Table E33.4.2 must also comply with Standards E33.6.1.1(13) and E33.6.1.1(14).

(1) Wastewater and washwater produced by industrial or trade activities must be disposed of on-site via the sanitary sewer, subject to approval from Watercare, or it must be collected, either for recycling or disposal, to a system or facility with all the appropriate authorisations to accept wastewater of that type. For the purposes of this rule, wastewater or washwater also includes:

(a) boiler blow down and condensate;

(b) all waste liquids generated or collected as part of an industrial or trade activity;

(c) cooling tower water excluding vapour; and

(d) condensate from air compressors.

(2) A spill response plan is prepared where any environmentally hazardous substance is handled, used or stored on land at a quantity greater than used for domestic purposes. These plans must meet the requirements of Table E33.9.1 as relevant and be supplied to the Council on request.

(3) For environmentally hazardous substances in quantities covered by Part 4 of the Hazardous Substances (Emergency Management) Regulations 2001, a spill response plan prepared in accordance with those regulations will be considered to comply with Standard E33.6.1.1(2) provided the emergency spill response plan also explicitly addresses matters (vi) to (x) in Table E33.9.1.

(4) For environmentally hazardous substances not covered by Part 4 of the Hazardous Substances (Emergency Management) Regulations 2001, a spill response plan prepared in accordance with Council's factsheet 'Being Prepared for a Spill' will be considered to comply with Standard E33.6.1.1(2).

(5) When the quantity of environmentally hazardous substances stored above the ground exceeds that used for domestic purposes, it must be stored:

(a) in a container and in a manner that prevents the entry of rainwater into the container; and

(b) within a secondary containment device or within a containment system that is constructed of impervious materials that are resistant to chemical attack from the substances contained therein.

(6) For environmentally hazardous substances in quantities covered by Part 4 of the Hazardous Substances (Emergency Management) Regulations 2001, storage requirements in accordance with those regulations will be considered to comply with Standard E33.6.1.1(5).

(7) For environmentally hazardous substances not covered by Part 4 of the Hazardous Substances (Emergency Management) Regulations 2001, storage requirements in accordance with council's factsheet 'Above Ground Storage' noting the following bund sizing criteria for secondary stage storage, will be considered to comply with Standard E33.6.1.1(5) where:

(a) for tanks the bund has a storage capacity of at least 110 per cent of the capacity of the largest tank taking into account the volume displaced by any equipment and/or materials stored within the bund; and

(b) for drums the bund has an effective storage height of at least 100mm, allowing for any sloping ground, and the bund is set back from the drums by a distance equal to half the height of the stacked or stored drums.

(8) All secondary containment devices must be designed, constructed and managed so that uncontaminated rainwater and stormwater runoff is prevented from flowing into the contained area.

(9) Weekly inspections must be undertaken and recorded to check that environmentally hazardous substances are stored and/or contained appropriately except as follows:

(a) National Grid - monthly inspections;

(b) electricity substations – annual inspections; and

(c) unmanned depots or facilities - monthly inspections.

(10) A regular reconciliation process must be undertaken for any environmentally hazardous substance stored in an underground storage tank that will identify any leakage or unaccounted losses of material from the tank.

(11) Any waste compactors and bins must be located and operated in such a manner that prevents leachate or waste leaking from them.

(12) All on-site vehicle re-fuelling areas must be segregated and housed under cover, and/or surrounded by a drain that drains to an appropriately designed and sized stormwater treatment and spill containment device fitted with a shut-off valve.

(13) Operations must be undertaken in accordance with an environmental management plan specific to the industrial or trade activity. This plan must be prepared in accordance with Table E33.9.2, and supplied to Council upon request.

(14) Where the industrial or trade activity is located within a sewage treatment facility then the wastewater generated on site by that industrial or trade activity may be disposed of within that facility.

E33.6.1.2. Discharge from an industrial or trade activity area

Activities listed as a permitted activity in Table E33.4.2 must comply with the following standard.

(1) The discharges of contaminants from an industrial or trade activity area must result in less than minor adverse environmental effects on the receiving environment without the need for stormwater treatment (with the exception of on-site vehicle refuelling areas requiring stormwater treatment and spill contaminant devices under the permitted activity Standard E33.6.1.1(12).

E33.6.2. Controlled Activities

E33.6.2.1. Use of land for an industrial or trade activity

Activities listed as a controlled activity in Table E33.4.1 must comply with the following standard.

(1) The activity must comply with ‘Use of land for an industrial or trade activity’ permitted activity standards E33.6.1.1(1) to E33.6.1.1(12).

E33.6.2.2. Discharge from an industrial or trade activity area

Activities listed as a controlled activity in Table E33.4.2 must comply with the following standards.

(1) The activity must comply with the relevant ‘Use of land for an industrial or trade activity’ in Standard E33.6.1.1.

(2) Treatment devices to treat the discharge of contaminants from the industrial or trade activity area are installed and operated to avoid, remedy of mitigate adverse environmental effects.

E33.7. Assessment – controlled activities

E33.7.1. Matters of control

The Council will reserve its control to all of the following matters when assessing a controlled activity resource consent application:

(1) management practices, treatment systems or devices, to the extent that they are required to avoid remedy or mitigate adverse environmental effects, having regard to:

(a) the degree to which the land use controls avoid or minimise the risk of discharge contaminants from the industrial or trade activity area; and

(b) the nature and sensitivity of the receiving environment and its susceptibility to the adverse effects of the contaminants of concern.

(2) the operation and maintenance requirements of any structural controls or treatment devices.

E33.7.1.1. Assessment criteria

The Council will consider the relevant assessment criteria below for controlled discretionary activities:

(1) policies in E33.3 Policies.

E33.8. Assessment - Restricted discretionary activities

There are no restricted discretionary activities in this section.

E33.9. Special information requirements

Table E33.9.1 Spill response plan requirements

No.	Requirement

i.	A protocol/method for identifying and stopping the discharge of environmentally hazardous substances to land or water and avoiding future events of this nature
ii.	Emergency containment and clean-up procedures
iii.	A list of appropriate spill kit contents to enable the containment and/or absorption of spilt material and a plan showing the location of the spill kits
iv.	A requirement for appropriate signage to identify the location of spill kits and the actions to be taken in the event of a spill
v.	Actions to remedy or mitigate any adverse effects on the environment or public health and safety arising from the discharges or spills of environmentally hazardous substances to land or water
vi.	Methods for disposal of spilt environmentally hazardous substances and any other contaminated materials used in the spill clean-up
vii.	A schedule of adequate training for personnel in the use of the emergency spill response plan and in anticipating and preventing the likelihood of spills
viii.	Up-to-date and accurate copies of all drainage plans for the land on which the industrial or trade activity is undertaken showing the location of the final discharge point to the public stormwater system or to land or water
ix.	A procedure for notifying as soon as practicable Council's 24-hour emergency response service and the relevant stormwater or wastewater network operator in the event of any discharge of environmentally hazardous substances that results in, or is likely to result in, contamination of any stormwater system, or land or water
x.	Methods for disposing of any spills in a secondary containment device. The plan must set out how it will be disposed of in an appropriate and authorised manner

Table E33.9.2 Environmental management plan requirements

No.	Requirement
i.	Specify how the permitted activity controls will be complied with
ii.	Identify the environmentally hazardous substances associated with the industrial or trade activity
iii.	Set out the methods to be used to avoid discharges of environmentally hazardous substances onto or into land or water
iv.	For discharge of contaminants arising from land on which the industrial or trade activity is undertaken, set out the primary treatment or source control methods that may be necessary to avoid, remedy or mitigate more than minor adverse effects on the receiving environment
v.	Specify the methods for the operation and maintenance of any treatment devices on site
vi.	Identifies assessment requirements to report on the performance of the environmental management plan

Note 1

The environmental management plan must be appropriate to the scale and significance of the risk at each site. Where appropriate, the environmental management plan may include cross references to relevant documentation that is readily accessible at the site, rather than including the full documents themselves.

Appendix C

WRC Stormwater Management Guideline Table 11.1 – Industrial Activities

Industrial Activity	Description of Trade	Contaminants of Concern	Likelihood of Release	Treatment Processes
Wood or paper product storage, manufacturing or fabrication	Treated timber storage	Cu, Cr, As, TSS	High	Settling, sand/peat filter
Wood or paper product storage, manufacturing or fabrication	Timber treatment	Cu, Cr, As, Sn, TSS, Oil and Grease, pesticides	High	Sand/peat filter
Transport and related activities	Boat or ship construction, repair or maintenance	Cu, Zn, TSS, Oil and Grease	High	Settling, oil/water separator, sand/peat/carbon filter
Research or defence	Naval and air force defence activities	Metals, pesticides, oil and grease	High	Settling, , oil/water separator, sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Metals (crushing, grinding, sorting or storage)	Oil and grease, TSS, Zn, Cu, Pb, Cd, Cr	High	Oil/water separator, sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Automotive dismantling	Oil and grease, TSS, particulate metals, Zn, Cu, Pb, Cd, Cr	High	Coarse settling, oil/water separator, sand/peat/carbon filter
Metal processing, metallurgical works or metal finishing	Processing of metals (smelting, casting)	Metals (Al, Pb, Zn, Cu, Fe), TSS, pH	High	Sand/peat/carbon filter
Metal processing, metallurgical works or metal finishing	Metal plating, anodising or polishing	Metals (Zn, Cu, Cr, Ni, Ag), pH, Cyanide	High	Peat filter
Transport and related activities	Marinas	TSS, Zn, Cu	Medium	Peat filter
Sewage treatment and handling	Sewage treatment plants	TSS, BOD, NO_3+NO_2, NH_3, Pathogens	High	Settling, wetlands, disinfection
Sewage treatment and handling	Sewage solids storage	TSS, BOD, NO_3+NO_2, NH_3, Pathogens	Low	Settling, wetlands, disinfection
Rubber industries	Synthetic rubber manufacturing	Zn, TSS, organics	Medium	Wetlands
Recycling, recovery, reuse or disposal	Tyres	Zn, TSS	High	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Chemical containers cleaning, reconditioning or recycling	Metals, COD, NO_3+ NO_2	Medium	GPT screen, coarse settling, oil/water separator, oxidation sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Waste transfer stations	GPs, TSS, COD, Metals, Oil & Grease, residual organic compounds	Medium	GPT screen, coarse settling, oil/water separator, oxidation, sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Hazardous materials storage or treatment	TSS, COD, Metals, Oil and Grease, organics	Medium	Sand/peat/carbon filter

Recycling, recovery, reuse or disposal	Non-metal recycling (composting, glass, paper or paper board	TSS, COD, NO_3+ NO_2, pathogens	High	Wetlands + oxidation
Recycling, recovery, reuse or disposal	Crushing, grinding or separation works (other than sand, gravel, rock or mineral - e.g. slag, road base, demolition material)	TSS, pH, Zn	High	Sand/peat filter, wetlands
Recycling, recovery, reuse or disposal	Landfills	Metals, TSS, BOD, No_3+NO_2, NH_3, organics	Low	Coarse settling, oil/water separator, oxidation, sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Chemicals	Fe, Al, pH, No_3+NO_2, metals, organics	Low	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Batteries	Pb, pH	Low	Sand/peat filter, carbonate filter
Product storage or handling centres	Bulk chemicals	AL, Fe, Zn, No_3+NO_2	Medium	Sand/peat/carbon filter
Petroleum or coal product manufacturing	Coal products	TSS, AL, Fe, pH	Medium	Settling, wetlands
Non-metallic mineral product manufacturing	Cement, lime, plaster and concrete products	TSS, Fe, pH, Oil and Grease	High	Settling, wetlands
Non-metallic mineral product manufacturing	Concrete batching plants (ready mixed concrete)	TSS (lime), pH	High	Settling, wetlands
Motor vehicle services facilities	Mechanical servicing of motor vehicles	Oil and grease, metals	High	Sand/peat/carbon filter
Motor vehicle services facilities	Service stations	Oil and grease, PAH, BTEX, TSS	High	Oil/water separator, sand filter, oxidation
Metal processing, metallurgical works or metal finishing	Refinement of ores	TSS, metals	Medium	Settlement, wetland
Metal processing, metallurgical works or metal finishing	Metal blasting or coating (excluding spray painting)	Zn, other metals, TSS	High	Sand/peat filter
Electronics	Circuit board manufacturing (excluding assembly only)	Metals (Zn, Cu, Cr, Ni), pH, organics	Medium	Sand/peat filter
Commercial livestock processing centres	Tanneries and Fellmongeries	BOD, oil and grease, sulfides, Cr, N	High	Oil/water separator, oxidation, peat filter
Chemical and associated product manufacturing	Fungicides, herbicides, pesticides, timber preservatives and related products	COD, pH, As, Cu, Cr, Pesticides	Medium	Sand/peat/carbon filter

Chemical and associated product manufacturing	Batteries	Pb, pH	Medium	Sand/peat filter, carbonate filter
Chemical and associated product manufacturing	Paint, pigment, inks and dyes	Al, Zn, Fe, COD, organics	Medium	Sand/peat/carbon filter
Chemical and associated product manufacturing	Acids, alkalis or heavy metals	PH, TSS, metals	Medium	Sand/peat/carbon filter, carbonate filter
Transport and related activities	Railway workshops or refuelling depots	Oil and grease, TSS, COD, Zn	Medium	Settlement, sand/peat filter
Transport and related activities	Road freight transport depot (bulk chemical)	Oil and grease, TSS, COD, Zn, organics	Medium	Sand/peat/carbon filter, oxidation
Transport and related activities	Truck refuelling facilities (non-service station)	TPH, PAH	Medium	Sand/peat filter
Transport and related activities	Shipping container reconditioning	Oil and grease, TSS, COD	Medium	Oil/water separator, Settlement
Rubber industries	Tyre manufacturing or retreading	Zn, TSS, organics	Medium	Sand/peat filter
Recycling, recovery, reuse or disposal	Oil, petroleum hydrocarbon wastes	Oil and grease, PAH, BTEX	Medium	Oil/water separator, sand/carbon filter
Recycling, recovery, reuse or disposal	Sewage solids treatment or storage facilities	TSS, BOD, No_3+NO_2, Pathogen	Medium	Retention, oxidation
Product storage or handling centres	Bulk hydrocarbons (non-service stations)	Oil and grease, PAH, BTEX	Medium	oil/water separator, sand/peat/carbon filter
Power	Gas, coal or liquid power generation	Oil and grease, Zn, TSS	Medium	oil/water separator, wetlands
Power	Electrical substations	Oil and grease	medium	Sand filter
Petroleum or coal product manufacturing	Bitumen/asphalt premix or hot mix	TSS, Zn, TPH	Medium	oil/water separator, Sand/carbon filter
Animal feedstuffs	Pet food manufacture	BOD	Medium	Sand/peat filter, swales
Agriculture support industries	Inorganic fertiliser manufacture, storage or handling	COD, TSS, Pb, Fe, Zn, P	Medium	Sand/peat filter, high plant surface area and soil organics
Wood or paper product storage, manufacturing or fabrication	Log storage yards (outside of forested areas)	TSS, COD, NO_3+NO_2	High	Wetlands
Chemical and associated product manufacturing	Synthetic resins	TPH, pH, Zn	Low	Sand/peat filter
Chemical and associated product manufacturing	Solvents	TPH	Low	Sand filter
Chemical and associated product manufacturing	Explosives and pyrotechnics	Metals (Pb, Zn), VOC's	Low	Sand/peat/carbon filter

Wood or paper product storage, manufacturing or fabrication	Particle board or other wood panel manufacturing	TSS, COD, NO_3+NO_2, oil and grease	Medium	GPT, Settling, sand filter
Wood or paper product storage, manufacturing or fabrication	Pulp, paper or paper board manufacturing	TSS, COD, NO_3+NO_2, oil and grease, Zn	Medium	Wetlands, oil/water separator
Wood or paper product storage, manufacturing or fabrication	Plywood or veneer manufacturing	TSS, COD, NO_3+NO_2, organics	Medium	Wetlands
Transport and related activities	Shipping, loading/unloading	Oil and grease, TSS, COD	Medium	Oil/water separator, sand/peat filter
Transport and related activities	heliports	Oil and grease, TSS, COD		Oil/water separator, sand/peat filter
Transport and related activities	Toad freight transport depot (non-chemical) with mechanical servicing	Oil and grease, TSS, metals	High	Oil/water separator, sand/peat filter
Petroleum or coal product manufacturing	Petroleum refining	Oil and grease, PAH, BTEX	Medium	Oil/water separator, sand/carbon filter
Petroleum or coal product manufacturing	Petroleum hydrocarbon, oil or grease manufacturing	Oil and grease, PAH, BTEX	Low	Oil/water separator, sand/carbon filter
Non-metallic mineral product manufacturing	Glass	Oil and grease, BOD, TSS	Medium	Oil/water separator, sand/peat filter
Metal product manufacturing	Sheet and structural metal products	Fe, Al, Zn	Medium	Sand/peat filter
Machinery or equipment manufacturing	Other machinery or equipment	Oil and grease, Fe, Al, Zn	Medium	Sand/peat filter
Machinery or equipment manufacturing	Industrial machinery or equipment	Oil and grease, Fe, Al, Zn	Medium	Sand/peat filter
Food or beverage manufacturing or handling	Vineyards or wine manufacturing	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Processed dairy foods manufacturing	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Oil or fat product manufacturing or handling	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Meat and meat product manufacture (including fish)	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Processed dairy foods handling	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Other foodstuffs handling	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area

Food or beverage manufacturing or handling	Meat product handling (including fish)	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Beverages or malt product handling	BOD, TSS, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Bakery product handing	BOD, TSS, oil and grease	Medium	Oil/water separator, high plant activity and surface area
Commercial livestock processing industries	Slaughter	BOD, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Commercial livestock processing industries	Manufacture, store or handle products derived from animal slaughter (gelatin, fertiliser or meat products	BOD, oil and grease, N	Medium	Oil/water separator, high plant activity and surface area
Commercial livestock processing industries	Scouring or carbonising greasy wool or fleeses	BOD, oil and grease, N	Medium	Oil/water separator, oxidation
Commercial livestock processing industries	Rendering or fat extraction	BOD, oil and grease	Medium	Oil/water separator, oxidation
Chemical and associated product manufacturing	Other chemical products (plastic manufacturing	pH, TSS, Zn, N	Low	Sand/peat filter
Chemical and associated product manufacturing	Polishes, adhesives or sealants	BTEX, pH, Zn	Low	Sand/peat/carbon filter
Chemical and associated product manufacturing	Medicinal, pharmaceutical or veterinary products	COD, As, Cd, Cr, Phenol	Low	Sand/peat/carbon filter
Chemical and associated product manufacturing	Industrial gas	N, pH, TSS	Low	Sand filter
Animal feedstuffs	Stock food manufacture storage or handling	BOD, TSS	Medium	Swale/high plant surface area and soil organics
Transport and related activities	Bus depots	Cu, Zn, TSS, TPH, PAH	Low	Sand/peat/carbon filter
Transport and related activities	Commercial airports	Oil and grease, TSS,COD	Low	Settling, oil/water separator, sand/peat/carbon filter
Machinery or equipment manufacturing	Motor vehicles or parts	Oil and grease, Fe, Al, Zn	Low	Sand filter
Food or beverage manufacturing or handling	Other foodstuffs manufacturing	BOD, TSS, oil and grease, N	Low	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Flour mill or cereal foods	BOD, TSS, oil and grease, N	Low	Oil/water separator, high plant activity and surface area
Chemical and associated product manufacturing	Cosmetics, toiletry, soap and other detergents	Zn, N	Low	oil/water separator, oxidation, peat filter

Appendix D

Contaminant Load Calculations

Catchments

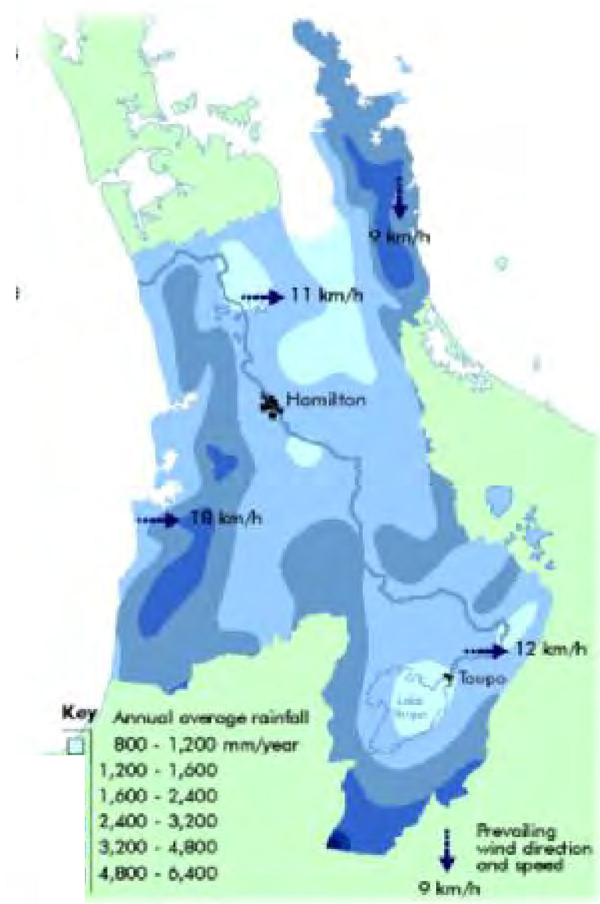
Rural

		Area (ha)	CN	% Imp	
A	4 Guys	7.0	70.45	0.05	
B	HJV	66.7	70.45	0.05	Not incl Sharksfin
F	Porters	69.9	70.45	0.05	
		143.7			

Existing Development **Catchment Areas and CN/RC** - as per design report

		Area (ha)	Curve Number	% Imperv	CN * A
A	4 Guys Pond	7.0	95.1	0.90	667.5
B	HJV	66.7	88.6	0.68	5912.5
F	Porters Pond	69.9	89.6	0.71	6260.8
		143.7		Sum	12840.9
				Weighted CN	89.38

Rainfall Sourced from WRC website:



Runoff Coefficients

Rural		0.45	based on CN of 70.5.	
Existing Equiv Rc (Existing D)		0.81	Conversion from 1D modelling curve number.	
Check against composite runoff coeff:				
		RC	Area	Rc x A
	Perv	0.45	42.7	19.2
	Imp	0.9	101.0	90.9
			Sum	110.1
			Composite Rc	0.77

Annual Runoff Volume

Area (ha)		143.7		
Annual Rainfall		1400	mm/year	- from WRC website - see diagram on right
Runoff coeff	Rural	0.45	based on CN of 70.5.	-see calculations above
	ED	0.75		
Annual runoff volume	Rural	905,070	m³/yr	
Annual runoff volume	ED	1,508,450	m³/yr	

Efficiencies

	Wetponds	Wetlands	Swales	Combined (Treatment train) Efficiency %	Lysaghts value
Total suspended solids	75	70	65	91	97
Total phosphorus	50	55	30	65	65
Total Nitrogen	40	35	30	58	52
Total Zinc	50	65	60	80	95
Total Copper	45	65	60	78	92

Efficiency Formula from NZTA (2010)

R = A + B – [(A x B)/ 100]

Where:
R = total removal rate
A = Removal rate of the first or upstream practice
B = Removal rate of the second or downstream practice

Loads and Concentrations - Rural

Contaminant	Load g/m²/yr	Load kg/year	Average concentration g/m³	Guideline Value	Guideline Ref
Total suspended solids	73.5333	105,639	116.7		No guideline value
Total phosphorus	0.0130	19	0.021	0.015-0.3	MfE Water quality guidelines for the control ob Undesirable Biological Growths in Water. (MFE,1992)
Total Nitrogen	0.4150	596	0.659	0.04-0.1	MfE Water quality guidelines for the control ob Undesirable Biological Growths in Water. (MFE,1992)
Total Zinc	0.0081	12	0.013	0.015	ANZECC
Total Copper	0.0024	3	0.004	0.0018	ANZECC

Loads and Concentrations - Industrial

Contaminant	Load g/m²/yr	Load kg/year	Load Post treatment (g/m2/year)	Average concentration g/m³	Guideline	Guideline Ref
Total suspended solids	32	45,972	4022.5	30.476		No guideline value
Total phosphorus	0.15	215	75.4	0.143	0.015-0.3	MfE Water quality guidelines for the control ob Undesirable Biological Growths in Water. (MFE,1992)
Total Nitrogen	0.35	503	211.2	0.333	0.04-0.1	MfE Water quality guidelines for the control ob Undesirable Biological Growths in Water. (MFE,1992)
Total Zinc	0.49	704	140.8	0.467	0.015	ANZECC
Total Copper	0.107	154	33.8	0.102	0.0018	ANZECC

Above guideline value

Between upper and lower guideline value

-Note - Concentration looks similar to loads because rainfall (1400mm/hr x rc (0.75) is almost 1000.

Appendix E

High Risk Activities - Comparison

GAPs- Items in ITA but not in SW Mgmt Guideline

Industrial Activities -Waikato SW Management Guideline	Description of Trade	Contaminants of Concern	Likelihood of Release	Treatment Processes
Research or defense	Research establishments	Less than 1000m2	More than 1,000m2	Activity is never high risk
Research or defense	Motor vehicles or parts	Less than 1000m2	1,000m2 to 5,000m2	More than 5,000m2

GAPS: Not on ITA or SW Mgmt Guideline

On HRFR		WW/Tradewaste Component??
2. Printers	Relatively large quantities of dyes and paints are handled at these sites. The risk of spillages is relatively high.	Yes
3. Spray painting facilities	Paints can not only be spilt at these sites but can enter stormwater as a consequence of drift from spray painting operations.	Yes- paint washing facilities
7. Truck wash facilities	The activity of truck washing can was hazardous contaminants of trucks as well as sediments and wastes from spillages on site.	Yes
9. Textile fibre and textile processing industries where dying and washing of fabric occurs.	Large quantities of dye and high BOD wastes (from wool scourers for instance) are handled on these site. The risk of spillage that could enter stormwater is high.	Yes
11. Footwear manufacture.	Large quantities of dye and high BOD wastes are handled on these site. The risk of spillage that could enter stormwater is high.	Yes
18. Stock saleyards.	High BOD run-off can be associated with these sites.	Yes
20. Car wash and valet services.	High oil, solvent and solid discharges can occur from these activities.	Yes
21. Commercial laundries (excluding self-service laundrettes and Laundromats)	The risk of of spillages associated with detergents, alkalis and salts used in the industry can be high.	Yes

Activities which have a lower risk rating in the Waikato Guideline to HRFR or AC ITA

Industrial Activities -Waikato SW Management Guideline	Description of Trade	Contaminants of Concern	Likelihood of Release	Treatment Processes	Classification elsewhere	WW/Tradewaste Component??
Sewage treatment and handling	Sewage solids storage	TSS, BOD, NO3+NO2, NH3, pathogens	Low	Settling, wetlands, disinfection	On HRFR	??
Recycling, recovery, reuse or disposal	Waste transfer stations	GPs, TSS, COD, Metals, Oil & Grease, residual organic compounds	Medium	GPT screen, coarse settling, oil/water separator, oxidation sand/ peat/carbon filter	On HRFR, Always high on AC ITA	No
Recycling, recovery, reuse or disposal	Chemicals	Fe, Al, pH, NO3+NO2, metals, organics	Low	Sand/peat/carbon filter	Always high on AC ITA	Yes
Recycling, recovery, reuse or disposal	Batteries	Pb, pH	Low	Sand/peat filter, carbonate filter	Always high on AC ITA	Yes
Chemical and associated product manufacturing	Batteries	Pb, pH	Medium	Sand/peat filter, carbonate filter	Always high on AC ITA	Yes
Chemical and associated product manufacturing	Fungicides, herbicides, pesticides, timber preservatives and related products	COD, pH, As, Cu, Cr, pesticides	Medium	Sand/peat/carbon filter	Always high on AC ITA	Yes
Chemical and associated product manufacturing	Cosmetics, toiletry, soap and other detergents	Zn, N	Low	Oil/water separator, oxidation, peat filter	Never low on AC ITA	Yes
Chemical and associated product manufacturing	Explosive and pyrotechnics	Metals (Pb, Zn), VOC's	Low	sand/peat/carbon filter	Never low on AC ITA	?
Chemical and associated product manufacturing	Industrial gas	N, pH, TSS	Low	Sand filter	Never low on AC ITA	?
Commercial livestock processing centres	Rendering or fat extraction	BOD, oil and grease	Medium	Oil/water separator, oxidation	Always high on AC ITA	Yes
Electronics	Circuit board manufacturing (excluding assembly only)	Metals (Nz, Cu, Cr, Ni), pH, organics	Medium	Sand/peat filter	Always high on AC ITA	No
Agricultural support industries	Other chemical products (e.g. plastic manufacturing)	Less than 1000m2	1,000m2 to 5,000m2	More than 5,000m2	On AC ITA but not on Waikato List	?
Commercial livestock processing centres	Rendering or fat extraction	BOD, oil and grease	Medium	Oil/water separator, oxidation	Always high on AC ITA	yes

Electronics	Circuit board manufacturing (excluding assembly only)	Metals (Nz, Cu, Cr, Ni), pH, organics	Medium	Sand/peat filter	Always high on AC ITA	?
Motor vehicle services facilities	Mechanical servicing of motor vehicles	Oil and grease, metals	High	Sand/peat/carbon filter	Never high on AC List	?
Petroleum or coal product manufacturing	Petroleum hydrocarbon, oil or grease manufacturing	Oil and grease PAH, BTEX	Low	Oil/water separator, sand/catbron filter	Never low on AC ITA	?
Recycling, recovery, reuse or disposal	Hazardous materials storage or treatment	TSS,COD, Metals, Oil and Grease, organics	Medium	Sand/peat/carbon filter	Always high on AC ITA	?
Recycling, recovery, reuse or disposal	Landfills	Metals, TSS, BOD, NO3+NO2, NH3, organics	Low	Coarse settling, oil/water separator, sand/peat/carbon filter, oxidation	Always high on AC ITA	?
Recycling, recovery, reuse or disposal	Sewage solids treament or storage facilities	TSS, BOD, NO3+NO2,Pathogen	Medium	Retention, oxidation	Always high on AC ITA	Yes
Transport and related activities	Road freight transport depot (non-chemical) with mechanical servicing	Oil and grease, TSS, metals	High	Oil water separator and, sand/peat filter	Never high on AC List	No

References:
HRFR= Waikato High Risk Facilities Register, referenced in the MCC SW Bylaw
AC ITA= Auckland Councils Industrial and Trade Activities list.

Waikato Stormwater Management Guideline - High Risk Industries

Industrial Activities	Description of Trade	Contaminants of Concern	Likelihood of Release	Treatment Processes
Agriculture support industries	Inorganic fertiliser manufacture, storage or handling	COD,TSS,Pb,Fe,Zb,P	Medium	sand /peat filter, high plant surface area and soil organics
Animal feedstuffs	Pet food manufacture	BOD	Medium	sand/peat filter, swales
Animal feedstuffs	Stock food manufacture storage or handling	BOD, TSS	Medium	Swale/high plant surface area and soil organics
Chemical and associated product manufacturing	Fungicides, herbicides, pesticides, timber preservatives and related products	COD, pH, As, Cu, Cr, pesticides	Medium	Sand/peat/carbon filter
Chemical and associated product manufacturing	Batteries	Pb, pH	Medium	Sand/peat filter, carbonate filter
Chemical and associated product manufacturing	Paint, pigment, inks and dyes	Al, Fe, Zn, Organics	Medium	Sand/peat/carbon filter
Chemical and associated product manufacturing	Acids, alkalis or heavy metals	pH, TSS, metals	Medium	Sand/peat/carbon filter, carbonate filter
Chemical and associated product manufacturing	Synthetic resins	TPH, pH, Zn	Low	Sand/peat filter
Chemical and associated product manufacturing	Solvents	TPH	Low	sand filter
Chemical and associated product manufacturing	Explosive and pyrotechnics	Metals (Pb, Zn), VOC's	Low	sand/peat/carbon filter
Chemical and associated product manufacturing	other chemical products (Plastic manufacturing)	pH, Tss, Zn, N	Low	Sand/peat filter
Chemical and associated product manufacturing	Polishes, adhesive or sealants	BTEX, pH, Zn	Low	Sand/peat/carbon filter
Chemical and associated product manufacturing	Medicinal, pharaceutical or veterinary products	COD, As, Cd, Cr, Phenol	Low	Sand/peat/carbon filter
Chemical and associated product manufacturing	Industrial gas	N, pH, TSS	Low	Sand filter
Chemical and associated product manufacturing	Cosmetics, toiletry, soap and other detergents	Zn, N	Low	Oil/water separator, oxidation, peat filter
Commercial livestock processing centres	Slaughter	BOD, oil and grease, N	Medium	Oil/water separator , high plant activity and surface area
Commercial livestock processing centres	Manufacture, store and handle manufacturer products derived from animal slaughter (gelatin, fertiliser or meat products	BOD, oil and grease, N	Medium	Oil/water separator , high plant activity and surface area

Commercial livestock processing centres	Scouring or carbonising greasy wool or fleeses	BOD, oil and grease, N	Medium	Oil/water separator, oxidation
Commercial livestock processing centres	Rendering or fat extraction	BOD, oil and grease	Medium	Oil/water separator, oxidation
Electronics	Circuit board manufacturing (excluding assembly only)	Metals (Nz, Cu, Cr, Ni), pH, organics	Medium	Sand/peat filter
Food or beverage manufacturing or handling	Vineyards or wine manufacturing	BOD, TSS,oil and grease, N	Medium	Oil water separator high plant activity and suraface area
Food or beverage manufacturing or handling	Processed dairy foods manufacturing	BOD, TSS,oil and grease, N	Medium	Oil water separator high plant activity and suraface area
Food or beverage manufacturing or handling	Oil or fat product manufacturing or handling	BOD, TSS,oil and grease, N	Medium	Oil water separator high plant activity and suraface area
Food or beverage manufacturing or handling	Meat and meat product manufacture (including fish)	BOD, TSS,oil and grease, N	Medium	Oil water separator high plant activity and suraface area
Food or beverage manufacturing or handling	Processed dairy foods handing	BOD, TSS,oil and grease, N	Medium	Oil water separator high plant activity and suraface area
Food or beverage manufacturing or handling	other foodstuffs handling	BOD, TSS,oil and grease, N	Medium	Oil water separator high plant activity and suraface area
Food or beverage manufacturing or handling	Meat product handling (including fish)	BOD, TSS,oil and grease, N	Medium	Oil/water separator , high plant activity and surface area
Food or beverage manufacturing or handling	Beverage or malt product handling	BOD, TSS,oil and grease, N	Medium	Oil/water separator , high plant activity and surface area
Food or beverage manufacturing or handling	Bakery product handling	BOD, TSS, oil and grease	Medium	Oil/water separator , high plant activity and surface area
Food or beverage manufacturing or handling	Other foodstuffs manufacturing	BOD, TSS, oil and grease, N	Low	Oil/water separator, high plant activity and surface area
Food or beverage manufacturing or handling	Flour mill or cereal foods	BOD, TSS, oil and grease, N	Low	Oil/water separator, high plant activity and surface area
Machinery or equipment manufacturing	other machinery or equipment	Oil and grease, Fe, Al, Zn	Medium	Sand/peat filter
Machinery or equipment manufacturing	Industrial machinery or equipment	Oil and grease, Fe, Al, Zn	Medium	Sand/peat filter
Machinery or equipment manufacturing	motor vehicles or parts	Oil and grease, Fe, Al, Zn	Low	Sand filter
Metal processing, metallurgical works or metal finishing	Refinement of ores	TSS, metals	Medium	Settlement, wetland
Metal product manufacturing	sheet and structural metal products	Fe, Al,Zn	Medium	Sand/peat filter
Non-metallic mineral product manufacturing	glass	Oil and grease, BOD, TSS	Medium	Oil/water separator, sand/peat filter
Petroleum or coal product manufacturing	Coal products	TSS, Al, Fe, pH	Medium	Settling, wetlands
Petroleum or coal product manufacturing	Bitumen/asphalt premix or hot mix	TSS, Zn, TPH	Medium	Oil/water separator, sand/carbon filter

Petroleum or coal product manufacturing	Petroleum refining	Oil and grease PAH, BTEX	Medium	Oil/water separator, sand/catbron filter
Petroleum or coal product manufacturing	Petroleum hydrocarbon, oil or grease manufacturing	Oil and grease PAH, BTEX	Low	Oil/water separator, sand/catbron filter
Power	Gas, coal or liquid power generation	Oil and grease, Zn, TSS	Medium	Oil/water separator, wetland
Power	electrical substations	Oil and grease	Medium	Sand filter
Product stoarge or handling centres	Bulk hydrocarbons (non-service stations)	Oil and grease, PAH,BTEX	Medium	Oil/water separator, sand/peat/carbon filter
Product storage or handling centres	Bulk chemicals	Al, Fe, Zn, NO3+NO2	Medium	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Synthetic rubber manufacturing	Zn, Tss, organics	Medium	Wetlands
Recycling, recovery, reuse or disposal	Chemical containers cleaning, reconditioning or recycling	Metals, COD, NO3 + NO2	Medium	GPT screen, coarse settling, oil/water separator, oxidation sand/
Recycling, recovery, reuse or disposal	Waste transfer stations	GPs, TSS, COD, Metals, Oil & Grease, redisual organic	Medium	GPT screen, coarse settling, oil/water separator, oxidation sand/
Recycling, recovery, reuse or disposal	Hazardous materials storage or treatment	TSS,COD, Metals, Oil and Grease, organics	Medium	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Landfills	Metals, TSS, BOD, NO3+NO2, NH3, organics	Low	Coarse settling, oil/water separator, sand/peat/carbon filter, oxidation
Recycling, recovery, reuse or disposal	Chemicals	Fe, Al, pH, NO3+NO2, metals, organics	Low	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Batteries	Pb, pH	Low	Sand/peat filter, carbonate filter
Recycling, recovery, reuse or disposal	Oil, petroleum hydrocarbon wastes	Oil and grease, PAH, BTEX	Medium	Oil/water separator, sand/carbon filter
Recycling, recovery, reuse or disposal	Sewage solids treament or storage facilities	TSS, BOD, NO3+NO2,Pathogen	Medium	Retention, oxidation
Rubber industries	Typre manufacturing or retreading	Zn, Tss, organics	Medium	Sand/peat filter
Sewage treatment and handling	Sewage solids storage	TSS, BOD, NO3+NO2, NH3, pathogens	Low	Settling, wetlands, disinfection
Transport and related activities	Marinas	TSS, Zn, Cu	Medium	Peat filter
Transport and related activities	Railway workshops or refuelling depots	Oil and Grease, TSS, COD, Zn	Medium	Settlement, sand/peat filter
Transport and related activities	Road freight transport depot (bulk chemical)	Oil and Grease, TSS, COD, Zn, organics	Medium	Sand/peat/carbon filter, oxidation
Transport and related activities	Truck refuelling facilities (non-service station)	TPH,PAH	Medium	sand/peat filter

Transport and related activities	Shipping container reconditioning	Oil and grease, TSS, COD	Medium	Oil/water separator, settlement
Transport and related activities	Shipping, loading/unloading	Oil and grease, TSS, COD	Medium	oil/water separator and sand/peat filter
Transport and related activities	bus depots	Cu, Zn, TSS, TPH, PAH	Low	sand/peat/carbon filter
Transport and related activities	commercial airports	oil and grease , TSS, COD	Low	Settling, oil/water separator, sand/peat/carbon filter
Wood or paper product storage, manufacturing or fabrication	Particle board or other wood panel manufacturing	TSS, COD,NO3+NO2, oil and grease	Medium	GPT , settling, sand filter
Wood or paper product storage, manufacturing or fabrication	Pulp, paper or paper board manufacturing	TSS, COD,NO3+NO2, oil and grease, Zn	Medium	Wetlands, oil/water separator
Wood or paper product storage, manufacturing or fabrication	Plywood or veneer manufacturing	TSS, COD, NO3+NO2, organics	Medium	wetlands

Appendix F

Recommended Updates to the WRC Stormwater Guideline Industrial Activities list.

Recommended changes to the risk ratings of activities on the WRC Guideline list

Industrial Activity	**Description of Trade**	**Contaminants of Concern**	**Current WRC Guideline rating: "Likelihood of Release"**	**Treatment Processes**
Recycling, recovery, reuse or disposal	Chemicals	Fe, Al, pH, NO3+NO2, metals, organics	Low	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Batteries	Pb, pH	Low	Sand/peat filter, carbonate filter
Chemical and associated product manufacturing	Batteries	Pb, pH	Medium	Sand/peat filter, carbonate filter
Chemical and associated product manufacturing	Fungicides, herbicides, pesticides, timber preservatives and related products	COD, pH, As, Cu, Cr, pesticides	Medium	Sand/peat/carbon filter
Commercial livestock processing centres	Rendering or fat extraction	BOD, oil and grease	Medium	Oil/water separator, oxidation
Electronics	Circuit board manufacturing (excluding assembly only)	Metals (Nz, Cu, Cr, Ni), pH, organics	Medium	Sand/peat filter
Commercial livestock processing centres	Rendering or fat extraction	BOD, oil and grease	Medium	Oil/water separator, oxidation
Electronics	Circuit board manufacturing (excluding assembly only)	Metals (Nz, Cu, Cr, Ni), pH, organics	Medium	Sand/peat filter
Recycling, recovery, reuse or disposal	Hazardous materials storage or treatment	TSS,COD, Metals, Oil and Grease, organics	Medium	Sand/peat/carbon filter
Recycling, recovery, reuse or disposal	Landfills	Metals, TSS, BOD, NO3+NO2, NH3, organics	Low	Coarse settling, oil/water separator, sand/peat/carbon filter, oxidation
Recycling, recovery, reuse or disposal	Sewage solids treament or storage facilities	TSS, BOD, NO3+NO2,Pathogen	Medium	Retention, oxidation

Recommended additions to the WRC SW Guideline List.

Description of Industrial or trade activity	**Description of Trade**	**Low risk**	**Moderate risk**	**High risk**
Research or defense	Research establishments	Less than 1000m2	More than 1,000m2	Activity is never high risk
Research or defense	Motor vehicles or parts	Less than 1000m2	1,000m2 to 5,000m2	More than 5,000m2

AC ITA= Auckland Council's Industrial and Trade Activities list.

Classification elsewhere	Recommended Risk Rating
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High
Always high on AC ITA	High

Appendix G

Device Locations and Catchments

ISSUE	AMENDMENTS	SIGNED	DATE
A	FOR INFORMATION		4/04/2017

DATUM | NAME | SIGNED | DATE
BENCH MK. | DESIGNED
RL | DES. REVIEW
SURVEY | DRAWN
SURVEY LB | DRW. CHECK
COORD DATUM | FILE LOCATION
DRAIN. REF.
SAP WBS

DATE | SIGNED
FOR CONSTRUCTION
DATE | SIGNED

CONSULTANT
Beca
CONSULTANT PROJECT REF. | CONSULTANT FILE REF.

PROJECT TITLE
MANGAHEKA MAXIMUM PROBABLE DEVELOPMENT CATCHMENT BOUNDARIES CLOSE UP

DRAWING TITLE
FOR INFORMATION ONLY

CONTRACT NUMBER
CAD DRAWING FILE REF.
ORIGINAL SHEET SIZE: A3
SCALES: 0 – 110 – 220 Metres
1:11,000 @ A3
CAD PROJECT FILE NUMBER
SHEET: 1 OF 1

P:\651\6512195\THY\GIS\Presentation Maps\Mangaheka revised catchment MPD close up.mxd

Appendix H

HCC Pollution Control Plan

POLLUTION CONTROL PLAN

Hamilton City Council
Te kaunihera o Kirikiriroa

Introduction

This document provides practical advice and guidance to help you prevent pollution.

There are frequent pollution incidents from work sites/ factories/ building sites/mechanical workshops/ restaurants/ etc. every year that damage the environment, yet most can easily be prevented.

Managing your activities properly on site will protect people's health and the natural environment.

What is a Pollution Control Plan?
A Plan is a written record detailing how you will manage the pollution risks from your site. It is designed to ensure your site is set up correctly and that you and your employees know how to minimise the potential for pollution to occur.

Your Plan will contain important information about your site such as stormwater drainage, chemical storage areas, loading areas, processing areas, etc. It will also contain information about activities that are undertaken by you and the risks of pollution from these.

Your Plan will contain written procedures in the event of spills or other emergencies. It will also contain details of staff training that you undertake to ensure preparedness for pollution incidents.

Why does my site need a Pollution Control Plan?
A pollution control plan is required under Hamilton City Council's Stormwater Bylaw and is designed to protect you, your company and the environment from pollution.

What is my role in protecting the environment?
Everyone has a responsibility to protect our environment – especially people and companies engaged in high-risk activities.

What is Hamilton City Council's role in protecting the environment?
Hamilton City Council is responsible for managing the city's stormwater network, ensuring the community's safety and protecting our environment.

The Council has a pivotal role in actively promoting and protecting the environment through a range of planning tools and legislative requirements. The Hamilton Stormwater Bylaw helps protect the natural environment by setting out everyone's responsibilities in regards to stormwater.

What is stormwater?
Stormwater is rain which has run off sealed/paved surfaces such as roads, carparks, roofs into stormwater drains. From there it drains into local waterways, lakes, streams and the Waikato River.
Stormwater is drained from Hamilton's urban catchment area of approximately 9000 ha that services approximately 140,000 people including domestic, industrial and commercial properties.

Who else is involved in protecting the environment?
The discharge of stormwater into waterways is regulated by Waikato Regional Council. Hamilton City Council has a 'citywide' Stormwater Discharge Consent from Waikato Regional Council to divert and

discharge stormwater from across Hamilton city to waterways and the river from the stormwater network.

Hamilton City Council works closely with Waikato Regional Council and Tainui to protect the greater Waikato water catchment.

Basic principles – things you should know

<table>
<tr>
<td>What is pollution?</td>
<td>Pollution is the release of any substance that can harm people or animals, plants, soil or water; for example, an oil spill, or sediment getting into a river.

Common pollutants from sites include: silt, oil (including fuel), cement, concrete, grout, chemicals, sewage, and waste materials.

Common causes of pollution are: illegal discharges, pollutants carried by stormwater run-off, poor site maintenance or supervision, accidental spillage and vandalism.</td>
<td></td>
</tr>
<tr>
<td>What's at risk from pollution?</td>
<td colspan="2">The Waikato River and Local Tributaries are at extreme risk from pollution.

• Pollution can kill fish and other aquatic life.
• Pollution affects other users of the Waikato River such as recreational users.
• Pollution can affect drinking water abstractions downstream
• Pollution can affect the ground water table.

It is an offence to pollute our environment.

Your site doesn't need to be next to a stream or river to cause a problem; any pollutants getting into stormwater drains can end up in the river even if it's miles away from site. The stormwater network in Hamilton doesn't have any filters or treatment devices in it, so anything that enters into a catch pit will end up in local streams, lakes and the Waikato River.</td>
</tr>
</table>

What are the consequences if you cause pollution?	If your site activities cause pollution you may face a significant fine and court costs. Under the Hamilton City Council Stormwater Bylaw you may be liable for penalties not exceeding $20,000. Under the RMA, polluters can face fines of up to $600,000 and even imprisonment. You may also have to pay clean up and restoration costs. 
What are Pollution Control Plans?	 Pollution Control Plans contain important information about your site such as stormwater drainage, chemical storage areas, loading areas, processing areas, etc. It will need to contain information about activities that are undertaken by you and how you intend to reduce and manage pollution risks. A Plan may be required under Hamilton City Council's Stormwater Bylaw, depending on the type of activity you are carrying out. It will generally be required for facilities that undertake high risk activities and sites that have ongoing stormwater pollution issues.

Contents

1. Company overview

1.1 Company description and site location

Insert a brief description of your company and details of the location= including:

- **Company operations**, what does your company do or produce?
- **Staff numbers** (include detail of contractors used in the company's operations).
- **Company structure** i.e. key responsibilities and reporting lines where relevant.
- **Site address and legal description** (for all areas your company utilises for operations).

1.2 Scope of this Pollution Control Plan

Insert the scope of your PCP to clarify what it covers. You should include:

- **Legal requirements** outline the status of your site with regard to requirements set out in the Regional and District Plan as well as any resource consents you hold for the activity carried out onsite.
- **Multiple activities on site?** Does your PCP cover your whole site or do you have separate PCPs for different activities carried out in separate areas?
- **Multiple sites?** If you have more than one site, does the PCP cover all of them? Or do you have separate PCPs specific to each site?
- **Onsite and off-site activities,** if your company carries out some activities on your own site but also works for example on customers sites installing products you may want to separate these activities into separate PCPs as the off-site activities are likely to have quite different environmental risks and mitigation procedures.

1.3 Site activities, facilities and stores

Insert an outline of your site's activities, facilities and stores.
Include detail on the following:

- What you do / make / process/ handle on the site.
- The raw materials stored on site, where on-site the storage areas are
- Waste products, the volume of these wastes, where they are stored on-site and how they are disposed of
- Other supporting activities like vehicle and equipment maintenance and washing, loading and unloading

1.4 Site Plan

Insert a summary of your site layout and drainage. The site plan should include:

- Layout of buildings and all outdoor activity areas
- Vehicle traffic areas and loading/unloading areas
- Vehicle/equipment washing areas
- Storage areas, particularly of hazardous substances or materials
- Stormwater flow paths and ponding areas
- Stormwater drains, manholes, catchpits and soakholes with direction of flow.
- Sewer and tradewaste drains, manholes and cesspits with direction of flow.

This information will help you to identify risk areas on your site and how contaminants can enter receiving environments. It will also become an important part of your spill response plan. To create, plan or confirm the accuracy of an existing plan you may need to involve a specialist to investigate your drainage systems (using CCTV or dye testing).

1.5 Consents and permits

Insert an outline of any consents and permits that your site has or requires to undertake its onsite activities. Complete Table 1 (overleaf) if it helps you to summarise this information.

Table 1.1: Summary of authorisations, consents and permits

Some examples have been inserted for your information; these should be replaced with details that relate to your company's situation.

Type and number	Agency	Status	Summary of key conditions and monitoring required
Tradewaste discharge permit – No. XYZ	Hamilton City Council	Granted (expires 2012)	Relates to discharge from factory and wastewater treatment bund – Discharge Xm3/s (continual monitoring) pH maximum 8 (daily monitoring, mid-flow)

2. Pollution risks and controls

2.1 Pollution risks

Insert a summary of your sites pollution risks. Also insert details of these pollution risks into Table 2.1 overleaf. This table was developed to help you identify your pollution risks and find solutions to minimise and mitigate these risks.

2.2 Pollution controls

2.2.1 Structural and procedural controls – existing:

Insert a summary of your site's pollution controls that have already been implemented. Also insert details of these pollution controls into Table 2.1. You could categorise them into a section each for structural and procedural controls which have been defined below.

Structural controls are physical structures that are designed to control the movement of materials/contaminants (including contaminated stormwater) around your site. Examples could include things like bunds, cut-off valves and physical covers.

Procedural controls are written or informal descriptions of how and where you carry out key activities on your site. They include written standard operating procedures (SOPs) for routine activities as well as for spills e.g. SOP's for spill response.
.

2.3 Spill Response Plan

A spill response plan' is a key pollution control document that formalises the procedures during a spill.

A good spill response plan should include:

- training for staff
- appropriate equipment
- location of equipment
- step by step instructions for spill response
- notification protocols (internal management & external parties)
- Clean up and dispose of the contaminated materials
- restocking the spill kit
- investigation into the cause of event
- review spill procedures post event

Table 2.1: Structural and procedural controls

This table relates to the pollution risks and pollution controls sections (2.1 and 2.2) above. You may use this table or create a similar one of your own.

Area of site: Chemical storage area in Warehouse B **Activity/facility/store:** Activity – Chemical delivery

Risk identification and contaminants of concern		**Existing pollution controls**		**Improved or new pollution controls required**		
Risk	**Contaminant(s)**	**Structural**	**Procedural**	**Structural**	**Procedural**	**Timeframe**
Spills during unloading of chemicals	• hydrocarbons • dissolved metals • chemicals	• bunding of chemical delivery area • sealed surface.	Procedure • deliveries only within bunded area • contractors use safe practices (pallets wrapping, trolley jacks) Inspection • regular checks of seal and bund integrity etc. Training • staff/contractors trained in procedures and Inspections.	• n/a – no further structural controls required	• procedure / Spill response required for staff and contractors to follow in the event of a spill or leak.	• four week review of spill response procedures and produce document
Traces of contaminants tracked from bunded chemical delivery area to yard	As above	• yard area sealed	Inspection: • yard area regularly swept and residues collected for disposal. • integrity of concrete checked 6 monthly.	• stormwater treatment – oil interceptor and sand/peat filter for trace hydrocarbons and metals in yard stormwater	Procedures required for operation and maintenance of stormwater treatment devices	• 12 weeks to install appropriate interceptor system

3. Pollution programmes and systems

3.1 Inspection and maintenance programme

To make sure your Pollution Control Plan is effective in preventing pollution, you need to make sure the structural controls are in good working order and that the procedural controls are being followed. The way to do this is to develop an inspection and maintenance programme.

Insert a summary of your Inspection and maintenance programme.

Completed inspections checklists and maintenance logs with create a paper trail to demonstrate that your inspection and maintenance programme is being followed and will be looked on favourably in the event of an unforeseen spill or non-compliance issue.

3.2 Management and monitoring programme for stormwater treatment devices

Stormwater treatment devices often require more comprehensive checks and more intensive maintenance – they have therefore been given this separate section to outline their specific management and monitoring.

Insert a summary of your pollution control and monitoring programme for any treatment devices you have on site and attach a copy of the programme including any supporting forms as an attachment.

3.3 Record keeping

Insert a summary of the records you will keep in order to ensure (and demonstrate) your PCP works effectively.

This is part of your insurance in case of a spill, accident or non-compliance event. You should include completed forms, checklists and maintenance logs, identified problems and corrective actions taken, monitoring data and results from stormwater treatment devices, incident forms and results of assessments and compliance visits.

3.4 Roles and responsibilities

All staff and contractors have a responsibility in ensuring your Pollution Control Plan is followed and that it is effective in preventing pollution and compliance costs to the company. In order for staff and contractors to understand what is required, you will need to record this in your PCP.

3.5 Pollution Control Plan review

You will need to review and update your Pollution Control Plan regularly to make sure it reflects the changing shape of your business and current best practice techniques

4. Attachment 1- Stormwater Incident Report Sheet – Example form

Stormwater Incident Report Sheet

Use this form to record details of any spill events

Details	
Date/time of incident	
Location of discharge:	
Material/s discharged:	
Approx. volume discharged:	
Cause of discharge:	
Did any material escape offsite? If yes, where to?	

Action Taken	
Who detected the spill and what did they do?	
Who else on the staff was notified and what did they do?	
Were any external agencies notified?	

Health & Safety	
Were there any injuries?	
Any damage to plant or property?	

Costs Report	
Estimate costs of staff down	

time for clean-up and other response	
External clean-up costs	
Disposal costs	

Prevention	
Discuss any changes needed to prevent similar accidents in the future:	
Spill procedures:	
Equipment:	
Staff training:	
Drains or structures:	
Housekeeping practices:	
Standard operating procedures:	

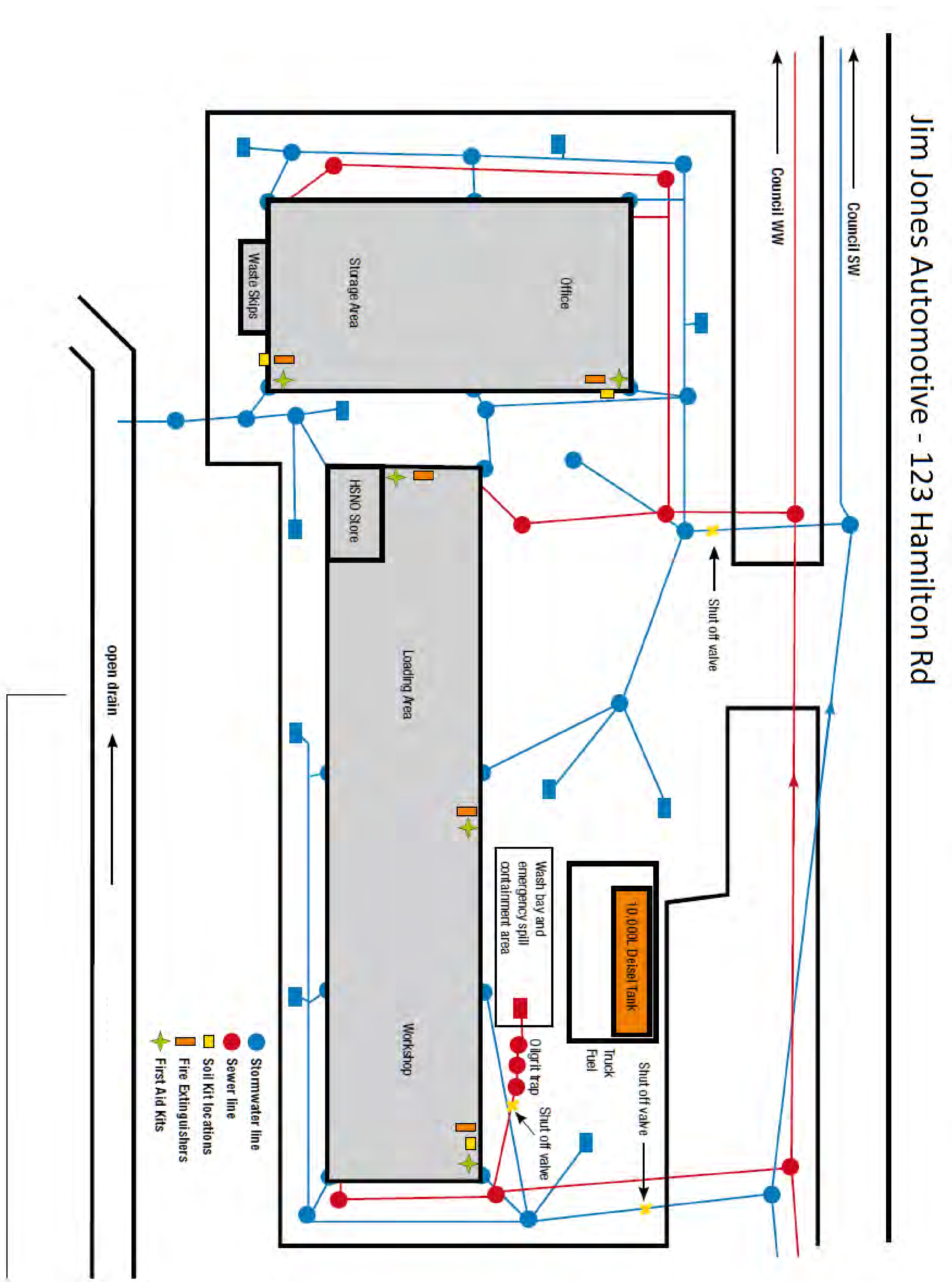
Other Recommendations

Photos

Report completed by

Report reviewed by

5. Attachment 2 – Site Drainage Example



Appendix I

Pollution Control Plan Checklist and Guidance Document

Hamilton City Council Pollution Plan Guide and Checklist - Industrial Zone Developments

Instructions

This guide/checklist should be filled out for all developments within the Industrial Zone as part of a Building Consent or Stormwater Connection (to the HCC network) Approval request .
Sections A to E need to be filled out by all developers.
Section E to J should be filled in if section E indicates you need to prepare a Pollution Plan

Regulatory Framework

HCC Partially Operative District Plan	
HCC Stormwater Bylaw 2015	HCC's Stormwater Bylaw 2015 requires that a person must take all practicable steps to store, handle, transport, and use materials in a way that prevents prohibited materials entering the stormwater system.
WRC Discharge Consents	HJV, Porters
HCC Comprehensive Stormwater Discharge Consent	

Definitions

Prohibited materials means anything	a) pose a danger to life b) pose a danger to public health c) cause flooding or any floor or sub-floor, or public roadway d) cause damage to property e) cause a negative effect on the efficient operation of the stormwater system f) cause damage to any part of the stormwater system g) cause erosion or subsidence of land h) cause long or short term effects on the environment i) cause adverse loss of riparian vegetation j) cause wastewater overflow to land or water k) and means anything that causes a breach of of any stormwater discharge consent condition binding Council.
Pollution Control Plan	Means a plan that includes appropriate policies, procedures and review timetable that is held onsite that guides appropriate management of any material either held on site or intended or likely to be onsite that may cause entry of prohibited materials into the stormwater system or any other breach of this bylaw.

A **Site Details**

1	Site Owner:	
2	Site Address:	
3	Site Legal Description	
4	Grid Reference location and manhole reference location of connection to HCC stormwater network:	
5	Downstream Treatment /Attenuation Facility	eg Porters Pond/HJV Pond

B **What size is your development?**

6	Total Area of lot (m^2)		
7	Proposed area of hardstand used by vehicles (m^2)		
8	Proposed area of hardstand used for product storage /other usages (m^2)		Product storage areas should be separate from other areas. Applicant to specify what "other" is .
9	Total Roof area (m^2)		
10	Total Landscaping area (m^2)		
11	Total area discharging to Tradewaste (m^2)		
12	Total Impervious Area (m^2)		

C **Traffic Movements**

13	How many traffic movements (on average) do you expect through your site per week?	
14	Cars	
15	Trucks	
16	Other (Please state type)	

D **Site/ Stormwater System Plans**

17	Please provide a detailed site plan including:	Lot boundaries Building locations Landscaping areas Parking areas Locations of likely vehicle movements Discharge point off site Stormwater catchments (based on proposed topography), conveyance paths from source, to treatment (if any) and to discharge point. Any proposed stormwater treatment system locations Locations where operations may result in contaminants entering the stormwater system Locations of any bunding to prevent contaminants entering stormwater
18	Please provide a more detailed plan of any proposed stormwater treatment systems ie Design Plans	

E **Do I need to prepare a Pollution Plan**

				Reference:
19	Proposed Business/Industry to be developed:			
20	Is your proposed business/industry on the WRC High Risk Facilities Register		If you answered Yes, please prepare a pollution plan according to the below guidance.	
21	Is your proposed business/industry on the list in Table 11.1 of the WRC SW Mgmt Guideline?		If you answered Yes, please prepare a pollution plan according to the below guidance.	Reference once published????
22	Is your proposed business/industry high/medium or low risk according to Table 11.1?	Low	No Pollution Plan required	
23		Medium	No Pollution Plan required	
24		High	If you answered Yes, please prepare a pollution plan according to the below guidance.	

E **Chemical Storage**

25	Do your site use/store/distribute chemicals		Yes - Please refer to HSNO regulations				
26	Are any of these chemicals regulated under the HSNO Act?		If yes, please provide details of controls required under the HSNO and any approvals required for these chemicals.				
27	Please list the chemicals your site ill use/store or distribute:						
	Chemical Name	**Storage Location**	**Reference to Site Plan and Pollution Plan**	**Sub catchment area**	**Storage Area**	**Volume Stored**	**Bunded Volume**
eg	Petrol	Outside not under cover	Fully bunded storage area draining to oil separator in NW corner of site. Discussed in Pollution Plan section x.x (State:)				
i							
ii							
iii							
iv							
v							
vi							

F

	Risk Assessment and Management		
	Refer section 11.3 of the WRC SW Mgmt Guideline or the High Risk Facilities Register		HSNO - storage and appropriate usage
28	For each contaminant listed, please answer :	Is the contaminant used/stored in a fully covered location?	
29		What source control measures have been implemented to prevent this contaminant entering the SW system? Eg bunding, sweeping	
30		If bunding is used, how is the stormwater within this managed and where is it discharged to?	
31		Are any Tradewaste discharges proposed for contaminated stormwater?	
32		Alternatively, what downstream on-lot treatment are you providing prior to discharge?	

33	Please provide details of how and where deliveries are made to site including:	What frequency, volume and type of deliveries are expected		
		Is it possible that contaminants could contaminate stormwater as a result of deliveries? Eg will some products be delivered in loose form and could be blown or dropped around the site?		

G	**Proposed Treatment System**			**Reference:**
	Downstream SW Treatment Systems have been provided to treat the following standard contaminants			
	TSS		Link to HCC consent conditions	
	Hydrocarbons		Link to HCC consent conditions	MfE petroleum guidelines require 15 mg/L - refueling areas only
	Nutrients		Link to HCC consent conditions	
	Zinc		Link to HCC consent conditions	
	Copper		Link to HCC consent conditions	
34	What other contaminants do you expect your Industry/operation to produce?			
35	Is it likely that this contaminant could be entrained in stormwater?			
36	What on-lot treatment systems are provided to remove contaminants that become entrained?			
37	What types/rates of removal of contaminants are you expecting this treatment system to remove			
38	What guideline has been used to design this system?			TP10, WRC Draft SW Mgmt Guideline

H	**Operation, Inspections and Maintenance**			**Reference:**
39	Please provide details of your proposed inspections including frequency, things to be inspected, and how you plan on ensuring that any maintenance identified as being required by the inspections, is carried out.			Section of WRC's SW Mgmt Guideline. Suggest there should be a check-list specific to the device being used - could use them from TP10 or something similar
40	Please provide details of any routine maintenance that will be carried out as well as frequency of this occuring.			TP10 section on Operation and Maintenance

I **Staff Education and training**

41 Please provide details of any current or proposed education/training programmes for staff in charge of managing discharges from the site?

42 Please provide details of when training will occur, and the frequency of retraining ?

43 Please keep a record of training for submission to HCC upon request

J **Spill Response Plan**

44 Do any regulations require you prepare a Spill Response Plan? If yes, please provide a copy of this plan?

L **Plan Review**

45 How often do you plan on reviewing this plan to ensure it is up to date, including responsibilities for carrying

Key References and Links

	Website Link
WRD Draft SW Management Guideline	

District Plan	
WRC High Risk Facilities Register	See: https://www.waikatoregion.govt.nz/council/policy-and-plans/rules-and-regulation/regional-plan/waikato-regional-plan/3-water-module/35-discharges/3512-high-risk-facilities/
HCC Stormwater Bylaw 2015	See: http://www.hamilton.govt.nz/our-council/policies-bylaws-legislation/bylaws/Documents/Hamilton%20Stormwater%20Bylaw%202015%20-%20Final%20-%20D-1598128.pdf
HSNO Regulations	

www.beca.com

Report

Mangaheka ICMP – Addendum to Water Quality Report

Prepared for Hamilton City Council

Prepared by Beca Ltd

27 August 2018

Revision History

Revision Nº	Prepared By	Description	Date
1	**Angela Pratt**	Draft Addendum Report	26/06/18
2	**Angela Pratt**	Final Addendum Report	11/07/18
3	**Angela Pratt**	Final Addendum Report – updated Table 5 to ensure consistency with Table 4 (typos).	27/08/18

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Angela Pratt**		27/08/18
Reviewed by	**Graham Levy**		27/08/18
Approved by	**Kristina Hermens**		27/08/18
on behalf of	CH2M Beca Ltd		

Contents

Appendices

1 Introduction

CH2M Beca Ltd was engaged by Hamilton City Council (HCC) to prepare the Mangaheka Water Quality Assessment report (CH2M Beca, February 2018a) in support of the Mangaheka Integrated Catchment Management Plan (ICMP). This report assessed (amongst other things), whether three existing devices in the Mangaheka Catchment were designed to adequately treat the contaminants likely to be generated after Maximum Probable Development (MPD) has occurred. This assessment was carried out based on available information at the time in terms of contaminant generation and removal rates.

Since the preparation of the Water Quality Report, further information has become available including:

- Hardness sampling in the Mangaheka catchment. This will impact the ANZECC Guideline values used for comparing the assessment results.
- The design of the HJV and Porters Wetlands have been more extensively reviewed due to issues during construction. This has confirmed that that they are likely to be functioning as wetlands, rather than ponds, contrary to CH2M Beca, (2018a).
- Some more recent contaminant generation data has been included in the assessment.

The purpose of this report is to incorporate this new information into the water quality assessment and to modify the conclusions where appropriate.

The associated Mangaheka Assessment of Environmental Effects (CH2M Beca, 2018b), and Ecological Assessment Report (BM, 2018) should also be read in conjunction with this report.

2 Hardness Modified Trigger Values

2.1 Overview

The toxicity of zinc and copper varies depending on the hardness of the surface water body. The ANZECC guidelines (ANZECC, 2000) provide methods to modify the trigger values depending on the hardness of the water. In preparing CH2M Beca, (2018a), no hardness data was available so the raw ANZECC guideline trigger values were used for comparison. Sampling has now been carried out in order to determine what the hardness of Mangaheka stream is and the trigger values modified accordingly. Table 1 of this addendum provides “Hardness Modified Trigger Values” (HMTV) for Zinc and Copper. This has resulted in the zinc and copper trigger values being higher i.e. effectively easier to meet.

2.2 Sampling Results

Two samples were taken in the Mangaheka Stream on the 14th of May 2018. These were tested for hardness, giving values of 41 and 43 g/m³ as $CaCO_3$. Using the formula in ANZECC, 2000 and a hardness value of 42 g/m^3 (average value), the guideline values for zinc and copper have been modified as shown in Table 1.

Table 1 – ANZECC Guideline Trigger Value and HMTV

Contaminant	ANZECC Guideline Trigger Value (mg/L)	Hardness Modified Trigger Value (mg/L)
Zinc	0.015	0.020
Copper	0.0018	0.0024

3 Treatment Performance

3.1 Existing Devices

CH2M Beca (2018a) provided advice on the theoretical treatment performance of the existing devices in the HJV and Porters developments. Whilst the existing devices had been designed as wetlands, our site visit (June 2016) concluded that some of the design requirements of wetlands had not been implemented and the performance was likely to be in line with ponds rather than wetlands.

Since the preparation of Beca (2018), further review of the HJV and Porters wetlands has been carried out (Beca, 2018b) including review against the Hamilton City Council (HCC) Infrastructure Technical Specifications (HCC, 2016a) and HCC Three Waters Management Practice Notes (HCC, 2016b). On the basis of this review, it can be concluded that the existing wetland designs are appropriate and that the level of treatment will be in line with that expected of a wetland. Table 2 provides a summary of the expected performance of wetlands versus ponds, which has been used to reassess the performance of the HJV and Porters wetlands from CH2M Beca (2018).

Table 2 – Wetland vs Pond Treatment Performance

Contaminant	% Removal - Ponds	% Removal - Wetlands
TSS	75	70
Total phosphorus	50	55
Total Nitrogen	40	35
Zinc	50	65
Copper	45	65

3.2 Proposed Devices

It should also be noted that whilst the water quality assessment has focussed on the existing devices, as the ICMP requires wetland treatment (in accordance with the HCC ITS) for new development, it is expected that the outcomes apply to the whole catchment.

3.3 Treatment Train Performance

To determine an overall treatment train performance, the formula in NZTA (2010) has been used, as per CH2M Beca (2018a). The same formula is used in the Auckland Council Contaminant Load Model (AC, 2010). As discussed in CH2M Beca (2018a), we clarify that performance of a treatment train is highly linked to incoming particle size distribution. It is therefore considered that the results of the treatment train formula are likely to be optimistic, however they are useful for comparison purposes. Table 3 provides the individual and total removals of the treatment train, as calculated using the NZTA formula. Table 3 provides information on the removal efficiencies that have been used for each component of the treatment train, and a combined efficiency.

Table 3 – Contaminant Removal Percentages

Contaminant	% Removal - Swales	% Removal - Wetlands	Overall % Removal
TSS	65	70	90
Total phosphorus	30	55	69
Total Nitrogen	30	35	55
Zinc	60	65	86
Copper	50	65	83

It should be noted that in the neighbouring Rotokauri catchment, the values quoted for contaminant removal are generally higher than those used for Mangaheka. This is because values for Mangaheka are based on a range of sources with different recommended removal rates, rather than just from one source (NZTA, 2010), as was the case for the Rotokauri.

4 Revised Contaminant Loads and Concentrations

This addendum revises some of the contaminant loads as shown in Table 4 below. This revision includes recent monitoring data collected for the HCC Comprehensive Stormwater Discharge Consent (T+T, 2017) which provided up to date Hamilton specific data for an existing industrial area (Northway Street). This monitoring data is from the same sampling sites as NIWA, 2001. A full table of source data (similar to Table 7.1 from CH2M Beca, 2018a), with the T+T data replacing the NIWA (2001) data is provided in Appendix A. Based on the sources referenced, a load value for each contaminant of concern has been selected and is stated in Table 4, along with justification for the selected value.

Table 4 – Revised Contaminant Loads – Industrial (kg/ha/yr)

Contaminant	Selected Load (kg/ha/yr)	Justification
TSS	320	TSS will mostly be sourced from paved surfaces. Selected value fits in the range also.
Total phosphorus	0.88	Average of source values. Beca (2018) stated the value was an average but it was the upper end of the commercial values.
Total Nitrogen	4.66	Average of source values. (Beca, (2018) value was labelled as average but it was actually the median).
Zinc	4.90	Value is the upper end of “Commercial” values in ARC TP10. Zinc sourced from paved areas where vehicles turn resulting in tyre wear (no exposed galvanising roofing material). The value selected here is lower than “paved surfaces other than roads” but as this value is applied to the whole development area (both roofs and roads), this value is considered appropriate. This value is also higher than the average of source values.
Copper	0.32	Upper end of “Commercial” values selected (ARC TP10). Copper is often sourced from paved surfaces. Value decreased compared to previous value in Beca, 2018a. That was based on whole catchment being paved surfaces, whereas the rate for the whole development would be less when roofs are taken into account. This value is still higher than the average of source values referenced.

Table 5 shows the pre and post treatment loads, calculated using the overall percentage removals from Table 3, and an average annual concentration. Refer to Beca (2018a) and Appendix A for details of calculation inputs other than the loads above (rainfall, catchment area, runoff coefficient). It also compares these concentrations to guideline values including the updated ANZECC Hardness Modified Trigger Values for zinc and copper. Those shown in red are higher than the guideline values.

Table 5 – Revised Contaminant Loads and Concentrations

Contaminant	Contaminant Load Pre-treatment (kg/ha/year)	Contaminant Load Post Treatment (kg/year)	Average Concentration (g/m^3)	Guideline Value (g/m^3)
TSS	320	4827.0	3.20	None
Total phosphorus	0.88	39.8	0.026	0.015-0.3[a]
Total nitrogen	4.66	304.6	0.20	0.04-0.1[a]
Zinc	4.90	98.6	0.065	0.02[b]
Copper	0.32	8.0	0.005	0.0024[b]

Note (a): MfE, 1992, (b): ANZECC, 2000. 90% species protection based on disturbed environment (hardness modified trigger value).

Table 5 above shows that total nitrogen, zinc and copper are higher than the guideline values, even after treatment. Values are however of a similar order of magnitude to the guideline values.

Table 6 below compares expected rural concentrations (CH2M Beca, 2018) (pre-development) with the updated concentrations from Table 5 above. It should be noted that these values are sourced from TP10 and AC's CLM. For some of the contaminants, these figures are not likely to represent that which is expected in flat Hamilton catchments like Mangaheka. We have therefore also included an average value (and range in brackets) from monitoring data collected by Boffa Miskell in the Mangaheka catchment (BM, 2018).

Table 6 – Comparison of Rural, Existing and Developed Contaminant Concentrations (g/m^3)

Contaminant	Rural (g/m^3) (calculated)	Existing Values (BM, 2018) (monitored) (g/m^3)	Post Treatment (g/m^3) (calculated)
TSS	116.7	13.9 (5 -31)	3.2
Total phosphorus	0.021	0.42 (0.035-2.6)	0.026
Total nitrogen	0.659	2.4 (0.44 – 4.6)	0.21
Zinc	0.013	0.0256 (0.0012 – 0.069)	0.065
Copper	0.004	0.0023 (0.0018-0.0028)	0.005

Table 6 indicates that even after treatment, discharges of total phosphorus, zinc and copper are all still higher than rural land. When compared to Boffa Miskell site specific sampling values (second column), it can be seen that phosphorus is much lower than existing. However for zinc, whilst the predicted value (0.065) is higher than the average Boffa Miskell value (0.0256), it is within the range of that measured in the catchment. For copper the predicted concentration is still higher than rural, as is normally expected of urban development. The calculated values are also expected to be improved based on the ICMP requiring no exposed zinc and copper building products

Whilst Table 5 and Table 6 indicate that the discharge will not meet all guideline values and will not be lower than existing for some contaminants, this is often the case for urban development. It should also be noted that the values presented are annual averages and it is possible that throughout an individual storm and over time, values may be higher or lower than that stated, depending on the time since last rainfall, rainfall intensity and other factors.

In addition, whilst the above assessment indicates some contaminants being elevated above guideline and existing values, as noted in BM, 2018, the Mangaheka catchment has some specific characteristics which indicate that such values are not having significant effects, most importantly that the existing environment often has zinc and copper concentrations above the ANZECC guidelines.

It is possible that additional treatment could be provided (e.g. 3+ stage treatment train). However, this would not be expected to greatly improve the overall treatment, as later devices in a treatment train are generally not as effective at removing particulate matter which contaminants are typically bound to, due to the first devices removing the larger particles and much smaller particles remaining. This leads to 'diminishing returns' on investment of device installation.

5 Comments from Submitters and Reviewers

There have been a range of other comments from submitters and reviewers in relation to CH2M Beca (2018a). Responses on these are provided below.

Comment from Waikato Regional Council (WRC):

The assessment uses TP10 and ARC CLM V2 (2010) as source data to estimate contaminant loadings for TSS, TP, TN, TZn and TCu. This is inappropriate given the more relevant and available contaminant load data from Hamilton specific sampling results (NIWA, 1999 and T&T, 2017), recent updates to the NIWA Urban Runoff Data Book (data in draft) and development of HCC's Citywide CLM (HCC to confirm status / WRC to review). Suggest reviewing the more relevant data and extrapolating for Mangaheka Catchment. Also having this peer reviewed by an expert stormwater quality scientist.

Proposed Response: As part of our assessment, Hamilton specific data has also been referenced (NIWA, 2001), and was in a similar range to that of TP10 and ARC's CLM. TP10 and ARC's CLM are widely used industry standard references. We have also compared to T+T, (2017) and updated values where considered appropriate (see Appendix A and Table 4).

Comment from WRC:

The observation re contaminant loads being greater in the catchment, even after treatment, is an important one. In view of current policy drivers to significantly improve water quality, the application of source controls in combination with more centralized treatment devices and other mitigations / receiving environment enhancements etcetera is a given. The ICMP needs to be directive on this, i.e. the central purpose of the ICMP.

Proposed Response: The above sections indicate that whilst nitrogen and metals values are expected to be higher than guideline values, nutrient concentrations are expected to decrease and metals to increase (after treatment) compared to existing values (Boffa Miskell existing values). Increases in contaminants, especially metals, is difficult to prevent even with the best treatment possible. As these contaminants are generally sourced from vehicles (car braking, tyres), to have an improvement in water quality outcomes, widespread reductions in the use of zinc and copper in tyres and brake pads is the only way such contaminants can be reduced in the environment. Such changes will likely require government legislation at a national level rather than local level and will take time to come up on government agenda's let alone be implemented. Increases in such contaminants therefore needs to be managed by treatment. The treatment train approach applied in Mangaheka is expected to provide a high level of treatment in line with industry best practice.

Comment from Porters Properties Ltd and TPL:

More information is required regarding expected proportion that will discharge in the dissolved (and therefore bioavailable) fraction compared to the fraction adsorbed to sediment which is available to be settled out in the wetland devices. Further assessment is required to confirm whether a requirement for on-lot contaminant removal is appropriate and will provide an effective method of reducing dissolved contaminant discharges into the downstream receiving environment.

Proposed Response: Numbers presented in CH2M Beca (2018a) and in this Addendum are based on total values i.e. dissolved + particulate contaminants. Many contaminants (other than sediment) have a portion of this total value in the dissolved form and the remainder as particulate. Given that there is little information available in widely used references like TP10 and ARC's CLM in regard to the removal of dissolved versus particulate contaminants in conventional stormwater treatment devices, and without doing detailed research into this, we have not incorporated this information into the assessment i.e. determined concentrations. BM (2018), does however provide some comments on this.

In regard to on-lot contaminant removals, the Mangaheka ICMP requires on-lot treatment (e.g. swales or raingardens) as a minimum for all lots. In addition, if an industry is high-risk, a Pollution Plan is required to demonstrate any source controls to be implemented and treatment required for contaminants over and above that likely to be removed in the downstream treatment systems. This treatment will vary depending on the industry and hence will be tailored to the contaminants generated. This will include dissolved contaminants. We are of the opinion that if prepared appropriately by the developer and assessed appropriately by HCC, this method of controlling contaminants is expected to be appropriate and effective.

6 Conclusions

Since the preparation of CH2M Beca (2018a); further information on water hardness in the Mangaheka Stream has become available, the provision of pre-treatment (e.g. swales or raingardens) on-lot has been included in the draft ICMP and the existing HJV and Porters wetlands have had further design review. As a result, updates to the water quality assessment have been carried out and are documented in this addendum. The associated AEE (CH2M Beca, 2018b) and Boffa Miskell Ecological Report (BM, 2018) provide a complete assessment of effects and should be read in conjunction with this report.

Updates to the assessment have shown that contaminant concentrations for zinc and copper, even after treatment, are all still likely to be higher on average than existing rural land (Boffa Miskell values, refer BM (2018)). BM, 2018 states that it is not expected that these increases will result in effects on aquatic community composition.

Given this, it is not considered that additional treatment, over and above the key mitigation measures proposed by the ICMP, would provide a significant benefit relative to cost of implementation. This is because typically, lower contaminant removals are expected from later devices in a treatment train.

The key Mangaheka draft ICMP mitigation measures are as follows:

- Restrictions on the types of building products i.e. no zinc and copper building products will help to reduce the rates of metals generation.
- Source control of contaminants.
- Treatment (on-lot and centralised).
- Centralised devices to be designed in accordance with "Best Practicable Options" and HCC standards. It will be important that designs are appropriate assessed by HCC during consenting processes.
- High-risk sites to prepare Pollution Prevention Plans and undertake contaminant management.

7 References

- ANZECC, 2000. *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand.
- Auckland Council, *Contaminant Load Model* (Spreadsheet), Version 2.0 March, 2010.
- Auckland Regional Council, 2003. *Stormwater Management Devices: Design Guidelines Manual. Technical Publication 10* (TP10).
- CH2M Beca, 2018a, *Mangaheka Water Quality Assessment*, CH2M Beca, February 2018.
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- CH2M Beca, 2018c. Mangaheka ICMP – *Review of Existing Stormwater Management Devices*, CH2M Beca Ltd, July 2018.
- BM, 2018, *Mangaheka Ecological Assessment*, *Boffa* Miskell Ltd, July 2018.
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Appendix A

Contaminant Concentration Calculations

Catchments

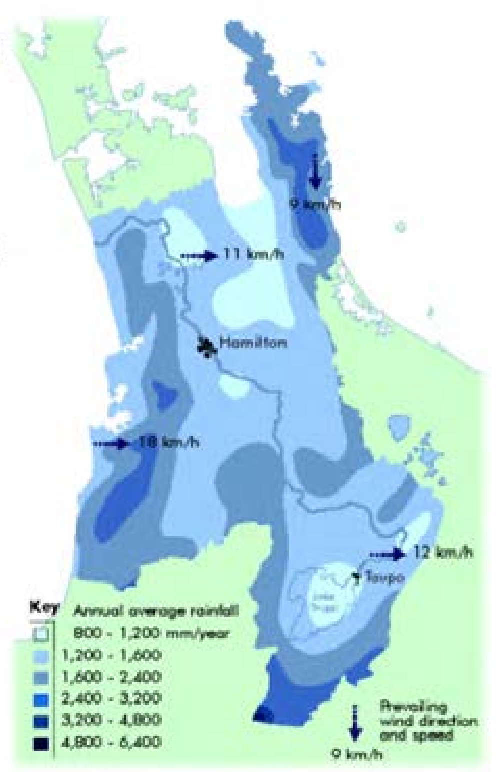
Rural

		Area (ha)	CN	% Imp	
A	4 Guys	7.0	70.45	0.05	
B	HJV	66.7	70.45	0.05	Not incl Sharksfin
F	Porters	69.9	70.45	0.05	
		143.7			

Existing Development **Catchment Areas and CN/RC** - as per design report

		Area (ha)	Curve Number	% Imperv	CN * A
A	4 Guys Pond	7.0	95.1	0.90	667.5
B	HJV	66.7	88.6	0.68	5912.5
F	Porters Pond	69.9	89.6	0.71	6260.8
		143.7	Sum		12840.9
			Weighted CN		89.38

Rainfall Sourced from WRC website:



Runoff Coefficients

Rural	0.45	based on CN of 70.5.		
Existing Equiv Rc (Existing D)	0.81 Conversion from 1D modelling curve number.			
Check against composite runoff coeff:				
	RC	Area	Rc x A	
Perv	0.45	42.7		19.2
Imp	0.9	101.0		90.9
		Sum		110.1
		Composite Rc		0.77

Annual Runoff Volume

Area (ha)		143.7		
Annual Rainfall		1400	mm/year	- from WRC website - see diagram on right
Runoff coeff	Rural	0.45	based on CN of 70.5.	-see calculations above
	ED	0.75		Average value from 1D modelling.
Annual runoff volume	Rural	905,070	m^3/yr	
Annual runoff volume	ED	1,508,450	m^3/yr	

Efficiency Formula from NZTA (2010)

Efficiencies

	Swale	Wetland	Combined
Total suspended solids	65	70	90
Total phosphorus	30	55	69
Total Nitrogen	30	35	55
Total Zinc	60	65	86
Total Copper	50	65	83

$R = A + B - [(A \times B)/100]$

Where:
R = total removal rate
A = Removal rate of the first or upstream practice
B = Removal rate of the second or downstream practice

Contaminant Load Source Data

	Rural	Farmed Pasture	**Value Used (Rural)**	Roads	Commercial	Roofs	Roads	Paved Surfaces other than roads	Industrial	Average	Median	**Value Used (Industrial)**
	g/m2/year											
TSS	10.3-58.3	152.0	**73.5**	28.1-72.3	24.2-136.9	5.0	21.3	32.0	39.3	44.9	30.1	**32.0**
TP	0.001-0.025	-	**0.013**	0.059-0.15	0.069-0.091	-	-	-	0.071	0.1	0.1	**0.088**
TN	0.12-0.71	-	**0.415**	0.13-0.35	0.16-0.88	-	-	-	0.81	0.5	0.4	**0.466**
Zn	0.002-0.017	0.0053	**0.0081**	0.018-0.045	0.17-0.49	0.020	0.0044	0.590	0.63	0.2459	0.1075	**0.490**
Cu	0.002-0.004	0.0011	**0.0024**	0.003-0.009	0.011-0.032	0.002	0.0015	0.107	0.009	0.0218	0.0100	**0.0320**
Source	ARC's TP10	ARC's CLM		ARC's TP10	ARC's TP10	ARC's CLM	ARC's CLM	ARC's CLM	T+ T 2017			

Loads and Concentrations - Rural

Contaminant	Load g/m²/yr	Load kg/year	Average concentration g/m³	Guideline Value	Guideline Ref
Total suspended solids	73.5	105,639	116.7		No guideline value
Total phosphorus	0.0130	19	0.021	0.015-0.3	MfE Water quality guidelines for the control of Undesirable Biological Growths in Water. (MFE,1992)
Total Nitrogen	0.4150	596	0.659	0.04-0.1	MfE Water quality guidelines for the control of Undesirable Biological Growths in Water. (MFE,1992)
Total Zinc	0.0081	12	0.013	0.015	ANZECC
Total Copper	0.0024	3	0.004	0.0018	ANZECC

kg/ha

Loads and Concentrations - Industrial

Contaminant	Load kg/ha/yr	Load Post treatment (kg/ha/year)	Load kg/year	Average concentration g/m³	Guideline	Guideline Ref		
Total suspended solids	320.00	33.60	4827.0	3.20		No guideline value		
Total phosphorus	0.88	0.28	39.8	0.0264	0.015-0.3	MfE Water quality guidelines for the control of Undesirable Biological Growths in Water. (MFE,1992)		
Total Nitrogen	4.66	2.12	304.6	0.20	0.04-0.1	MfE Water quality guidelines for the control ob Undesirable Biological Growths in Water. (MFE,1992)		
Total Zinc	4.90	0.69	98.6	0.0653	0.02	ANZECC HMTV	0.174	1.306667
Total Copper	0.32	0.06	8.0	0.0053	0.0024	ANZECC HMTV		

Above guideline value

Between upper and lower guideline value

Contaminant	**Rural** Average concentration g/m³	Boffa Miskell Data Mangaheka Existing Average g/m³	Industrial Developed (adjusted with T + T 2017 values) Average concentration g/m³
Total suspended solids	116.720	13.9	3.20
Total phosphorus	0.021	0.42	0.026
Total Nitrogen	0.659	2.4	0.20
Total Zinc	0.013	0.0256	0.065
Total Copper	0.004	0.0023	0.005

Higher than Guideline | Higher than Rural (BM value)

Appendix D

Watercourse Assessment

Engineers & Consultants

Mangaheka Watercourse Assessment and Programme of Works

Final

Prepared for Hamilton City Council by Morphum Environmental Ltd
22/05/2017

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MORPHUM ENVIRONMENTAL LTD

Engineers & Consultants

Document Control

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Revision History

Status	Date Issued	Author	Reviewed By	Released By
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Reviewed by:

Reviewer: Emily Reeves **Signature:**

Released by:

Reviewer: Damian Young **Signature:**

Executive Summary

Hamilton City Council is currently preparing integrated catchment management plans (ICMPs) for several catchments within the city boundary. One of the objectives of an ICMP is to identify effects on the receiving environment and to propose mitigation solutions. This process is critical in catchments where growth pressure is changing Greenfield land to Brownfield and the focus to date has largely been around erosion. To get a better understanding of existing condition and future impacts a number of assessments have been undertaken focusing on the downstream receiving environments of greenfield areas to assess existing erosion and erosion susceptibility. These assessments (to date in Kirikiriroa and Te Awa O Katapaki catchments) have led to a programme of works being developed to provide resilience against erosion including both exacerbation of existing erosion issues, and potential erosion in currently stable (or artificially stabilised) reaches associated with growth areas.

A large portion of the HCC catchments are either developed or has HCC and WRC consents. These assessments are designed to address the residual effect of increased volumes from the growth areas on the receiving environment channels. Although these growth areas are assumed to be mitigating all onsite requirements for treatment and attenuation, it is acknowledged that this is not always possible and the gully systems and current farm drains may need restoration and management.

Erosion in watercourses, although a natural process, can be intensified due to increased flow rates and volumes from urbanisation. Increased sediment mobilisation and deposition within a watercourse can have detrimental effects on fish and macroinvertebrate populations and channel erosion can result in the loss of private and public land.

Morphum Environmental Limited (Morphum) was engaged by Hamilton City Council (HCC) to undertake an assessment of the Mangaheka Stream from the HCC boundary to the upstream boundary of the Tanirau Wetland. The assessment is aiming to inform concept projects and management options that are required to mitigate ongoing erosion within the Mangaheka Stream including the portion of the stream that is located within Waikato Regional Council's administered Ngaruawahia Drainage Area. The portion of the stream outside the WRC administered drainage area is managed by Waikato District Council and Waikato Regional Council's Waipa Zone catchment programme..

Morphum undertook an assessment on Wednesday the 22nd February 2017 which consisted of a walkover survey of the 5 km reach and collection of data using the ArcGIS application Collector. Following this assessment, four scenarios have been developed with varying mitigation works and actions. These scenarios have been developed in consideration of the fact the works are proposed on private land and both WRC and HCC want to minimise any impacts to landowners including the loss of grazing land.

The final costings should be considered as indicative only. A pricing activity of erosion mitigation works should occur during detailed designs. The following details and costs form the four scenarios:

Scenario One: Do nothing.
No mitigation works will likely result in increased erosion, bank slumping and loss of land through the Mangaheka Stream network. There is no capital cost associated with this scenario.

Scenario Two: Low Level Mitigation.
This scenario provides the minimum mitigation works that Council should consider for the Mangaheka Stream network. The works include planting that aim to support top of bank stability and isolated reinforcement with toe protection. It should be noted that overall bank erosion for the reach may still increase given the lack of bank stabilisation works however, there is potential for seed dispersal to occur on the banks which would provide some bank resilience. The total physical works cost including

20% contingency for this scenario is $1.2M and could be implemented over a 5 year period, with a 5 year maintenance period following completion.

Scenario Three: Medium Level Mitigation.
This scenario provides the mitigation options that should be considered by council to further protect the watercourse from erosion and provide better stability to erosion prone banks while providing a larger ecological corridor and buffer for flora and fauna. The works include further planting, installation of toe protection and riprap for isolated areas and the battering back of some banks. The total physical works cost including 20% contingency for this scenario is $1.9M and could be implemented across a 5-10 period, with a 5 year maintenance period following completion.

Scenario Four: High Level (Best Practice) Mitigation.
This scenario provides the mitigation works that would provide the banks with further protection from erosion and while providing sufficient shade and habitat for flora and fauna. The works include retiring a total of 10m either side of the channel for staged planting and installing erosion protection such as riprap along extended reaches of the upper network. The total physical works cost including 20% contingency for this scenario is $4.3M and could be implemented over a 10 period, with a 5 year maintenance period following completion.

Based on the scenarios described above, it is recommended that Scenario 3 is the chosen option and the described works to be considered for inclusion into the ICMP. Option 4 should be considered for its restorative value and as a longer term solution subject to landowner consent.

Operation and maintenance costs are considered further in this report and vary with each scenario.

Contents

1.0 Assessment Methodology

The assessment was undertaken on Wednesday the 22nd February and consisted of a walkover survey of the 5 km reach. The ArcGIS application Collector was used to collect data in the field. Ecolines (as per the HCC ICMP receiving environment module, HCC 2015) were recorded for reaches of streams that were similar in morphology. The ecoline data schema includes the assessment of upper bank stability using the Pfankuch Bank Stability Assessment (Pfankuch, 1975). The ICMP Data schema does not include the Lower Bank and Bottom (channel) erosion susceptibility assessments. During the assessments the erosion susceptibility of lower banks were assessed with consideration of previous photos (Boffa Miskell, 2015) and previous studies (Coffeys Geotechnics, 2012). Locations were also identified where localised erosion hotspots or bank slumping was observed and GPS photos points recorded.

A total of 10 reaches were identified, based on changes in bank morphology and landform e.g. roads. Figure 1 shows subject reaches and overview.

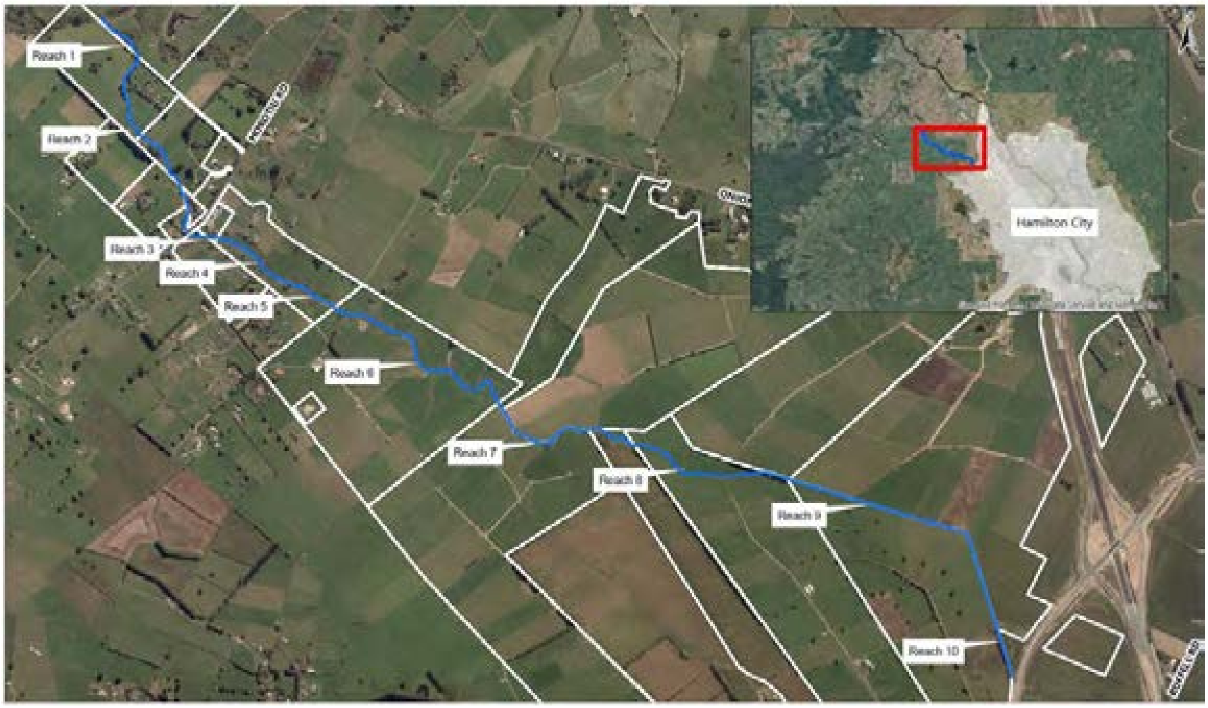

Figure 1 Overview of assessment area and reaches

2.0 Watercourse Function and Capacity

According to NZWERF, the primary function of farm drainage waterways is to lower the water table 30 cm below the soil surface within 24 hours, or 50 cm within 48 hours of a one-year return period, to improve pasture health (NZWERF, 2005). The portion of the Mangaheka Stream located in the Ngaruawahia Drainage Area is administered by WRC's Integrated Catchment Management Directorate (ICM) with a Drainage Board (comprising local land owners within the drainage area) in place to make decisions about operation and maintenance requirements for the drainage system. Maintenance is often undertaken by WRC contractors and will include spraying and the digging out of drains within the drainage area. Weed management is generally undertaken annually within the channel located in the drainage area with aquatic species being targeted by the spray programme that includes spraying the base of the channel (additional spraying maybe undertaken by individual landowners). Blanket spraying can occur which results in the loss of desirable vegetation. It is recommended that for any further spraying required, a spot spraying method should be considered. Furthermore, drain maintenance in the form of channel substrate removal should be limited to 20% of the total stream length per year and rotated over a 5 year period.

Farm drainage systems have ecological value even when they are highly impacted. During the assessment a single 110 mm Longfin eel (*Anguilla dieffenbachii*) was observed, as well as a number of coarse fish species such as Koi carp (*Cyprinus carpio)* and Mosquito fish (*Gambusia affinnis)* along reach 7.

Within the drainage area in the Mangaheka Stream catchment, the primary level of service is to manage groundwater levels to a level to enable rural activities to occur. The secondary level of service is to drain ponded water from a 10 year ARI event within 3 days, so as to ensure pasture damage is avoided. The Mangaheka ICMP – Stormwater 1-D Modelling report (February 2017) carried out by Beca Group (Beca) investigated the effects of development on stream water levels, peak flows and flooding duration at 12 locations along the Mangaheka channel, 3 of which were within the scope of this report (locations 8, 9 and 10; Figure1: Reporting Locations, pg 4 of Beca Report).

2.1 Existing Development Modelled with Climate Change

The results of the Beca modelling indicate that with the existing level of development there will be a 30% increase in flows at the top of Morphum study reach 10 during a 100 year rainfall event as a result of climate change (Table 3: pg 5, Beca Report). When modelled on a 10 year rainfall event at the same location (Location 8 of Beca model), it is expected that there will be an increase of 14% in maximum flow rate in response to climate change.

2.2 Maximum Probable Development Modelled with Climate Change

The results of this modelling show that during a 100 year rainfall event (factoring in climate change), there will be a 39% increase in maximum flow at the top of reach 10 following the completion of proposed developments (Table 3: pg 5, Beca Report). During a 10 year post-development flow increases by 45% of existing development levels to 2.52 m^3/s at the top of reach 10. The drain down times (post maximum probable development and mitigation) for these events at the bottom of the study reaches (Horotui Rd) are 11 hours and 5.5 hours for a 100 year and 10 year event respectively. The current drain down times for the existing development scenario are 8.8 hours and 4.2 hours for a 100 year and 10 year event respectively.

These results show that implementing all proposed mitigation techniques, outlined on page 7 of the Beca Report, will result in peak flows which are at or below existing development water levels. However, there are likely to be residual ongoing effects, of the development on the drainage network, such as increased annual flow volumes and extended duration of peak flows which may exacerbate downstream erosion and scour effects.

2.3 Restoration Vision 2012

The Draft Mangaheka Stream and Drain Network Restoration vision was developed by Boffa Miskell in August 2012 and will be considered for adoption by WRC's ICM directorate and inclusion in the Waipa Zone Management Plan depending on zone prioritisation and availability of budget and resources. . It was intended by the authors of the restoration vision that implementation of the vision would occur within 10 years of 2012. The vision was first developed through the consenting process for the Rotokauri Industrial Development which identifies targeted rates as the primary source of funding. The purpose of the vision is to guide regional and district councils, Tangata whenua and public efforts to help restore and enhance the ecology of the Mangaheka Stream network. Funding for the implementation of the restoration vision has not been determined.

The Restoration vision statement is:

"To restore the lowland stream values of the Mangaheka Stream to a high quality aquatic environment, thereby providing for the long term availability of the stream for existing and potential uses consistent with the concept of sustainable management."

The works described in this report take into account the restoration vision and provide an additional resolution by providing concepts, design geometry and dimension.

3.0 Limitation for assessing costs for remediation works

The following specific limitations are provided as follows:

- Volumes for proposed excavations are approximate for each reach as bank height and channel width are averages for the study reaches as per the walkover assessment and did not involve survey levels just inferred bank angles and lengths to determine volumes.
- Detailed surveying of significant erosion hotspots will be required to accurately cost the proposed remediation works outlined in this memorandum.
- Dimensions for planting areas are approximate and based on:
    - Planting area for Scenario 2 will begin at the margin of the top of bank.
    - Planting areas for Scenarios 3 and 4 will begin on the lower bank margins following any proposed excavations.
    - Fence lines are indicative only. Best practise fencing may lead to straightening of proposed fence lines.

Please note the Reach Percentages are for both banks i.e. 30% of total reach. The supporting other details for costs are included in unit rates Table 2.

4.0 Reach Summaries

The following section provides a high level summary of each reach. Table 1 provides a summary of the reaches assessed.

Table 1 Reach Summary

Reach #	Reach Length (m)	Average Bank Height (m)	Average Erosion Scarring (%)	Erosion Susceptibility	District	Area Management
1	330	0.5	<20	Low	Waipa	Waipa River Zone
2	633	0.5	<20	Low	Waipa	Waipa River Zone
3	20	0.6	<20	Low	Waipa	Waipa River Zone
4	260	0.6	<20	Low	Waipa	Waipa River Zone
5	276	0.6	<20	Low	Waipa	Waipa River Zone
6	800	1.6	<20	Low-Moderate	Waipa	WRC Land Drainage
7	521	1.9	20-40	Moderate	Waipa	WRC Land Drainage
8	458	0.9	<20	Low-Moderate	Waipa	WRC Land Drainage
9	917	1.1	<20	Low-Moderate	Waipa	WRC Land Drainage
10	551	1.5	<20	Low-Moderate	Waipa	WRC Land Drainage

4.1 Reach 1, 2 and 3

Reach 1, 2 and 3 are characterised as low energy, highly depositional wetland environments. The reaches are characterised as wide cushiony floodplains that have approximately 0.5 m of water below the surface. The reaches were assessed to have low susceptibility to erosion given the proximity to upstream development and relatively low grade. The most likely process resulting in erosion is from the disturbance of soil and bank structure caused by stock during grazing of these wetland areas. This is due to the lack of exclusion fences in most of these wetland type areas.

Figure 2: Figure 2a and 2b illustrate the fencing off of the channel along reach 2 however, the surrounding low lying pasture land that is not encompassed within this fence has been identified as a floating wetland type as described above. Figure 2c shows the wetland in panorama.

4.2 Reach 4 and 5

Reach 4 and 5 are both considered as low energy, transport reaches due to the low grade of the incised channel. The low bank height and complete vegetation cover on the flood plain minimise the risk of erosion during inundation from high flows. The susceptibility of these reaches to erosion is therefore considered low as there is little evidence of erosion scarring under current conditions. The lack of fencing along these reaches is a concern as stock are evidently grazing right up to the bank, again increasing the likelihood that bank structure may be compromised and increase localised erosion along these reaches.

Figure 3: Illustration of the grazing pressure along the unfenced reach 5. The far bank (TLB) is not grazed, while the near bank (TRB) has been grazed. Grazing pressure was observed right up to the channel edge.

4.3 Reach 6 and 8

Reach 6 spans the width of the Hancock property and was identified by the Coffey Geotechnic assessment as one of the worst affected areas. This report identifies reach 6 (*Figure 4a and c*) and reach 8 (*Figure 4b*) as low – moderate energy systems as there is an increase in channel grade and localised confinement relevant to the downstream reaches. There is little concern for widespread bank instability under normal conditions however; the proximity of fence posts to the upper bank has become a focal point for localised erosion, mainly caused by overland flow paths during heavy rainfalls. Concentrated stress at these points during high magnitude events could be the source of weak points. In the upstream segments of Reach 6 the bank height increases to 1.6 m and the bank steepens. The changes in bank geometry have resulted in increased signs of bank instability such as slumping of both the upper and lower bank, exacerbating the weak points associated with post positioning at the top of the bank which is likely to require toe protection and bank stabilisation works.

Figure 4: Figures 4a and 4b demonstrate the close proximity of the fencing along reaches 6 and 8 respectively. Figure 4c highlights the issues of fences located too close to the waterways.

4.4 Reach 7

Although not highlighted by the Coffey Geotechnics report as an erosion hotspot, this report notes that Reach 7 is considered a moderate energy system, as the channel grade and proximity to the upstream catchment increase the susceptibility of the channel banks to further erosion. Reach 7 has a highly-incised channel with steep banks. The channel appears to have had the channel excavated which has resulted in banks that are now exposed and in places near vertical and undercut. The bank erosion of this reach can be attributed to removal of channel bed substrate although instabilities have been exacerbated by an increase of ash within the soil. As a result, there are multiple points where bank stabilisation methods may need to be implemented to reduce increased sediment loss in the future and reduce erosion susceptibility.

4.5 Reach 9 and 10

Reach 9 and 10, although highly incised, have been classified as having low to moderate erosion susceptibility due to a stable bank structure and a decrease in channel grade in comparison to reach 7. The drain erosion assessment carried out by Coffey Geotechnics in 2012 identifies these reaches as one of the worst affected areas of the Mangaheka Stream, which aligns with the findings of this report. Slumping of the upper bank is evident in some locations, although the primary cause of this instability appears to be the alignment of the fence in relation to the bank edge in conjunction with very steep near vertical channel banks. Steep banks may have been exacerbated by spraying or where the steepness in the bank has resulted in conditions where grass has not been able to establish in the summer months. The instabilities of the upper bank are extensive along both reaches and may require a high level of remediation in the form of channel reshaping due to the proximity of the reach to the upstream development.

Figure 5: Figure 5a and 5c indicate the typical channel form along reaches 9 and 10 respectively. Figure 5b and 5d illustrate upper bank instabilities along reaches 9 and 10 caused by steep bank angles and poor fence alignment.

5.0 Programme of Works Scenarios and Costs

Four scenarios are developed as part of this programme of works with varying mitigation efforts. Planting in the scenarios are supported by Figure 6. All scenarios will need to be designed to allow the continued function of the drainage system by lowering the water table of surrounding fields to ensure the pasture health of these fields is not compromised during high magnitude rainfalls that may result in surface flooding.

These scenarios have been developed with the consideration that the works are proposed on private land and both WRC and HCC want to minimise any impacts to landowners including the loss of grazing land. Additionally this is not detailed design but high level costs of scenarios only and it is anticipated a detailed design process should be undertaken prior to any works being undertaken.

5.1 Do nothing (Scenario 1)

Maintain current management regime. No mitigation works will likely result in increased erosion, bank slumping and loss of land through the Mangaheka Stream network.

5.2 Low level Mitigation (Scenario 2)

This scenario provides the minimum mitigation works that Council should consider for the Mangaheka Stream network. The works include planting that aim to support top of bank stability and isolated reinforcement with toe protection using appropriately sized riprap. It should be noted that overall bank erosion for the reach may still increase given the lack of bank stabilisation works however, there is potential for seed dispersal from the newly planted areas to occur on the banks which would provide some bank resilience.
The works include:

1. Retiring 3 m either side of the stream from farm land to riparian buffer.
2. Plant retired land using type 1a as per Table 2.
3. Fencing the outer perimeter of the planted area.
4. Installing erosion protection for isolated areas identified during the site visit.

5.3 Medium Level Mitigation (Scenario 3)

This scenario provides the mitigation options that should be considered by council to further protect the watercourse from erosion and provide better stability to erosion prone banks while providing a larger ecological corridor and buffer for flora and fauna. The works include:

1. Retiring 5 m either side of the stream from rural land to riparian buffer.
2. Plant first 3 m of retired land using planting type 1b as per Table 2.
3. Plant remaining 2 m strip of retired land using planting type 2 as per Table 2.
4. Fencing the outer perimeter of the planted area.
5. Installing erosion protection for isolated areas identified during the site visit.
6. Battering back banks for sections of reaches that require increased stabilisation.

5.4 High Level (Best Practice) Mitigation (Scenario 4)

This scenario provides the mitigation works that would provide the banks with further protection from erosion and while providing sufficient shade and habitat for flora and fauna. The works include:

1. Retiring a total of 10 m (or where the natural floodplain extends to, such as the upper banks of reaches 1, 2 and 3) from rural to riparian buffer.
2. Plant first 3 m of retired land using planting type 1b as per Table 2.

3. Plant 2 m of retired land strip using planting type 2 as per Table 2.
4. Plant the remaining 5 m outer strip of retired land using planting type 3 as per Table 2.
5. Fencing the outer perimeter of the planted area.
6. Battering back banks for sections of reaches that require increased stabilisation.
7. Installing erosion protection for extended areas of reach 7, 9 and 10 and isolated areas of reach 6 and 8.

6.0 Cost and unit rates for mitigation options

The following rates are based on schedules of works and quotes from the last 5 years in the Auckland market. The rates are therefore considered conservative but should take into account upwards price pressure in the immediate future. The final costings should be considered as indicative only. A pricing activity of erosion mitigation works should occur during detailed designs. It is anticipated that these costs are considered by council to inform a funding request and are limited in that no detailed design work was done.

Table 2 Cost and unit rates

Mitigation	Unit	Cost	Assumptions and exclusions
Erosion Protection	m	\$50	Assumes use of 0.25m^3 of rock per linear metre. At \$200 per m^3; This includes isolated toe protection and bank stabilisation using riprap.
Type 1a Carex Planting at 3 plants per m^2	m^2	\$21.40	Includes boom spray of glyphosate single application; Planting at 4 plants per m^2. Carex and Juncas; Plant grade PB3s; Assumes team of 6 planting 350 plants each per day; Cost includes portaloo hire, quad and trailer hire, and fertiliser.
Type 1b Carex Planting at 4 plants per m^2	m^2	\$28.50	Includes boom spray of glyphosate single application; Planting at 3 plants per m^2. Carex and Juncas; Plant grade PB3s; Assumes team of 6 planting 350 plants each per day; Cost includes portaloo hire, quad and trailer hire, and fertiliser.
Type 2 Monocot* Planting at 1 plant per m^2	m^2	\$7.25	Includes boom spray of glyphosate single application; Planting at 1 plant per m^2, Carex, toetoe, flax and cabbage tree; Plant grade: PB3s; Assumes team of 6 planting 350 plants each per day; Cost includes portaloo hire, quad and trailer hire, and fertiliser.
Type 3 Native Planting at 1 plant per m^2	m^2	\$7.25	Includes boom spray of glyphosate single application; Planting at 1 plant per m^2, Carex, toetoe, flax and cabbage tree; Plant grade: PB3s; Assumes team of 6 planting 350 plants each per day; Cost includes portaloo hire, quad and trailer hire, and fertiliser.
Fencing	m	\$7.50	7 wire fence with 5m posting.
Bank batter	m^3	\$70	\$50/m^3 for excavation; \$20/m^3 for haulage away from site and disposal to clean fill; Does not include setting up diversions/erosion and sediment control; Assumes 45° banks.
Grazing land lost	m^2	\$0.38	Based on 10% of average land sale cost in Waikato Region as reported by REINZ 2016; 10% assumes land lease rather than sale; http://www.interest.co.nz/rural/resources/farm-sales.

*Indicative Monocot species include Flax and ToeToe.

Figure 6 provides the indicative planting arrangements using the types in for Scenario 2, 3 and 4.

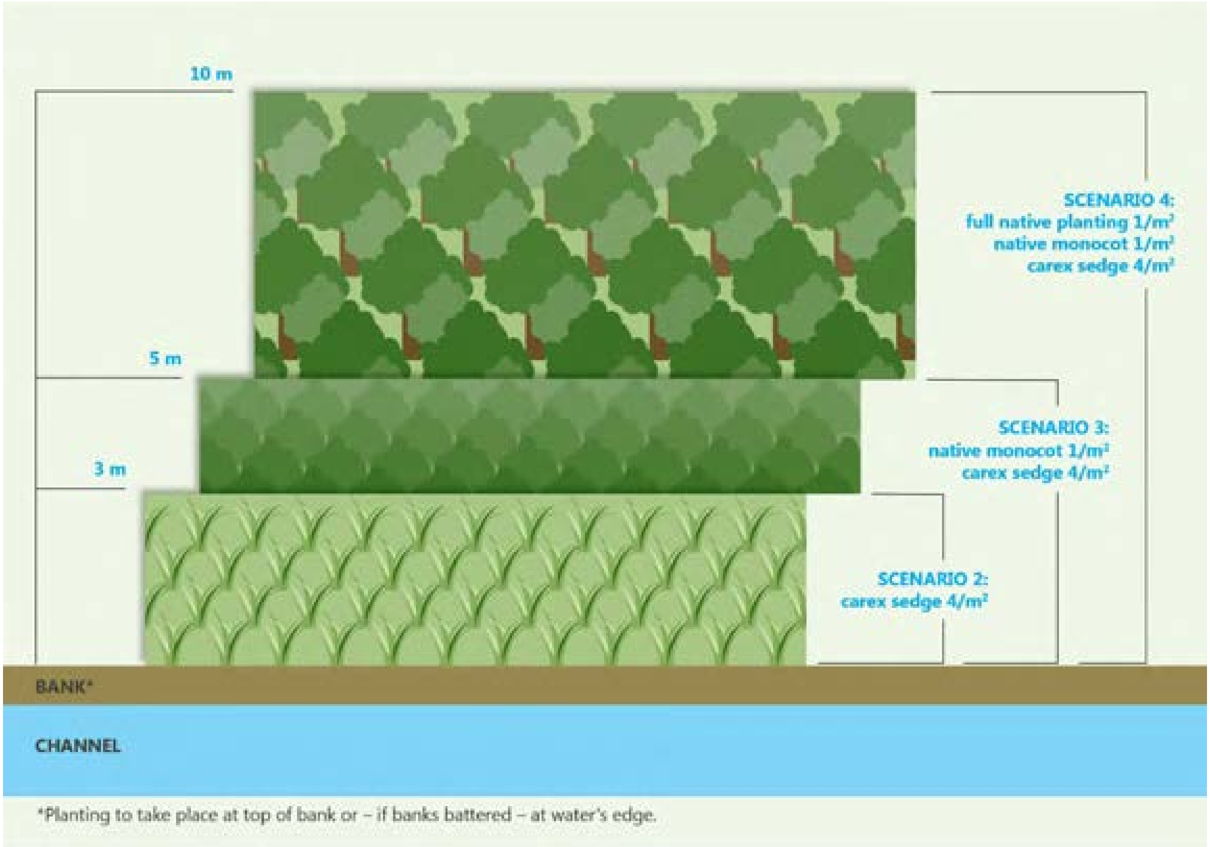

Figure 6 Scenario 2, 3 and 4 Planting Plan

Table 3, Table 4 and Table 5 provide the cost estimates for scenarios 2, 3 and 4 respectively.

Table 3 Scenario 2 Erosion Mitigation Works and Costs

Reach number	Planting Total	Fencing Perimeter	Erosion Protection %	Erosion Protection Cost	Batter Banks %	Batter Banks Cost	Grazing Land Cost	Detailed Design	Totals
1	$ 57,120	$ 5,110		$ -		$ -			
2	$ 108,946	$ 9,645		$ -		$ -			
3	$ 14,309	$ 1,361		$ -		$ -			
4	$ 44,735	$ 4,038		$ -		$ -			
5	$ 47,889	$ 4,303		$ -		$ -			
6	$ 137,482	$ 12,152	5%	$ 2,000		$ -		$60,000	
7	$ 89,798	$ 7,979	10%	$ 2,605		$ -			
8	$ 79,387	$ 7,060	10%	$ 2,290		$ -			
9	$ 157,482	$ 13,911	10%	$ 4,585		$ -			
10	$ 95,127	$ 8,443	10%	$ 2,755		$ -			
Sub total	**$ 832,273**	**$ 74,001**		**$ 14,235**				**$60,000**	**$ 920,509**
Total including contingency 20%									**$1,176,611**

Table 4 Scenario 3 Erosion Mitigation Works and Costs

Reach number	Planting Total	Fencing Perimeter	Erosion Protection %	Erosion Protection Cost	Batter Banks %	Batter Banks Cost	Grazing Land Cost	Detailed Design	Totals
1	$ 85,856	$ 5,181		$ -		$ -			
2	$ 219,253	$ 10,643		$ -		$ -			
3	$ 47,153	$ 2,401		$ -		$ -			
4	$ 67,111	$ 4,091		$ -		$ -			
5	$ 71,941	$ 4,377		$ -		$ -			
6	$ 206,355	$ 12,208	10%	$ 4,000	10%	$ 4,298		$80,000	
7	$ 134,792	$ 8,039	30%	$ 7,815	50%	$ 48,190			
8	$ 119,195	$ 7,131	10%	$ 2,290	10%	$ 779			
9	$ 236,454	$ 13,987	30%	$ 13,755	30%	$ 12,436			
10	$ 142,920	$ 8,518	30%	$ 8,265	30%	$ 19,059			
Sub total	**$ 1,331,030**	**$ 76,575**		**$ 36,125**		**$ 84,760**		**$80,000**	**$1,608,490**
Total including contingency 20%									**$1,930,188**

Table 5 Scenario 4 Erosion Mitigation Works and Costs

Reach number	Planting Total	Fencing Perimeter	Erosion Protection %	Erosion Protection Cost	Batter Banks %	Batter Banks Cost	Grazing Land Cost	Detailed Design	Totals
1	$ 254,828	$ 5,977		$ -		$ -	$ 5,752	$100,000	
2	$ 235,094	$ 10,711		$ -		$ -	$ 11,323		
3	$ 105,668	$ 2,486		$ -		$ -	$ 2,416		
4	$ 156,998	$ 5,015		$ -		$ -	$ 4,886		
5	$ 260,472	$ 5,039		$ -		$ -	$ 4,056		
6	$ 376,867	$ 14,075	30%	$ 12,000	50%	$ 21,489	$ 13,485		
7	$ 180,899	$ 8,212	30%	$ 7,815	90%	$ 86,741	$ 3,940		
8	$ 278,077	$ 7,291	30%	$ 6,870	50%	$ 3,893	$ 3,582		
9	$ 260,101	$ 14,143	30%	$ 13,755	90%	$ 37,307	$ 6,993		
10	$ 1,201,855	$ 8,724	50%	$ 24,795	90%	$ 57,176	$ 4,898		
Sub total	**$ 3,310,860**	**$ 81,674**		**$ 54,215**		**$ 206,606**	**$ 61,331**		**$ 3,608,080**
Total including contingency 20%									**$ 4,329,696**

6.1 Capital Cost Summary

The costs outlined in Tables 2,3 and 4 are summarised by costs below:

- The physical works costs (including a 20% contingency) for Scenario 2 is $1,176,611.
- The physical works costs (including a 20% contingency) for Scenario 3 is $1,930,188.
- The physical works costs (including a 20% contingency) for Scenario 4 is $4,329,696.

These costs are physical works costs with additional 20% contingency. They do not include design and feasibility, resource consents, defects liability or operations and maintenance fees. These additional costs have been included in the scenario 3 costing table (Table 7) in Appendix B.

6.2 Operation and Maintenance Costs

Years 1 and 2 (post works completion) should be included as part of the capital works defects liability. It is assumed this would include:

- 10% of capital projects cost,
- Annual plant maintenance costs as per Table 6,
- Post works sign off walkover,
- Six months follow up walkover,
- Annual walkover assessment.

Years 3 and 4 costs should include:

- Annual plant maintenance costs as per Table 6 with reduced visit frequency to 3 per year,
- Annual walkover assessment,
- Full assessment of reach in the third year and update the concept programme of works.

Years 5 + cost should include:

- Annual plant maintenance costs as per Table 6 with reduced visit frequency to 2 per year,
- Annual walkover assessment,
- Full assessment of reach every three years and update the concept programme of works.

Table 6 Annual Planting Maintenance per year

Scenario	Area (m^2)	Days per visit	Year 1 and 2		Year 2 and 3		Years 5 +	
			visits per year	Cost per year	visits per year	Cost per year	Visits per year	Visits per year
Scenario 2	38,891	**4**	4	$23,040	3	$17,280	2	$11,520
Scenario 3	69,599	**7**	4	$40,320	3	$30,240	2	$20,160
Scenario 4	171,049	**17**	4	$97,920	3	$73,440	2	$48,960

Assumptions of costs in Table 6 include:

- 10,000m^2 per day;
- Team of 4 spot spraying and hand releasing;

- $45 per hour per person;
- 4 visits per year;
- Totals are for one year only.

6.3 Implementation Timeline

It is understood that implementation may occur over a long term period given that the development of the Mangaheka industrial area is due to be completed over 20 years. The following gives an indication on timeframes for implementation:

- Scenario 2 – 5 year implementation plus 5 year maintenance;
- Scenario 3 – 5-10 year implementation plus 5 year maintenance;
- Scenario 4 – 10 year implementation plus 5 year maintenance.

7.0 References

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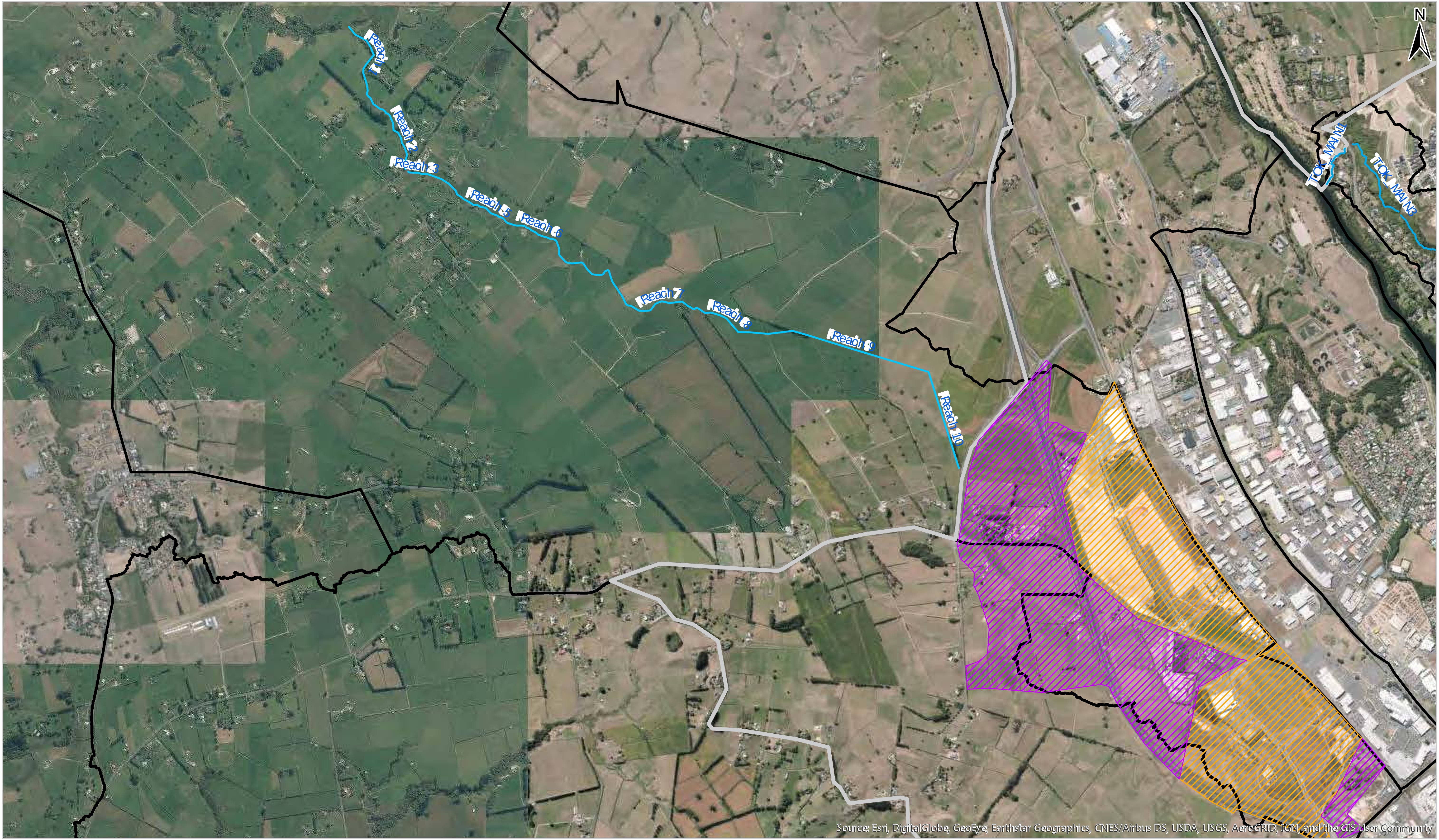
Appendix 1 Greenfields and Assessment Map

Mangakeha Assessment Reaches and Greenfield Areas

MORPHUM ENVIRONMENTAL LTD



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Mangaheka Greenfields

- Consented
- Unconsented
- Hamilton City Boundary
- Hamilton City Catchments
- Mangaheka Ecoline

Client Hamilton City Council
Project **Mangaheka Erosion Assessment**

Project no. P01103
Date 16 May 2017
Drawn ER
Approved CU

0 1 2 km

Appendix 2 Greenfields Development Contribution

The projects are intended to provide a high level cost of identified remedial and restoration works within the subject reaches. Proportional cost estimates are provided to assist in calculating appropriate financial contributions to mitigate stormwater effects within the stream associated with new development. The subject of this memo is specifically the residual effects of the development in Mangaheka.

The project contribution costs have been estimated for Scenario 3.

The total cost of projects identified in the subject reaches of the Mangaheka Stream is $2,437,491. Proportional cost estimates (based on contributing catchment area of the greenfields site) associated with effects of the proposed development for remediation and prevention is $1,554,143 which accounts for 2,856 per Ha.

Limitations

Project identification was restricted to existing and potential erosion issues and does not include additional water quality, ecological enhancement, or amenity value aspects of identified projects or of any separate projects. It should be noted that some erosion mitigation physical works may result in a net adverse impact on ecological values.

A planning assessment has not been undertaken and the following have not been considered in the identification of projects:

- HCC and WRC objectives and policies;
- Consent requirements to implement identified projects;
- Legislative framework regarding financial contributions;
- Other HCC strategic plans (including Gully Management).

Projects identified are intended for consideration of offset of any residual impacts and all appropriate measures should be taken on site to avoid, or minimise potential downstream impacts (in accordance with the appropriate consented stormwater treatment design).

These projects are also not intended to be used as offset mitigation for the loss of any stream values on site.

It is recommended that a detailed options analysis and planning assessment is conducted at a later date including ecological assessment and concept design of remediation and prevention options to inform capital works, which will require site assessment.

Growth and Development Proportions

The projects identified aim to support resilience against erosion including both exacerbation of existing erosion issues, and potential erosion in currently stable (or artificially stabilised) reaches associated with upstream development.

The extent of influence from increased stormwater volume from Mangaheka Catchment within the HCC boundary on erosional effects downstream reduces with distance downstream due to increasing influence from the wider catchment.

A summary of the total cost for each identified project and potential contributing costs is provided below.

Table 7 Apportioning Cost Based on Contributing Catchment

Tributary Name	Physical Works Cost	Total Cost*	Upstream Catchment Area (Ha)**	Upstream Greenfield Area (Ha)***	% Greenfield as Total Area	Cost Proportional to Greenfield Area
Reach 1	$91,036	$144,536	1124	544.2	48%	$69,991
Reach 2	$229,896	$381,864	1068	544.2	51%	$194,668
Reach 3	$49,554	$86,411	1068	544.2	51%	$44,051
Reach 4	$71,202	$112,992	1007	544.2	54%	$61,085
Reach 5	$76,318	$121,157	1007	544.2	54%	$65,499
Reach 6	$226,860	$359,158	1007	544.2	54%	$194,164
Reach 7	$198,835	$309,374	916	544.2	59%	$183,795
Reach 8	$129,394	$205,065	740	544.2	74%	$150,863
Reach 9	$276,632	$436,187	740	544.2	74%	$320,896
Reach 10	$178,762	$280,748	568	544.2	96%	$269,131
Total	**$1,528,490**	**$2,437,491**				**$1,554,143**
				Per Ha Rate		**$2,856**

**Cost includes Design and Feasibility (10% of physical works), Resource Consent fees (3% of physical works), defects liability (10% of physical works), 20% contingency and 5 year maintenance costs.*

***Upstream catchment areas are taken from the Beca Mangaheka Integrated Catchment Management Plan - Stormwater 1D Modelling Report.*

****This is based on 544.2 ha of greenfields land in upper Mangaheka catchment which includes consented and unconsented land.*

Appendix E

Ecological Assessment

MANGAHEKA STREAM

Assessment of Ecological Values to inform an Integrated Catchment Management Plan

Prepared for Hamilton City Council

12 July 2018

Boffa Miskell

Document Quality Assurance

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Cover photograph: Mangaheka Stream, © Louise Saunders, 2014

CONTENTS

Appendices

Appendix 3 – Aquatic Macroinvertebrate Results

Executive Summary

Hamilton City Council (HCC) is preparing an Integrated Catchment Management Plan (ICMP) for the Mangaheka Stream catchment. Mangaheka Stream is a small tributary of the Waikato River located north of Hamilton City. The southern part of the catchment has been, or will be, converted from rural to industrial/employment land use. The Waikato Expressway and connecting arterial roads also pass through the south western portion of the catchment.

This ecological assessment has been prepared to enable HCC to set clear objectives for the Mangaheka Stream catchment that will be achieved by implementing Best Practicable Options (BPO). The assessment characterises the state of the stream receiving environment in the context of the wider rural catchment and existing impacts. The assessment also identifies the risks and sensitivities of the stream with respect to industrial and road stormwater discharges managed for attenuation and treatment to TP10 standards as a minimum.

Based on field surveys and review of existing information, the Mangaheka Stream has the following characteristics:

- The stream headwaters are artificial drains, which discharge into the modified stream main stem within a surface flow path, before becoming a natural stream channel north of Horotiu Road.
- In the upper catchment drain networks, aquatic habitat quality provides poor conditions for biota, and indigenous fish diversity is limited by intermittent flow and lack of riparian cover.
- In the middle stream catchment, aquatic habitat quality provides moderate conditions for biota, and the indigenous fish community is more diverse although aquatic macroinvertebrate diversity is poor throughout the catchment.
- Water quality is typical of groundwater-fed rural Hamilton streams with some water quality parameters exceeding the tolerances of aquatic species. Concentrations of total copper and zinc exceed ANZECC guidelines, and nutrients are elevated. The toxicity of metals is likely to be limited by formation of mineral complexes with phosphorus and organic material, meaning the bioavailable dissolved form of metals in the water column is low.
- Benthic sediment has elevated arsenic concentrations at Te Kowhai Road but this is likely to be a localised issue and does not exceed ANZECC guidelines.
- The drains provide habitat for shortfin eels, and threatened[1] longfin eels and black mudfish. The stream provides habitat for shortfin eels and banded kokopu, and threatened[1] giant kokopu and longfin eels. The presence of threatened species confers ecological significance on the catchment.

In the context of TP10 stormwater design principles and the water quality assessment, the risks and sensitivities of the Mangaheka Stream catchment have been identified with objectives and actions as follows:

[1] Threat Status: At Risk (declining) (Goodman *et al* 2013)

- There is potential for stormwater discharges to change downstream drain hydrology from intermittent to perennial, reducing the habitat value for black mudfish that rely on intermittent flows to avoid eel predation pressure. This can be avoided by maintaining extended detention volumes to avoid continuous flows into the downstream drains from stormwater treatment devices.
- There is potential for thermal pollution from stormwater discharges to cause adverse effects downstream, even with TP10 devices installed for stormwater treatment. Open water areas should be avoided in treatment devices and wetland plant cover maximised. Where devices have low wetland plant cover, supplementary planting should be undertaken to reduce potential thermal effects.
- The unavoidable increase in discharged stormwater volume has potential to cause bank instability in downstream drain networks, particularly where drain banks are steep and unvegetated. Preventative measures should be implemented in conjunction with landowners and Waikato Regional Council's drainage board to armour bank sediments. Appropriate preventative measures are detailed in the Mangaheka Restoration Vision.
- There is potential for ecologically significant fish habitat within the Rotokauri Structure Plan employment zone to be affected by development. Mitigation or offset of this effect should be managed in conjunction with Waikato Regional Council to provide new offline habitats. Newly created habitats have potential to have significantly better habitat values than the existing marginal drain habitats.
- The performance of treatment devices must be monitored to ensure that they achieve the design standards set, particularly for vegetation cover and discharge temperature.
- Existing riparian vegetation is providing an important role for water cooling and bank stability. Where riparian or aquatic vegetation has been, or will be removed, it should be replaced to reduce effects on water and habitat quality, and bank stability.
- A monitoring regime is recommended to ensure that the objectives set to maintain and/or enhance the ecological values of the Mangaheka Stream are achieved.

1.0 Introduction

Boffa Miskell Ltd (BML) was engaged by Hamilton City Council (HCC) to assess the ecological values of the Mangaheka Stream to support the development of an Integrated Catchment Management Plan (ICMP). The Mangaheka Stream is a small rural catchment located on the northwest periphery of Hamilton draining in a northwest direction to its outlet into the Waipa River.

Before development, the Mangaheka Stream upper catchment was comprised of two small drain networks within HCC boundaries joined at a confluence immediately downstream of Koura Drive. This very flat land with poorly defined catchment boundaries was originally serviced by drains excavated to reduce shallow groundwater levels to allow rural land use (mainly for cropping).

Within HCC boundaries, the catchment includes the 177ha Rotokauri Structure Plan industrial area between the Waikato Expressway and the North Island Main Trunk railway and an employment zone between the Expressway and Burbush Road/Koura Drive. More than 120ha of industrial land in this area has been developed since 2012. Farm drains have been replaced with stormwater treatment swales and detention basins with discharge points into the downstream drain network. The Waikato Expressway and connecting roads was constructed with stormwater treatment swales discharging into existing, new and realigned drains within the Mangaheka catchment.

Downstream of Koura Drive within Waikato District, the Mangaheka Stream has a rural catchment (mainly dairy farming or grazing) comprised of artificial drains, modified stream, and the extensive Tangirau gully wetland. The adjacent catchments are Te Rapa Stream to the east (discharging into the Waikato River) and Lake Rotokauri to the west (discharging to the Waipa River).

The purpose of this assessment is to describe the existing values of the waterway, including ecological values and habitat. Further, the assessment evaluates whether land development and stormwater discharges into the waterway from existing and proposed industrial/employment areas and roading may have actual or potential effects, and how far downstream those effects (if any) would be expected to be measurable.

The results of this ecological assessment will enable HCC to set clear objectives for the Mangaheka Stream catchment that will be achieved by implementing Best Practicable Options (BPO). A monitoring programme can then determine whether the BPO have been effective at achieving the objectives.

1.1 Location and General Description

The Mangaheka Stream is a small tributary of the Waipa River located northwest of Hamilton City. Its catchment encompasses around 2,080ha of flat to rolling Waikato lowlands in the area generally defined by Park, Horotiu, and Onion Roads and the railway in the east, Ngaruawahia and Te Kowhai Roads in the west, and the Waikato Expressway and Tasman Road to the south (see Figure 1 in Appendix 1). The stream flows southeast-northwest towards the Waipa River.

In the upper catchment, the two main branches of drain network meet immediately downstream of Koura Drive. Prior to development, the drain networks comprised the stream headwater catchments located within the Rotokauri Structure Plan industrial/employment area, which was originally peat swamps. As a result of development of the industrial area and Waikato Expressway designation, the drains were replaced with planted swales and detention basins. Future development is expected to result in the same waterway conversion process.

Downstream of the industrial area and Waikato Expressway, artificial farm drains flow north and northwest to Koura Drive, where they meet at the drain main stem. The drain then flows northwest through farmland before transitioning to a modified stream channel with perennial flow where natural topography forms a surface drainage channel. Outside the Hamilton City boundary, the catchment of the drains is almost entirely rural (dairy farming), comprising artificial farm drains, with very little riparian vegetation.

Between Koura Drive and Horotiu Road, the waterway is comprised of a single main stem drain or modified stream with drains discharging into it from adjacent farmland. The stream develops a more defined floodplain within an increasingly entrenched gully landform as it approaches Horotiu Road. At Horotiu Road, the road embankment and invert levels of the twin culverts dictate the groundwater levels, flood levels, and peak flows discharging downstream. Given that the culverts are perched at the downstream end, it appears that the road embankment and culverts are resulting in higher shallow groundwater levels and stream water depths than would be expected naturally. The modified stream catchment is entirely rural with almost no riparian vegetation.

Between Horotiu and Ngaruawahia Roads (SH39), the stream transitions into the large willow-dominated Tangirau wetland in an entrenched gully network. The wetland appears to have formed as a result of the road embankment impounding the stream upstream of its natural outlet to the Waipa River. Other branches of the stream form arms of the gully network at numerous confluences. The main stem flows northwest through an extensive rural (dairy farming) gully system that becomes increasingly deep and wide. The gully system is fully vegetated with a willow-dominated treeland and indigenous sedge understorey. The outlet to the Waipa River downstream of Ngaruawahia Road is via a short stream reach.

Most of the Mangaheka Stream catchment is alluvial plains of the Waikato and Waipa Rivers which would originally have supported indigenous forest (Cornes *et al*. 2012). The topography and remnant vegetation indicates that the area would historically have included wetlands, particularly in low-lying flood plains and valley floors where groundwater emerges. Some of these wetlands would have included highly organic and/or peat soils, and peat swamps are known to have existed in the upper catchment.

Similar to almost all rural land in this area, by the early to mid-1900s, most wetland areas would have been drained to create farmland, and the vegetative cover changed from predominantly alluvial secondary native vegetation to exotic pasture (Nicholls 2002). Vegetation throughout the catchment is now dominated by exotic pasture with shelterbelts and shade trees associated with rural-residential and rural properties.

1.2 Development Principles and Design

The Mangaheka Stream catchment crosses several important boundaries. The upper catchment upstream of Koura Drive is within the Hamilton City boundary; the remainder of the catchment is within Waikato District. The catchment also crosses the boundary between the Central Waikato zone management plan and the Waipa zone management plan, which are Waikato Regional Council (WRC) policy documents that drive implementation of all river and catchment management activities. However, the Mangaheka Stream is not mentioned specifically in either document. Instead, stream/drain management is driven principally by the

WRC Waikato Central Drainage Board sub-committee based on contractor inspections and in response to landowner concerns.

Within HCC's boundary, existing regional consents authorise treated stormwater discharges from two 60ha industrial areas into the Mangaheka Stream catchment (as the preferred alternative to discharges to adjacent catchments[2]). Detailed design of stormwater treatment and attenuation devices for the industrial areas was based on modelling undertaken for the consent process which determined that attenuation to 70% of pre-development volumes would be required to avoid downstream flooding and erosion effects. The remaining land within the Rotokauri Structure Plan industrial/employment areas will also be required to undertake modelling and design of stormwater devices and consenting processes.

The discharge consents included an adaptive management component to address uncertainties regarding downstream erosion and scour effects within the drain network resulting from additional discharge volume, recognising that the drains were stable at the time of consenting and that third party activities (landowners and Drainage Board contractors) could have unknown effects on drain bank stability.

As an adjunct to the stormwater consent process, the Mangaheka Restoration Vision was commissioned to define the restoration elements necessary to improve water quality, habitat quality, and bank stability downstream of the discharge points. This was prepared on the basis that the existing drainage district would be extended to include the industrial/employment areas and that the properties within the drainage district would be levied targeted rates. These rates would then be applied to either mitigation of downstream erosion effects or implementation of the Restoration Vision in accordance with the adaptive management consent conditions. To date the drainage district extension process has not been undertaken.

Wastewater and water supply infrastructure are expected to be provided by way of conventional water mains from a HCC reservoir and wastewater pipelines and pump stations to the HCC wastewater treatment plant.

The urbanisation activities most likely to affect aquatic ecological values as a result of continued development of the industrial and employment areas and stormwater discharges are the effects of stormwater discharges and effects of earthworks on aquatic habitats. Along with general land development earthworks, the remaining upstream extents of the farm drain networks will be filled in to facilitate land development and replaced with piped and surface stormwater infrastructure including wetlands and swales.

Ongoing operation of water and wastewater infrastructure are not expected to have a direct effect on the Mangaheka Stream catchment and are not considered further. Earthworks effects on aquatic ecosystems are expected to be addressed through regional resource consent applications and monitoring, but are considered in this assessment with regard to fish habitat.

This assessment focuses mainly on stormwater infrastructure and the ongoing effects of post-development stormwater discharges. The land uses that contribute to stormwater flows include:

- Existing industrial land and roads,
- Land under development for industrial use,
- Rural land proposed for industrial/employment zone development within the Structure Plan area, and
- Rural land.

[2] The two alternatives for stormwater discharge were to the Te Rapa Stream and to the Lake Rotokauri catchment.

For the proposed industrial/employment zone development, design parameters and stormwater management have been or will be established through subdivision, land use consent, and/or discharge consent processes. This means that post-development land cover and imperviousness, design and location of stormwater infrastructure, and discharge points are, for the most part, pre-determined.

The assessment is based on the following assumptions:

- Most of the Mangaheka Stream catchment within Hamilton City will be urbanised and the headwater drains to the Structure Plan boundary will be filled in and/or replaced with stormwater infrastructure.
- Post-development industrial imperviousness can be expected to reflect typical modern industrial imperviousness of 85-95%, and stormwater infrastructure has been, or will be, designed to accommodate stormwater volumes on that basis. Employment zone imperviousness can be expected to be similar or slightly less.
- No notable land use change will occur on the rural land adjacent to the Structure Plan area (defined by Koura Drive, Onion Road, Ruffell Road, and Te Kowhai Road) or in the Waikato District portion of the catchment.
- Stormwater management for all development areas is or will be designed to at least TP10[3] standards requiring an average removal of 75% of suspended sediment and associated contaminants, and stormwater volume attenuation of a large proportion (usually 70-80% depending on the location and device) of the pre-development volume for a 1 in 10 year design rainfall event.
- Stormwater management for the industrial/employment areas includes onsite stormwater controls specific to the proposed site use[4], reticulated onsite stormwater network discharging to central wetland swale networks servicing the development, and stormwater detention devices comprised of a sediment detention basin discharging into a storage basin with a low flow area planted as a wetland for stormwater treatment or a pond. These devices will discharge to the Mangaheka Stream at Ruffell Road (existing discharge point), upstream of Waikato Expressway (existing discharge point), and at Te Kowhai Road (assumed future discharge point).
- Stormwater management for the road corridors will consist either of conventional kerb and channel flows to catchpits discharging to the swale network or diffuse surface flows to the swales.
- Fish passage will not be provided within existing industrial development since there is no upstream aquatic habitat except the detention basins.
- Fish passage may be required in future industrial/employment zone development depending on the size and significance of fish populations in remaining drain habitats.

1.3 Stormwater Discharges

Rural catchments are typically dominated by pervious pasture or cropping land with small areas of less pervious farm tracks and impervious hardstands, buildings and roads comprising around

[3] Auckland Regional Council, 2003. Stormwater Management Devices: Design guidelines manual. Technical publication 10.

[4] Required to be designed and implemented as set out in the Pollution Control Plan, a requirement of all building consents for all High Risk Facilities.

1-2% of the catchment. The Mangaheka Stream has a predominantly rural catchment with a small area of rural-residential development clustered around Horotiu Road and Ngaruawahia Road. The upper catchment within the HCC boundary has 177ha within the Rotokauri Structure Plan area that has recently or will be urbanised, which comprises around 9% of the total catchment area.

Rural waterways around Hamilton generally have very similar water chemistry and water quality. Originating in relatively flat terrain and being predominantly fed by shallow groundwater, these waterways are typically characterised by:

- Contaminants of concern being nutrients, turbidity/colour, microbial pathogens, and metals.
- Metals (e.g. aluminium, iron, manganese, nickel, copper and zinc) detected at elevated concentrations (often exceeding ANZECC guidelines) even in the absence of urban stormwater discharges or agricultural uses. These are assumed to be entering shallow groundwater due to mineralisation of organic matter in drained wetland/peat soils.
- Low suspended sediment concentrations.
- High turbidity and colour in the absence of sediment.
- High concentrations of iron and manganese resulting flocs that contribute to turbidity and distinctive orange staining.
- High nutrient concentrations.
- Variable faecal pathogen loads.
- Poor habitat values, little riparian vegetation, and summer temperatures sometimes exceeding the thermal tolerances of aquatic organisms.

The Mangaheka Stream has all these characteristics.

The quality, volume, and flow rate of stormwater discharged from a fully urbanised area is different to the pre-development stormwater characteristics where the catchment is comprised of mainly rural land. When fully developed, the Rotokauri Structure Plan area is expected to have typical industrial imperviousness of around 80-90%. As a proportion of the total catchment, imperviousness will increase from the pre-development rural rate of around 2% to a fully developed catchment-wide imperviousness of around 8%. The increase in imperviousness will result in greater stormwater discharge volumes and flow rates than would be expected from rural land.

The change in land use from predominantly agricultural to a higher proportion of industrial and employment zone land and/or roading can also be expected to change the stormwater contaminant profile in the upper catchment. Industrial stormwater contaminants typically include gross pollutants, temperature, sediment, petroleum hydrocarbons, and metals.

Boffa Miskell Ltd has data from water quality samples collected from Hamilton waterways at 23 rural sites and 11 urban sites, including samples taken longitudinally along waterways across rural-urban boundaries. Based on this data and the information provided in the Mangaheka Water Quality Assessment (CH2M Beca, 2018), industrial stormwater discharges are expected to have lower concentrations of nutrients, higher concentrations of sediment and petroleum hydrocarbons, and slightly higher temperature than the existing rural environment. For some metals, reduced imperviousness may mean that the loads entering from shallow groundwater in pre-development conditions are replaced with loads entering from surface stormwater, and the difference in concentrations may be minimal.

It is important to note that the additional mass load of contaminants from new industrial development will be partly or completely offset by the reduction in rural contaminant mass loads through land use conversion and loads removed by the wetland/swale devices.

2.0 Assessment Purpose and Scope

The purpose of this assessment is to:

1. Evaluate existing aquatic ecological values, water chemistry/quality, and sediment quality of the Mangaheka Stream.
2. Identify the risks and sensitivities of the Mangaheka Stream in relation to the actual and potential effects of stormwater discharges from new and existing urban development.
3. Evaluate risks of future removal of existing drain habitat.

To provide context to the assessment, it is important to note that:

- Urbanisation to an industrial or employment land use within the HCC boundary is a foregone conclusion.
- The urbanised area will be a small proportion of the total catchment (around 9%).
- Agriculture is expected to remain the dominant land use within the catchment.

As set out in Table 1, this assessment has been based on surveys of riparian and aquatic habitat, biota, sediment quality and water quality present in the Mangaheka Stream. Existing information sources relating to aquatic ecology values were also evaluated.

Most of the assessment described in this report was completed prior to the Receiving Environment Module guidance on ecological assessment for ICMPs. The scope is considered to provide sufficient information to guide development of catchment objectives. The influence of the HCC industrial sub-catchment on the downstream rural catchment is described in sufficient detail that further assessment is not considered necessary at this stage.

Table 1: Data collection and methodology

Parameter	Methodology
Habitat values	Stream habitat assessment (instream and riparian qualitative assessments). Review of Land Cover Database. Review of Cornes *et al*. 2012 for identified sites of ecological significance. Review of Waikato Regional Council Regional Policy Statement and supporting technical reports regarding habitat evaluation for ecological significance.
Water quality	On-site measurement of temperature, pH, dissolved oxygen, and conductivity. Review of Waikato Regional Council water monitoring database.
Water contaminants	Water samples analysed for pH, suspended sediment, turbidity, metals, nutrients, carbonaceous biochemical oxygen demand, faecal bacteria and petroleum hydrocarbon compounds. Review of Waikato Regional Council water monitoring database.

Sediment contaminants	Sediment samples analysed for arsenic, cadmium, chromium, copper, lead, nickel, and zinc.
Aquatic macroinvertebrate fauna	Aquatic macroinvertebrate samples collected using Protocols C2 and C4 (MfE, 2001).
Fish fauna	Evaluation of Freshwater Fish Database records and fish survey.

3.0 Methods

In 2012, site reconnaissance in the Mangaheka Stream catchment identified three waterway reach types namely:

- artificial watercourses (drains) in the upper third of the catchment;
- natural/modified watercourse (stream) in the middle third of the catchment; and
- wetlands in the lower third of the catchment (Tanirau Wetland).

On that basis, four survey sites were selected for field surveys combined with stream walkover (see Figure 2 in Appendix 1). The survey sites were selected as being representative of the three reach types. The walkover and habitat assessment of the Mangaheka Stream was completed over a 3 week period from 24th April to 8th May 2012. The weather was fine with light winds and no rainfall (>2mm) had been experienced for 6 to 8 weeks prior to the assessment.

In 2016, a gap analysis of the 2012 survey data and existing data sources was completed to determine whether additional field surveys and/or analyses were required. It was determined that the 2012 survey should be repeated at similar sample sites and fish survey undertaken. This survey was completed on 19th April 2016. To allow comparison with the 2012 survey results, sites close to earlier survey sites were given preference over other locations. The weather was fine with light winds and no significant rainfall had been experienced in the week prior to sampling. During the 2016 assessment, the drains at two of the three proposed survey sites were dry or contained only stagnant water within the waterways, compared to flowing water present during 2012 survey. No data was gathered from these two sites.

The 2012 and 2016 sampling sites and 2012 walkover extents are identified on Figure 2 (Appendix 1). The 2016 surveys and updated satellite photography identified that land uses had remained largely unchanged since 2012 such that a repeat of the walkover was not necessary. The field surveys and habitat assessment of the Mangaheka Stream were completed as follows:

- The 2012 walkover assessments included observations of riparian, bank and channel vegetation, water clarity, algal cover, structures, fencing, and adjacent land use. As part of the habitat assessment, the severity and extent of erosion and scour processes was noted. This included observing whether scour and erosion is active or historic, the location of the erosion or scour (undercutting at the waterline, bank failure, sloughing of bank materials, vegetation collapse, etc.) and the likely processes causing the erosion or scour (e.g. vegetation spraying, stock treading, stock pressure at fencelines, undersized or poorly placed culverts, etc.).

- Water and sediment samples were collected from each survey site, chilled and sent to Hill Laboratories for analysis with accompanying chain of custody documentation.
- Aquatic macroinvertebrates were collected from sites with suitable habitat using a 500 µm mesh net following Protocol C4 (soft-bottomed, Quantitative – Macrophytes) (Ministry for the Environment 2001), preserved in ethanol and analysed according to Protocol P1: coded abundance. The soft-bottom Semi-Quantitative Macroinvertebrate Community Index (SQMCI-sb) was calculated for each sample (Stark & Maxted 2007). Species richness and number of EPT[5] taxa were also calculated. The macroinvertebrate community was sampled at two sites by collecting replicate samples from similar aquatic macrophyte vegetation using Protocol C4 (MfE 2001). The locations for collection were limited by the lack of macrophyte vegetation either in the channel or on the banks over most of the drains. The two accessible locations with sufficient vegetation for sampling were at Te Kowhai Road and the Murray farm culvert. The samples were preserved with isopropyl alcohol at 75% and sent to BML for analysis. Other protocols were not used because of inadequate suitable substrate (hard substrate, woody debris, or bank overhang) and dominance of aquatic macrophytes. The soft-bottom Semi-Quantitative Macroinvertebrate Community Index (SQMCI-sb) was calculated for each sample (Stark & Maxted 2007). Species richness and number of EPT[6] taxa were also calculated. Sample collection was not possible at one site due to insufficient suitable substrate of any kind.
- Replicate aquatic macroinvertebrate samples were collected from the Horotiu survey site during the 2016 sampling round. Three replicate samples were collected using a 500 µm mesh net following Protocol C2 (soft-bottomed, semi-quantitative – Macrophytes) (Ministry for the Environment 2001), preserved in ethanol and analysed according to Protocol P3: Full count. The soft-bottom Semi-Quantitative Macroinvertebrate Community Index (SQMCI-sb) was calculated for each sample (Stark & Maxted 2007). Species richness and number of EPT[7] taxa were also calculated. The samples were preserved with alcohol and sent to Ryder Consulting for analysis.
- Due to low water levels, only one site was suitable for fish survey in 2016. Fish survey methods used are shown in Table 2. The range of habitats was representative of that found on the Mangaheka Stream and considered the most likely fish capture locations.

Table 2: Fish Survey Methods

Methods	Horotiu Road
Fyke nets	✓
Gee's minnow traps	✓
Kilwell bait nets	✓

Five baited fyke nets were set upstream of the culvert beneath Horotiu Road. Six baited Gee's minnow traps and six baited bait traps were also set interspersed between the fyke nets. The

[5] EPT: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), the most sensitive aquatic macroinvertebrate species indicative of good water quality and habitat.

[6] EPT: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), the most sensitive aquatic macroinvertebrate species indicative of good water quality and habitat.

[7] EPT: Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies), the most sensitive aquatic macroinvertebrate species indicative of good water quality and habitat.

nets were deployed in the afternoon and retrieved the following morning. All fish caught were identified, measured, and released, except for pest fish, which were disposed of humanely.

A single electric fishing survey was conducted along the Horotiu sample reach. Due to the depth of water levels and abundance of aquatic weed, electric fishing was not an effective means for measuring fish abundance/diversity over the surveyed stream reach.

A review of the NIWA Freshwater Fish Database was carried out for surveys undertaken on the Mangaheka Stream and adjacent waterways.

4.0 Results

4.1 Habitat Values

4.1.1 Site Context

The Mangaheka Stream catchment is located within the Waikato Ecological Region and the Hamilton Ecological District. The indigenous vegetation of the Hamilton Ecological District is severely depleted, with only 1.6% of the original native vegetation remaining and at least 20% of its indigenous flora threatened or extinct (Clarkson & McQueen 2004). Almost all of the original alluvial floodplain vegetation and swamps of the Waikato lowlands have been cleared and drained for farming (Nicholls, 2002). The Mangaheka Stream lower catchment is different in this respect with additional wetland area inadvertently created in the gully upstream of Ngaruawahia Road. Within Hamilton City, there is less than 20 hectares of high quality indigenous habitat remaining (Clarkson & McQueen, 2004), although substantial restoration is occurring. Restoration is also proposed for the Tanirau Wetland in the Mangaheka Stream lower catchment in Waikato District.

The Lands Environments of New Zealand (LENZ) database classifies most of the Mangaheka Stream catchment as Environment A5.3 which is comprised of poorly-drained peat soils of low to very low fertility or Environment A7.2 comprised of imperfectly drained soils of low fertility. There are very small patches of Environment F6.1 which is comprised of mid-age well drained soils of low fertility from rhyolitic tephra, outcropping mainly at Horotiu Road and around the Onion Road ridgeline.

4.1.2 Terrestrial Vegetation

The terrestrial flora within the Mangaheka Stream catchment mirrors the situation in the surrounding areas. Historic vegetation cover was secondary succession alluvial vegetation (Nicholls 2002), most likely kahikatea swamp forest, with mixed conifer-broadleaf forest on higher ground (Clarkson *et al*. 2007, Cornes *et al*. 2012). Extensive areas of peat bog vegetation (Clarkson *et al*., 2007) and lowland swamp vegetation have been present in the flat upper catchment, with variable drainage downstream to waterways of the three adjacent catchments.

Today, the area is almost entirely vegetated in exotic pasture grasses or crops. Larger trees and shrubs are limited to exotic species planted as shelterbelts, or for amenity and animal welfare purposes (livestock shade). Plate 1 below shows the typical vegetation cover throughout the catchment, consisting of pasture or crops and exotic trees/hedges. Within the stream floodplain in the middle reach, the vegetation also includes scrub (blackberry etc.), rushland/sedgeland, and willow weed associated with damp, poorly drained soils. In the lower catchment, pasture and willow weed extends to the margin of the gully wetlands. Apart from indigenous rushes and sedges in pasture, indigenous plants are virtually non-existent.

Plate 1: Mangaheka Stream – typical catchment vegetation

In the upper and middle reaches, there is typically limited riparian vegetation adjacent to the waterways (see Plates 1 and 2). Although most waterways have no canopy cover, some have cover from shelterbelt trees comprised of Lawson's cypress, hawthorn, privet, gorse, blackberry or barberry. Some fenced drains have margins that are not maintained (e.g. sprayed) and riparian vegetation is comprised of rank grass, mixed native and exotic rushes, herbaceous weeds (buttercup, willow weed, dock, etc.) and occasional shrub/vine weeds such as gorse, broom, pampas, and blackberry. However, much of the waterway is fenced at the bank crest and periodically sprayed so riparian vegetation is very limited.

In general, native plants are only rarely present beneath exotic shrubland or trees or as planted specimens. However, as the stream approaches Horotiu Road, there is increasing cover of tall sedges (*Carex lessoniana/geminata*) and rushes associated with swampy ground where stock access is more limited as shown in Plate 2 below.

Plate 2: View downstream near Horotiu Road, showing Carex sedgeland and rushes on swampy true left bank.

In the lower catchment, the riparian vegetation consists of wetland vegetation with a canopy dominated by grey willow (*Salix cinerea*), with understorey vegetation comprised variously of *Carex* sedgeland and other species as described in Section 4.1.4.

The most recent vegetation survey within Hamilton City did not identify any key ecological sites of significance within the Mangaheka Stream upper catchment (Cornes *et al*. 2012). Using the criteria of Cornes *et al*., vegetation observed in the Tanirau Wetland would be considered significant but is outside Hamilton City. Cornes *et al*. has not identified any other key ecological sites with connectivity to the Mangaheka Stream catchment.

4.1.3 Aquatic Habitat – Drains

From northwest of Avalon Drive to approximately midway between Ruffell Road and Horotiu Road, the watercourse type is an artificial watercourse (drain). The drains were excavated to drain historic wetlands and high groundwater/springs in the upper catchment to facilitate pasture development for farming. Pre-development soils show the upper catchment wetlands were peat swamps, and it is likely that peat lenses are present as subsoil layers influencing pH and water chemistry throughout the upper catchment. The drains are characterised by steep banks, straight channels, uniform channel morphology and ephemeral flows with standing water during dry periods.

The drains provide poor habitat for fish and aquatic macroinvertebrates, with slightly better aquatic habitat associated with shelterbelt or dense riparian plant cover. Water depths vary considerably depending on historic drain maintenance. Some dish channels and drains through or between paddocks are shallow and likely to be continuously dry except immediately after rainfall. Few of the drains have natural surface drainage and most are fed predominantly by groundwater. The drain main stem does not have perennial flow. It dries up and retains pools of water as potential habitat refuges during dry periods when groundwater levels drop. The drain dimensions vary considerably from place to place, from 0.75m to 2.5m wide, and 0.5m to 2.8m channel depth. Water depth can vary considerably from no water to around 0.3-0.5m deep. Bed sediment is uniformly soft sediment, typically silt and clay with sand where the channel is cut through pumice sand layers.

All the drains have poor habitat diversity (see Plate 3 below), with uniform width and depth, few pools, very little woody debris, poor water clarity, and minimal stable habitat, shade or riparian vegetation. There are no debris jams and no notable physical fish passage barriers. However, low or no flow, periods of time with no water at all, high temperatures, low dissolved oxygen, and very poor water clarity are likely to present fish passage barriers.

Plate 3: Mangaheka Stream typical drain habitat

Depending on Drainage Board activities, there are times when drain riparian vegetation has been sprayed over substantial drain lengths. Because of the low cohesion of the underlying soils and bank steepness, vegetation removal has been observed to result in widespread bank slumping compared with unsprayed banks on which erosion and slumping are noticeably less.

Landowners have observed that, prior to the construction of the Waikato Expressway and Koura Drive, the drains only flooded during extreme events. Subsequently, relocation of some drains has resulted in localised flooding after rainfall events.

4.1.4 Aquatic Habitat – Modified Stream

From midway between Ruffell Road and Horotiu Road, the watercourse enters undulating topography and a defined gully system that becomes deeply incised over a short distance with a wide floodplain and steep gully walls. The watercourse type is a modified stream and has a relatively natural channel with reaches where historic straightening has occurred.

From approximately 1,200m upstream of Horotiu Road, the gully intersects the groundwater table as evidenced by large springs and seeps discharging from the gully toe and floodplain throughout the gully system. This contributes to progressively increasing base flows with distance downstream. The stream dimensions vary considerably from place to place, typically from 1.5m to 2.5m wide, and 0.75m to 2.0m channel depth. However, some pools can measure up to 6m wide, with channel depth close to 2.5m where scour downstream of a culvert has changed channel morphology. Water depth can vary considerably from no water to around 0.3-1.0m deep. Bed sediment is uniformly soft sediment, typically silt and clay with sand where the channel is cut through pumice sand layers.

Riparian vegetation consists predominantly of rank pasture with some areas of indigenous sedges and ferns, particularly where large springs preclude grazing. Landowners indicate use of the floodplain upstream of Horotiu Road is generally limited to summer grazing because the springs make ground conditions too boggy for stock access.

The stream has poor to moderate habitat diversity (see Plate 4 below), with diversity increasing with distance downstream. Typically the stream has uniform width but variable depth, with occasional pools. There is a small amount of organic debris from riparian vegetation, but little woody debris and minimal to moderate stable habitat depending on riparian conditions. Some shade is provided by the banks and aquatic macrophytes, toe undercutting, and riparian vegetation, but water clarity is poor.

Plate 4: Typical modified stream reach at upstream extent south of Kay Road.

Depending on Drainage Board activities, there are times when stream riparian vegetation has been sprayed over substantial lengths. Because of the low cohesion of the underlying soils and bank steepness, vegetation removal has been observed to result in widespread bank slumping compared with unsprayed banks on which erosion and slumping are noticeably less. Erosion repair responses in this reach have included deposition of rock riprap into slumped areas. This has caused further bank collapse and diversion of flows to adjacent banks where toe undercutting and slumping subsequently occurs.

There are no debris jams causing fish passage barriers. Collapsing lobes of riprap and bank sediment may form temporary fish passage barriers. The twin culverts at Horotiu Road are perched and could provide a fish passage barrier to non-climbing fish species, although non-climbing species (black mudfish) have been found upstream.

Plate 5: Rock armouring collapsing into the stream

Landowners observe the depth and frequency of flooding increases with distance downstream. At Horotiu Road, the flood depth can exceed 1.5m and floods the gully floor up to 4 times per year, with smaller floods escaping the stream banks between 5 and 10 times per year. Downstream of Horotiu Road close to the swamps, the flood height can reach 2.0-2.5m.

At the time of the 2012 assessment, bank failure was severe in some places as shown in Plate 5 below. There was one property on which the channel was mostly unfenced so cattle access was unrestricted and stock treading affected bank failure. However, fencing was in progress and this erosion is expected to have largely ceased as a result. In other places, as shown in Plate 5, fencing too close to the bank crest is contributing to bank instability.

Plate 6: Modified stream reach bank instability. Note also the iron staining from groundwater inflows at the waterline.

4.1.5 Aquatic Habitat – Tangirau Wetland

From approximately 820m downstream of Horotiu Road to Ngaruawahia Road (SH39), the watercourse becomes a wetland (specifically a lowland shrub – sedge swamp[3]) within a rolling to very steep gully. The watercourse varies considerably depending on the characteristics of the wetland at any given location. The wetland has standing water, multiple flowing channels (leads), and numerous large seeps and springs flowing into the wetland around the flood plain and gully walls. The channel appears to be almost entirely natural with little historic modification. However, as noted earlier, it is likely that partial impoundment of the stream channel occurred as a result of the SH39 road embankment construction and culvert invert levels, resulting in a wetland environment replacing the former stream environment.

A survey of the wetland vegetation was not undertaken. Observations of the vegetation downstream of Horotiu Road, Crawford Road, and Ngaruawahia Road indicate the vegetation generally consists of a canopy dominated by grey willow (*Salix cinerea*) with an understorey of indigenous sedges (*Carex virgata, Carex geminata*) and a minor component of indigenous trees and shrubs (*Coprosma* species), mahoe (*Melicytus ramiflorus*), mamaku (*Cyathea medullaris*), cabbage trees (*Cordyline australis*) and kahikatea (*Dacrycarpus dacrydioides*). The gully is very densely vegetated and the vegetation is likely to provide almost 100% shade over most of the wetland leads.

It is likely that the wetland floods frequently but because the wetland is largely inaccessible, it is unlikely that floods affect the use of the area. Floods occasionally restrict or prevent access across farm access tracks. While there are likely to be occasional debris jams within the wetland associated with tree fall, given the multiple wetland leads, obstruction of fish passage is unlikely to occur.

This wetland catchment provides high quality aquatic habitat with high habitat diversity, woody debris, almost complete channel shade, and almost completely stable habitat.

Plate 7: Typical stream reach downstream of Crawford Road through the wetland.

4.2 Water Quality

4.2.1 Standards for Water Quality

The Waikato Regional Plan rules for stormwater discharges refer to the ANZECC 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality as one of the standards against which hazardous substances in stormwater are to be assessed in order to achieve the conditions associated with the relevant rule.

HCC was granted a comprehensive consent from WRC for the discharge of stormwater from its urban area. The comprehensive consent conditions refer to the USEPA (United States Environmental Protection Agency) National Recommended Water Quality Criteria as the standard which the concentration of hazardous substances in discharges are required to meet.

Based on correspondence with WRC staff, we understand that the USEPA criteria are considered more appropriate than the locally derived ANZECC criteria because they reference the dissolved fraction of stormwater contaminants (specifically metals such as copper, lead and zinc) and provide standards for acute (short-term) exposure as well as chronic (long-term) exposure. NIWA and WRC considered the dissolved fraction of contaminants to be more relevant to the toxicity effects experienced by water column-dwelling biota exposed to stormwater discharges compared to total concentrations which includes the particulate fraction. Acute exposure is considered to be more relevant to the intermittent rain event-derived nature of stormwater discharges.

However, given that the purpose of this assessment is to establish the existing quality of the environment, not the impact of specific stormwater discharges, it is appropriate to assess existing water quality against the ANZECC guidelines on the basis that they set thresholds for chronic exposure of aquatic organisms to existing contaminants.

4.2.2 Results

A results summary is presented below in Table 3 and laboratory reports are provided in Appendix 2. In Table 3, the results are compared against the guideline values noted in the footnotes. Results in bold and shaded exceed the guideline value. Results in bold only are values that are elevated but for which there is no guideline value. The range of analytes varied between sampling events. However, results are compared with BML water quality data from five other Hamilton catchments to assess likely water quality in drain flows.

A multifunction water quality meter was used to determine in-stream pH, temperature, and dissolved oxygen during both the 2016 assessments. Seasonal variations in these parameters are discussed below.

Table 3: Water Quality Results											
Analytes	**Units**	**Site 1 Ruffell Rd**			**Site 2 Te Kowhai Rd**	**Site 3 Farm Culvert**	**Site 4 HJV Boundary**			**Site 5 Horotiu Rd**	**Guideline Values**
Water Quality	**Date**	**Nov 2011**	**June 2012**	**July 2014**	**June 2012**	**June 2012**	**Nov 2011**	**June 2012**	**July 2014**	**April 2016**	
Temperature	°C	-	10.6	-	11.4	11.4	-	12.7	-	15.7	-
pH (Hills Laboratory)	pH Units	6.8	6.5	7.1	6.4	6.4	6.7	5.8	7	6.9	6-9 [8]
pH (on site – 2016)	pH Units	-	-	-	-	-	-	-	-	7.3	6-9 [8]
Conductivity (on site – 2016)	µs/cm	-	-	-	-	-	-	-	-	132.8	-
Dissolved oxygen (on site)	mg/L	-	47.8	-	30.5	63.1	-	26.2	-	44.0	-
Turbidity	NTU	**33**	**18.2**	**-**	**18**	**23**	66	**12.9**	-	6.2	-
Total Suspended Solids	g/m^3	20	10	31	13	13	19	6	8	5	-
Carbonaceous Biochemical Oxygen Demand ($CBOD_5$)	g O2/m3	-	<2	-	<2	<2	-	<2	-	<2	-
Faecal Coliforms	cfu/100mL	**110**	**430**	-	**700**	**900**	58	**1,100**	-	**410**	100 [9,10]
Metals											
Dissolved Copper	g/m^3	-	-	0.0012	-	-	-	-	**0.002**	<0.0005	0.0018 [8]
Total Copper	g/m^3	**-**	**0.0022**	**0.0021**	**0.0028**	**0.0026**	**-**	**0.0025**	**0.00179**	<0.00053	0.0018 [8]
Dissolved Lead	g/m^3	-	-	0.00012	-	-	-	-	<0.00010	<0.00010	0.0056 [8]
Total Lead	g/m^3	-	0.00032	0.00119	< 0.00011	0.00019	-	0.00024	0.00015	<0.00011	0.0056 [8]
Dissolved Zinc	g/m^3	-	ND	**0.0186**	-	-	-	-	0.0081	<0.0010	0.015 [8]
Total Zinc	g/m^3	**-**	**0.069**	**0.024**	**0.023**	**0.033**	**-**	**0.0175**	**0.0118**	0.0012	0.015 [8]
Nutrients											
Total Nitrogen	g/m^3	**2.7**	**4.2**	**2.8**	**2.5**	**4.6**	**0.97**	**1.66**	0.013	**0.44**	0.04-0.10 [11]
Total Kjeldahl Nitrogen	g/m^3	**-**	**1.08**	**-**	**1.12**	**1.21**	**-**	**1.14**	-	**0.38**	0.04-0.10 [11]
Total Ammoniacal N	g/m^3	-	-	-	-	-	-	-	-	0.064	1.43 [8]
Nitrite N	g/m^3	-	-	-	-	-	-	-	-	0.004	0.04-0.10 [11]
Nitrate N	g/m^3	**0.073**	-	**2.8**	-	-	**0.63**	-	<0.002	**0.055**	0.04-0.10 [11]
Nitrate-N + Nitrite-N	g/m^3	**-**	**3.1**	**-**	**1.39**	**3.4**	**-**	**0.52**	**-**	**0.058**	0.04-0.10 [11]
Dissolved Reactive Phosphorus	g/m^3	**0.017**	0.005	<0.004	0.012	0.007	<0.004	0.005	0.014	0.005	0.015-0.03 [11]
Total Phosphorus	g/m^3	**2.6**	**0.056**	**-**	**0.106**	**0.077**	**0.046**	**0.058**	**-**	**0.035**	0.015-0.03 [11]
Hydrocarbons											
PAHs	g/m^3	-	-	BDL	-	-	-	-	BDL	-	-
Total Petroleum Hydrocarbons C7-C36	g/m^3	-	<0.7	<0.7	<1.4	<1.4	-	<0.7	<0.1	<0.7	-

[8] Australian and New Zealand Environment and Conservation Council; Agriculture and Resource Management Council of Australia and New Zealand. 2000. Australian and New Zealand Guidelines for Fresh and Marine Waters Quality. Trigger values for aquatic ecosystem protection at 90% protection of species, based on a highly disturbed system as indicated by the aquatic macroinvertebrate community composition.

[9] Australian and New Zealand Environment and Conservation Council; Agriculture and Resource Management Council of Australia and New Zealand. 2000. Australian and New Zealand Guidelines for Fresh and Marine Waters Quality. Livestock drinking water guidelines – Faecal coliforms.

[10] Ministry for the Environment 2003. Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas. Ministry for the Environment, Wellington.

[11] Ministry for the Environment, 1992. Water Quality Guidelines No. 1: Guidelines for the Control of Undesirable Biological Growths in Water.

The Mangaheka Stream has water chemistry very similar to other rural waterways around Hamilton. The iron flocs observed throughout indicate a strong inflow of anaerobic groundwaters, sourced predominantly from wetland or peat deposits. Observations indicate that the groundwater contribution to watercourse baseflow increases rapidly with distance downstream as evidenced by the increase in flow rate and volume and the continued discharge of springs and seeps from the incised gully toe, even after a dry period of several months when soil moisture deficits were high and surface flows in upper catchment drains were minimal or absent.

4.2.2.1 Sediment/Turbidity

Being a groundwater-fed stream originating in relatively flat terrain, suspended sediment concentrations are low, but observations at Horotiu Road indicate suspended sediment increases rapidly after rainfall so suspended sediment spikes are likely to be common. As is typical for rural streams within this land type, low suspended solids concentrations do not always reflect turbidity, indicating that elevated turbidity is influenced by sources other than sediment. The observed orange staining and iron flocs are likely to be contributing (in part) to elevated turbidity, supported by elevated iron concentrations. There is no guideline value for total iron. Although not analysed, it is expected that concentrations of manganese would be similarly elevated and contributing to turbidity. Other reasons for elevated non-sediment turbidity are discussed below.

Although there is no guideline value for turbidity, the ANZECC Guidelines refer to research into banded kokopu avoidance behaviour at turbidity of 20NTU and WRC water quality scientists typically use turbidity of 10NTU or suspended sediment concentration of 10g/m^3 as the threshold above which recreational and ecological effects occur. Turbidity almost always exceeds 10NTU at all sites which is typical of rural streams around Hamilton draining peat/organic wetland soils.

4.2.2.2 Metals

The 2016 sample had very little land drainage inputs since the upstream drainage network was dry. Based on the available Mangaheka results and the results from all other Hamilton catchments, the Mangaheka metals concentrations mirror that of other Hamilton catchments when drains are flowing as follows:

- Arsenic, cadmium, chromium, lead, and nickel generally below ANZECC guidelines.
- Aluminium, copper, and zinc exceeding ANZECC guidelines.
- Iron is elevated.

Based on these results and combined with observations of aquatic species distribution, habitat values, and algal growths in the Mangaheka and other Hamilton catchments, it is considered likely that metals are forming phosphates and oxides. These compounds are likely to be increasing turbidity in the absence of suspended sediment, reducing nutrient availability and limiting metal bioavailability and therefore toxicity in the water column.

Concentrations of total copper and total zinc exceed ANZECC guidelines indicating potential for biological harm, but concentrations of the bioavailable dissolved fraction are likely to be below ANZECC thresholds.

Because there was almost no urban stormwater being discharged into these waterways at the time of sampling, metals are likely to be sourced from agricultural uses and land drainage as found in all Hamilton catchments. This is supported by the average total copper, lead, and zinc concentrations being very similar to the median total concentrations of 28 samples taken at 20 rural waterways close to Hamilton[12], each with little or no urban stormwater discharges.

It is considered likely that elevated metals are a typical water quality component resulting from land drainage. Metals complexes may have localised impacts on dissolved oxygen concentrations, especially where iron discharges occur.

4.2.2.3 Nutrients

Elevated concentrations of nitrogen and phosphorus are ubiquitous in waterways around Hamilton, and generally far exceed the Ministry for the Environment water quality guidelines required to limit algal growth. However, the Mangaheka catchment has the lowest phosphorus concentrations of the Hamilton catchments with concentrations of total and dissolved phosphorus well below the median concentrations. Nitrogen concentrations were also among the lowest of the Hamilton catchments. With respect to algal growth, the sequestration of phosphorus into metal phosphates and the predominance of particulate phosphorus may limit bioavailable phosphorus to concentrations below that required for algal growth to some extent.

Filamentous algal growth was observed frequently throughout the Mangaheka drain reaches during site assessment but was not observed in the modified stream reaches or wetlands. Filamentous algal growth was most noticeable where aquatic macrophytes had recently been sprayed and in reaches downstream of this.

4.2.2.4 Faecal Pathogens

Elevated faecal coliform levels are ubiquitous in waterways around Hamilton regardless of their catchment land uses, although rural drains tend to have lower levels than urban waterways. In the Mangaheka catchment, faecal coliforms exceed ANZECC guidelines for livestock watering and Ministry for the Environment guidelines for human contact at all sampling sites and the average for Mangaheka sites is close to the median for all Hamilton streams.

4.2.2.5 Water Quality

Petroleum hydrocarbons and carbonaceous biochemical oxygen demand (CBOD) were not detected. With agricultural land uses, it is likely that CBOD fluctuates in response to inputs of organic matter. A preliminary (2011) water sample taken in the Ruffell Road drain adjacent to maize cropland had very high concentrations of CBOD compared to all other sample locations. It is considered likely that CBOD fluctuates substantially in response to inputs of organic matter associated with crop harvesting.

Temperature and dissolved oxygen will experience diurnal and seasonal fluctuations. Water temperature was cool (10.6 – 15.7°C) at the time of sampling, but observations indicate that summer water temperatures will exceed thermal tolerances of aquatic fauna throughout the upper catchment drains where riparian cover is limited and water depth is shallow. The open water areas in swales and detention basins in the industrial area are likely to experience ongoing elevated turbidity and suspended sediment loads. This may result in thermal storage causing temperatures exceeding 20°C during summer and low dissolved oxygen concentrations downstream of the discharge points.

In the modified stream channel where the stream has perennial groundwater-sourced baseflow and riparian vegetation cover, water temperature is likely to remain below the thermal tolerances of most fish and aquatic macroinvertebrate species.

[12] BML unpublished data, 2012 – 2015.

4.2.3 Water Quality Assessment

A water quality assessment (CH2M Beca 2018) has been carried out to compare the expected post-development contaminant load with the existing rural load. The results indicate that expected stormwater discharges post-development will have the following characteristics:

- Suspended sediment concentrations below the Mangaheka lowest recorded concentrations.
- Total phosphorus concentrations below the Mangaheka lowest recorded concentrations.
- Total nitrogen concentrations below the Mangaheka lowest recorded concentrations.
- Total zinc concentrations exceeding Mangaheka average zinc concentrations, but below the highest recorded zinc concentrations in the catchment. The expected industrial zinc concentration is 56% of the highest recorded rural zinc concentrations.
- Total copper concentrations exceeding Mangaheka's highest recorded copper concentrations and the highest recorded rural copper concentrations.

Based on this assessment, the Rotorkauri industrial development and its associated stormwater devices can be expected to produce an improvement in the nutrient and sediment inputs into the Mangaheka Stream. Therefore, the proposed means of compliance can be expected to result in enhanced water quality for these contaminants.

Expected zinc concentrations remain within the current range of Mangaheka rural zinc concentrations, a situation which mirrors that recorded in Hamilton City's waterways where rural and urban zinc concentrations are very similar. As occurs in the existing environment, zinc will sometimes exceed ANZECC guidelines. Therefore, the proposed means of compliance can be expected to maintain water quality for zinc.

Expected copper concentrations may exceed the current range of Mangaheka rural copper concentrations, a situation which mirrors that recorded in Hamilton City's waterways where urban copper concentrations often exceed rural concentrations in the same waterway.

However, it is important to recognise that Mangaheka's existing minimum copper concentrations are at the ANZECC guidelines and average copper concentrations exceed the ANZECC guideline. The expected industrial discharge concentrations may raise copper concentrations above what is typically experienced in the rural catchment, but this increase is in the context of copper concentrations that are already elevated and a biological community comprised of pollution-tolerant species. Whether increased copper concentrations impact on this biological community depends in part on what form the copper is discharged, with dissolved copper presenting a greater risk of biological harm than copper adsorbed to particulate matter or bound up in compounds such as phosphates. However, the primary factor influencing the impact of increased copper concentrations is the tolerance of the aquatic species present in the downstream receiving environment.

4.3 Sediment Quality

A results summary is presented below in Table 4 and full laboratory reports are provided in Appendix 2. In Table 4, the results are compared against the ANZECC 2000 Interim Sediment Quality Guidelines (ISQG) as noted in the footnotes. Results in bold and shaded equal or exceed the guideline value.

Table 4: Sediment Sample Analysis

Analytes	Units	2012 Pre-development				2016	ISQG - Low Guideline Values[13]
		Ruffell Rd	Te Kowhai Rd	Farm Culvert	HJV Boundary	Horotiu Rd	
Total Recoverable Iron	mg/kg	6,100	37,000	16,300	12,300	-	-
Total Recoverable Arsenic	mg/kg	5	**20**	12	13	8	20
Total Recoverable Cadmium	mg/kg	< 0.10	1.05	0.23	0.38	0.16	1.5
Total Recoverable Chromium	mg/kg	4	10	6	7	3	80
Total Recoverable Copper	mg/kg	4	51	9	26	2	65
Total Recoverable Lead	mg/kg	4.9	15.7	12.3	14.1	3.2	50
Total Recoverable Nickel	mg/kg	2	7	3	3	<2	21
Total Recoverable Zinc	mg/kg	28	162	54	33	34	200

Except for arsenic, the concentration of metals is below the ISQG-Low trigger concentrations.

Arsenic concentrations equal the ISQC-Low concentration indicating the potential for adverse effects on benthic biota. Although the Te Kowhai road sediment has the highest concentrations of contaminants in sediment, there is no indication of risk to people or livestock.

4.4 Aquatic Macroinvertebrates

The full macroinvertebrate analysis reports are provided in Appendix 3 and the summary table is shown below.

Table 5: Macroinvertebrate Sample Analysis

Metric	2012 Pre-development		2016
	Farm Culvert	Te Kowhai Rd	Horotiu Rd
Total Abundance	180	470	320
Taxonomic richness	18	25	12.7
No of EPT Taxa	1	1	1
%EPT abundance	12.2	0.2	13
MCI–sb	50.3	71.8	54.5
QMCI–sb	2.6	3.2	1.7

[13] Australian and New Zealand Environment and Conservation Council; Agriculture and Resource Management Council of Australia and New Zealand. 2000. Australian and New Zealand Guidelines for Fresh and Marine Waters Quality. Interim sediment quality guidelines.

In 2012, the macroinvertebrate community was characterised by high abundance and moderate diversity, with the dominant fauna comprising Oligochaete worms, Diptera larvae and snails. Other fauna present included flatworms, dragonflies and caddisflies in low numbers. A total of 32 taxa were identified (8 at the farm culvert, 16 at Te Kowhai Road), including only two sensitive EPT (Ephemeroptera, Plecoptera, Trichoptera) taxa. Although the two sites had quite different macroinvertebrate communities, both were characterised by low Macroinvertebrate Community Index (MCI-sb/QMCI-sb) scores of 50.6/2.6 for the farm culvert and 71.8/3.2 for Te Kowhai Road. This reflects the low abundance of sensitive taxa and indicates probable severe pollution, as well as a lack of habitat diversity.

The 2016 macroinvertebrate samples were dominated by flatworms, with caddisflies (*Oxyethira albiceps*) also featuring prominently. Other fauna present in relatively high numbers included species of crustaceans and molluscs. Similar to 2012, a total of 19 taxa were identified at the Horotiu Road site, including only one EPT taxa which is tolerant. Similar to the 2012 results, the Macroinvertebrate Community Index (MCI-sb/QMCI-sb) scores of 54.5/1.7 reflect the low abundance of sensitive taxa and indicates probable severe pollution, as well as a lack of habitat diversity. These species are found in many other waterways around Hamilton City including those locations with elevated copper concentrations, and are expected to be tolerant of the expected post-development copper concentrations.

4.5 Fish

In the Waipa River catchment, 14 native fish species have been recorded (Speirs 2001). The NIWA Freshwater Fish Database (FFDB) contains 14 records for fish surveys at 7 sites undertaken from 1984 to 2016 in the Mangaheka Stream. Survey locations included Crawford Road, Horotiu Road, and within the Structure Plan area drains. As shown in Figure 5, five species were identified including one exotic species (mosquitofish) and four native species namely shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachii*), banded kokopu (*Galaxias fasciatus*), and black mudfish (*Neochanna diversus*). Black mudfish and longfin eels are classified at an At Risk – Declining species (Goodman *et al*. 2013).

Responding to the requirements of the Freshwater Fish Regulations and under the provisions of MPI permit NFT174 for fish translocations, the fish populations of the two largest industrial land parcels were removed prior to land development in 2011/2012. The fish were translocated to the Tanirau Wetland at Crawford Road. The species caught and transferred were black mudfish (12), longfin eel (2) and shortfin eel (16).

Anecdotal evidence from landowners indicates that fish species in the Crawford Road wetland area and stream include shortfin eel, longfin eel, giant kokopu (*Galaxias argentus*), banded kokopu, and koura (*Paranephrops planifrons*).

During the 2016 fish survey, a total of four fish species were identified (Table 6), including one exotic species (mosquitofish) and three native species (longfin eel, shortfin eel and banded kokopu). Four longfin eel were caught ranging from 500 to 1200mm, while three short fin eel were also captured ranging from 500 to 700mm. The banded kokopu consisted of one large adult approximately 150mm in size. A single shortfin eel, approximately 300mm in size, was captured during the single electric fishing run. Over 300 mosquito fish were caught.

Table 6: Fish Survey Results

Fish Species	Horotiu Rd
Longfin eel	4
Shortfin eel	3
Banded kokopu	1
Mosquitofish	>300
No. of species	4

The culverts at Ngaruawahia Road and Horotiu Road may present a barrier to fish passage, particularly non-climbing species. However, permanent water flow over the willow root mass into the culvert is not expected to be a barrier for capable climbing species such as eels and kokopu. Black mudfish have also been found upstream so the culverts may present only a minor fish passage barrier, or the upstream populations may be isolated from downstream populations. A complete waterway walkover was undertaken in 2012, excluding the inaccessible wetland area. Debris jams were not observed and would not normally be expected in a soft sediment waterway with little riparian cover or in the gully floor swamps.

The diversity and abundance of fish species is likely to increase substantially with distance downstream, as flows become perennial, channel morphology is less modified, habitat diversity increases, and riparian vegetation cover increases.

However, the intermittent drains and wetland areas throughout the catchment with peat-influenced groundwater baseflows will provide important habitat for threatened black mudfish. As discussed in Section 5.5 below, it is likely that small relict populations of the non-migratory species is present in suitable habitats with population size and distribution varying with water levels allowing eel access as occurs in similar locations east of the Waikato River. The relative habitat value of each intermittent drain is likely to be adversely affected by Drainage Board management activities such as spraying and excavation.

4.6 Erosion and Scour

Based on the 2012 walkover, upper catchment drains between Rotokauri Structure Plan Area and Te Kowhai/Koura Drives are small headwater waterways that are receive baseflows predominantly from groundwater rather than overland flow due to flat topography. Downstream of Te Kowhai/Koura Drives, the drains are substantially deeper and wider but baseflows are likewise groundwater-fed and surface drainage is minimal. As a result, fluvial erosion and scour are rare in the drains and bank instability tends to result from non-fluvial factors such as over steep banks (resulting from excavation) and vegetation removal (from spraying). This was confirmed by geotechnical investigation[14] into drain bank instability which concluded the most likely mechanism is bank vegetation removal from weak soil strata. Drain bank instability is localised and limited. Two notable locations of bank instability are at the confluence of the two upper catchment drain networks immediately downstream of Koura Drive and at the farm culvert sampling location, both present prior to the Rotokauri industrial site development.

In the modified stream reach upstream of Horotiu Road the channel is deeply incised with very steep banks and channel morphology indicates the bed is eroding. This reach has extensive

[14] Coffey Geotechnics Ltd, 2012. Memorandum: Phase 1 - Drain Erosion Qualitative Assessment in Relation to the Proposed Rotokauri Industrial Development, Hamilton, Waikato

bank instability with erosion and scour resulting in undercutting and bank failure ranging from small slumps to severe mass bank failure. This is principally in the channelised stream reach and appears to be the natural fluvial process of re-establishing a meandering flow path. In some areas, large scale bank failure is associated with large springs emanating near the bank toe.

Where rock riprap has been deposited to stabilise bank failure, underlying sediments have collapsed further causing lobes of sediment and rock within the channel diverting flows and causing scour upstream, opposite, and downstream of the lobes.

Most stream reaches are fenced to exclude stock but some fence and gate placement may be contributing to instability as a result of livestock pressure. As noted in Section 4.1.4, some stream reach were unfenced at the 2012 assessment with extensive erosion from livestock access but this is likely to have ceased after fencing. As for the drain reaches, the bank instability described above was present pre-development.

Downstream of Horotiu Road in the reach upstream of the wetland, the stream has a flatter gradient, is notably less incised and more connected with the adjacent floodplain. Erosion, scour and bank instability are rare. Likewise within the observable wetland channels, erosion and scour are likely to be associated only with discrete drain discharge points.

5.0 Discussion

5.1 Water Quality

Small headwater tributaries are vulnerable to effects from land use change because new stormwater discharges can make up a large proportion of post-development flows and therefore have a disproportionately large effect on downstream water quality. Although the proportion of existing and proposed industrial/employment zone land and roading in the Mangaheka Stream catchment is small, stormwater management based on TP10 design parameters (see Sections 1.2 and 1.3) could have effects on water quality downstream due to the small channel size and flow volume at the discharge points in spite of the existing poor water quality.

The Mangaheka Stream has water quality and water chemistry that is very similar to other Hamilton waterways. From its predominantly rural catchment, the stream receives ongoing inputs of sediment, turbidity, nutrients, metals, and faecal pathogens. Metals and phosphorus appear to have relatively limited bioavailability through the formation of metal phosphate compounds which increase turbidity, and dissolved copper and zinc concentrations exceed ANZECC thresholds. The instream aquatic community is comprised of pollution tolerant species that can withstand the harsh drain environments.

An analysis of the water quality of Hamilton's rural, semi-urban, and urban waterways shows that although total contaminant loads may increase following urbanisation, contaminant concentrations can be expected to remain similar to pre-development. This is likely to be a result of pre-development stream baseflows sourced from shallow groundwater draining soils of historic wetlands which release continuously elevated metals loads. Analysis indicates that regardless of the proportion of urbanised catchment, concentrations of stormwater metals (copper, lead, zinc) do not change substantially even in catchments with large industrial catchments such as Waitawhiriwhiri Stream.

The water quality assessment indicates that this is likely to be the case for the zinc concentrations. While copper concentrations are likely to increase above the current range, the aquatic species present in the Mangaheka upper catchment are found in other Hamilton catchments with similar water quality and are therefore likely to be tolerant of increased copper concentrations.

Provided that existing and proposed wetlands and detention basins maintain contaminant concentrations to within the current range, the most important water quality issue associated with the upper catchment drains is elevated temperature and turbidity. Large open water areas and unplanted or sparsely planted stormwater swales are known to impact water quality by raising temperature, reducing dissolved oxygen, and causing reduced water clarity. These conditions are likely to be adversely affecting the diversity and distribution of indigenous aquatic organisms in downstream habitats, when water flow in the upper catchment is occurring.

The faecal pathogen load is high (but about average compared to other catchments) which makes the water unsuitable for human contact or livestock consumption throughout the catchment. The high faecal pathogen load may present a public health risk for anyone in contact with the water or for fish and watercress consumption (Edmonds 2001). These activities are most likely in the lower catchment at the marae on the downstream end of the wetland. Water quality testing has not been carried out at this location.

On balance, the water quality and water chemistry of the Mangaheka Stream catchment is considered to be moderate to poor, but similar to most Hamilton waterways. The expected water quality of the industrial stormwater discharges is likely to be improved for nutrients and sediment, maintained for zinc, and slightly degraded for copper but within the tolerances of the aquatic species present.

There is a significant risk of effects from thermal pollution on the modified stream and drains that provide mudfish habitat, particularly after summer rainfall when drains are flowing and particularly if ponds are used as attenuation devices rather than planted wetlands or swales. On that basis, stormwater devices throughout the catchment must use planted swales and wetlands with >80% cover to maintain cool stormwater discharge temperatures.

5.2 Water Quantity

Based on the pre-development topography and soils of the upper catchment, and the location and flow direction of surface drains, when flowing, the drains provide groundwater-sourced base flows to the stream that it would not naturally have received. The peat wetlands are likely to have been self-contained systems with no outlet fed by local shallow groundwater systems, although deeper groundwater flow is likely to have been generally north-northwest. Increased impervious surfaces throughout the industrial/employment area combined with removal of the remaining drains to facilitate development will increase the volume of water discharging downstream, but may decrease the baseflows at low flows because water is being held in detention basins.

The stream has ecological significance as habitat for a range of threatened species in the middle and downstream catchments. The upper catchment is habitat for longfin eel and black mudfish. Eel and black mudfish populations are known to fluctuate in relation to one another based on the complex interplay between rainfall, baseflows, and fish passage. Where rainfall maintains baseflows, eel populations will enter a drain network and reduce mudfish populations through predation. When drains dry up regularly, eel populations migrate downstream or survive only in pool refugia, and mudfish populations can remain viable in the intermittently dry drain habitat where eel predation is limited or absent.

The upper catchment drains, including those within Hamilton City boundaries, are known to provide habitat for black mudfish and longfin eels, and are therefore considered to have ecological significance providing habitat for these threatened species. Provided that the post-development stormwater devices continue to discharge intermittently into the existing drain network and include surface swales and detention basins to maximise infiltration, then the hydrology of the drain network can be expected to remain approximately similar to pre-development.

5.3 Sediment Quality

Benthic fauna are likely to be limited to those species capable of withstanding periodic smothering from suspended sediment loads, intermittent flow, and high temperatures. Sediment contaminants are likely to have less important effects on benthic fauna diversity in the Mangaheka Stream than factors such as hydrology, suspended sediment inputs, benthic habitat quality, water temperature, sediment oxygen profile, and presence of aquatic macrophytes.

Overall, sediment quality is typical of agricultural watercourses with all metals detected but no notable issues.

5.4 Aquatic Macroinvertebrates

The MCI /SQMCI scores are consistent with those measured in similar open rural drain networks with intermittent water flow, groundwater-derived base flows, low aquatic macrophyte and riparian vegetation cover, poor bank stability, and water with elevated sediment, nutrient and metal concentrations. This reflects the catchment’s rural and rural-residential land use and long term land drainage.

On balance, no change in the MCI/SQMCI scores can be expected as a result of completion of the industrial/employment areas development because macroinvertebrate communities are already comprised of very hardy and pollution tolerant species. The proportion of the total stream catchment being urbanised is small, and given the stormwater treatment proposed, effects on water quality and quantity are likely to be relatively small such that the aquatic macroinvertebrate community composition in the downstream environment is likely to remain unchanged.

The aquatic macroinvertebrate community diversity on the Mangaheka Stream could be improved with riparian vegetation replanting around the drain networks, as described in the Mangaheka Restoration Vision. This would provide channel shade, reduced temperature and increased organic material.

5.5 Fish

The factors to consider when assessing the fish diversity associated with rural waterways include aquatic and riparian habitat quality, water quality, community composition, and the presence of significant barriers to fish passage. Bearing in mind the relative lack of fish survey records for the large Tangirau Wetland area, actual fish diversity is likely to be greater than recorded fish diversity, with bully species absent from the records but likely to be present. However, in the remainder of the waterway, species diversity is close to what would be expected in natural conditions for this type of intermittent lowland Waikato stream with peat influences. Although inanga (*Galaxias maculatus*) and smelt (*Retropinna retropinna*) would normally be expected, these species are unlikely to naturally occupy the willow wetland reaches, precluding movement upstream into the middle and upper reaches.

Of importance to this assessment, the intermittent upper catchment would naturally be expected to provide habitat only for eels and black mudfish which have been observed either in fish surveys or translocations. Provided that stormwater treatment maintains dissolved contaminant concentrations within the same range as is currently experienced and within the tolerances of fish species present, and the design assumptions set out in Sections 1.2 and 1.3 are implemented, continued development of the Rotokauri Structure Plan industrial and employment areas is unlikely to affect fish diversity.

Replanting riparian vegetation cover throughout the modified stream catchment may increase the viable habitat for species such as banded kokopu, giant kokopu, and bullies further upstream in the catchment, but their upstream extent will be limited to perennial reaches. Likewise, replanting riparian vegetation in the drain networks would improve habitat for mudfish, eels and aquatic macroinvertebrates, while also improving bank armouring.

Given the species found upstream, the perched Horotiu Road culverts are not a significant fish passage barrier.

5.6 Erosion and Scour

Ongoing development of the industrial/employment areas will substantially increase impervious areas over part of the upper catchment, reducing infiltration to groundwater and increasing the volume and speed of surface runoff. This is mitigated by two existing stormwater detention basins designed to TP10 standards installed to attenuate peak flows and reduce discharge velocity to less than pre-development rates at the pre-existing drain network discharge points. Development of additional industrial/employment areas is likely to have similar volume and peak flow attenuation requirements.

However, regardless of the degree of flow attenuation, increased imperviousness will result in larger stormwater volumes being discharged over longer durations based on the modelled pre-development and post-development runoff characteristics. Based on topography and existing waterway characteristics, particularly the pre-development erosion pattern, there is potential for additional flow volumes to cause bank instability in the drains immediately downstream of the discharge points, particularly non-vegetated drains with very steep banks. Additional volume may also exacerbate existing erosion at the Koura Drive confluence.

Increased erosion related to increased volume is less likely in shallow drains with battered banks and riparian vegetation cover and/or aquatic macrophytes upstream of Te Kowhai Road. Most erosion effects would be expected to be experienced in the first several hundred meters downstream of discharge points, but may extend further downstream over time as channel morphology changes in response to the new flow regime. The effect of increased erosion on the drains relates principally to bank stability, rather than the riparian or aquatic environment which is artificial and has low ecological values.

Based on visual assessment of the waterways, there is unlikely to be a measurable change in the existing bank instability in the modified stream reach upstream of Horotiu Road.

Erosion and scour effects can be prevented by:

- Fencing the waterways to prevent stock access.
- Battering back banks to reduce instability.

- Planting indigenous riparian plants specifically chosen to improve bank stability and protect the channel bed (see Plant Selection Tool for Waikato Waterways and Mangaheka Restoration Vision).

However, given the complexities of the downstream waterway ownership and management, and the poor quality artificial habitat, it may be more appropriate to monitor for changes in erosion and bank stability and retrofit solutions if effects are detected.

6.0 Risks and Sensitivities

On the basis of Sections 2.0 – 5.0 above, there are a number of risks associated with stormwater management in the Mangaheka Stream catchment as a result of industrial/employment zone land development, based on the particular sensitivities identified.

The upper catchment waterways (drains) are small, artificial, and have poor habitat values. Water quality is modified by land drainage and agricultural land use, and affected by intermittent flow and lack of riparian or instream vegetation. Water quality is likely to experience spikes of contaminants (sediment, metals, and nutrients) after rainfall, particularly when drains have previously been dry. The aquatic macroinvertebrate community reflects the combination of poor habitat values and poor water quality. The water quality assessment indicates that water quality will be improved for sediment and nutrients, maintained for zinc, and possibly reduced for copper based on assumed means of compliance installation and performance. However, thermal pollution is considered to be largest ecological risk to downstream waterways if swales and detention basins are not planted or plant cover is low with potential for significant effects on threatened black mudfish. Rainfall draining from rural land does not experience thermal enrichment to the same extent as industrial land. Although black mudfish are adapted to waterways with intermitted flows or isolated pools, they are not adapted to extreme temperature spikes resulting from heated stormwater discharges.

In the drains with steep banks and little riparian vegetation, there is a risk that increased stormwater discharge volumes will increase bank instability.

Sediment quality is moderate to good. Based on conventional TP10 stormwater design, this is likely to be unchanged by urbanisation or roading.

Fish diversity in the catchment is close to what would be expected naturally and the identified fish passage obstacles present only a minor barrier. However, lack of riparian cover and waterway habitat values in the upstream drains limit the use of the habitat by fish, provide poor conditions for the aquatic macroinvertebrate community, and impact water quality.

The existing farm drains in the undeveloped portions of the Rotokauri Structure Plan industrial/employment areas are likely habitat for threatened fish species (longfin eel and black mudfish). The presence of these threatened species means the drains have ecological significance under the provisions of the RPS, and their removal will require mitigation and offset measures to replace the habitats.

Effects of stormwater discharges, bank instability, and drain removal/modification are not expected to be measurable in the modified stream reach or the Tangirau Wetland.

Table 7 summarises the assessment of risks and sensitivities of the upper drain catchment associated with stormwater discharges into the Mangaheka Stream and industrial/employment zone land development.

Table 7: Mangaheka Stream upper catchment risks & sensitivities

Environmental value	Existing state or values	Potential effects of future stormwater management?	Proposed Objective
Riparian habitat	Variable, but typically low intrinsic value in stream and drain reaches.	Yes	Explanation: The very limited existing riparian values are unlikely to be changed by future stormwater discharges. Low riparian vegetation cover affects bank stability and water quality. Increased stormwater volumes may cause bank instability in steep unvegetated drains. Objective: Riparian vegetation density and cover is maintained and/or enhanced downstream of stormwater discharge points on the Mangaheka Stream to maintain habitat stability and water quality. Recommendations: To avoid bank instability, dense riparian vegetation cover must be maintained where present. Where riparian vegetation replanting is proposed to avoid downstream bank instability, it must consist of indigenous eco-sourced plant species appropriate to the lowland Waikato location in accordance with the Mangaheka Restoration Vision.
Aquatic habitat	Moderate, ecological significance	Yes	Explanation: Site development in the undeveloped industrial/employment areas will remove riparian vegetation and waterways that are potential habitat of threatened fish species (longfin eel and black mudfish). Objective: Meet the requirements of the RPS provisions for avoiding adverse effects on habitats of significance indigenous fauna. Recommendations: Work with WRC and landowners of undeveloped land in the Rotokauri Structure Plan industrial/employment areas to identify appropriate methods of providing longfin eel and black mudfish habitat either within the site or in alternative offsite habitats.

Environmental value	Existing state or values	Potential effects of future stormwater management?	Proposed Objective
Water quality	Poor	Yes	Explanation: There is potential for stormwater discharges to impact water quality if inappropriate devices are installed or if installed devices do not achieve design standards for treatment. Objectives: Mass loads or concentrations of stormwater contaminants in the Mangaheka Stream are maintained within the current range and/or within the tolerances of the aquatic species present as a result of industrial/employment zone land development. Temperature in the Mangaheka Stream is not increased above 23°C in summer and 14°C in winter downstream of all stormwater discharge points when flow is occurring. Recommendations: To avoid potential thermal pollution, stormwater treatment devices must avoid open water ponds and achieve wetland/riparian plant cover >80% to maintain cool downstream temperatures. Undertake monitoring (Section 10) to confirm device performance, and detect changes in contaminant profile and temperature over time. Work with WRC and downstream landowners with unplanted drains to establish dense riparian vegetation consisting of indigenous eco-sourced plant species appropriate to the lowland Waikato location in accordance with the Mangaheka Restoration Vision.
Water quantity	Intermittent	Yes	Explanation: Intermittent flows are important to maintaining habitat for threatened black mudfish. Changing drain hydrology to perennial flow should be avoided. Objective: Discharges into the Mangaheka Stream from the Rotokauri Structure Plan industrial/employment areas continue to provide intermittent flows. Recommendation:

Environmental value	Existing state or values	Potential effects of future stormwater management?	Proposed Objective
			To avoid increasing drain base flows, stormwater devices are not required to discharge continuously to the Mangaheka Stream receiving waters.
Sediment quality	Moderate - Low	No	Explanation: On the basis of TP10 minimum design standards for treatment and existing sediment quality, there is unlikely to be a notable change in sediment quality as a result of stormwater discharges into Mangaheka Stream receiving waters.
Aquatic macroinvertebrates	Low	Unlikely	Explanation: On the basis of the water quality assessment, stormwater discharges are unlikely to reduce biodiversity as a result of increased stormwater copper concentrations. See objective in Water Quality above and Erosion & Scour section below.
Indigenous fish	Moderate, threatened species present	Yes	Explanation: Site development in the undeveloped industrial/employment areas will remove riparian vegetation and waterways that are potential habitat of threatened fish species (longfin eel and black mudfish). See objective in Water Quality above and Erosion & Scour section below.
Erosion & Scour	Stable in drain reaches, unstable in modified stream reaches.	Yes	Explanation: There is potential for increased erosion resulting from increased stormwater volume in drain reaches downstream of discharge point, particularly where banks are steep and unvegetated. If monitoring determines that drain bank instability downstream of discharge points is increasing, riparian planting is the most appropriate method of increasing armouring of bank sediments while enhancing water and habitat quality in an ecologically significant habitat. Bank battering and engineered solutions may be required in specific locations. Objective: Bank instability of Mangaheka Stream drains downstream of stormwater discharge points is not increased.

Environmental value	Existing state or values	Potential effects of future stormwater management?	Proposed Objective
			Recommendations: Undertake monitoring (Section 10) of drains downstream of the discharge points to detect changes in bank instability over time. On drain reaches downstream of stormwater discharge points where an increase in bank instability is measured and confirmed as a result of stormwater discharges, drains must be managed to improve bank stability in conjunction with the landowner and WRC using a combination of methods appropriate to the specific location such as: Batter back over-steep drain banks and fence drains to exclude stock at less than 1m from the bank crest. Plant indigenous eco-sourced riparian and/or wetland/aquatic plant species with rhizome root systems appropriate to the lowland Waikato location in accordance with the Mangaheka Restoration Vision.

7.0 Enhancement Opportunities

The Mangaheka Stream outlets are at or near the HCC boundary. Within HCC boundaries, the waterway consists entirely of stormwater infrastructure and a short reach of artificial farm drains. Beyond HCC boundaries, the downstream catchment and riparian margins are in private ownership, and are maintained by the drainage board for conveyance and flood drainage. As discussed in Section 4.0, most riparian vegetation is grass beside artificial drains with small areas of shelterbelt trees. Therefore, enhancement opportunities are limited to changes in management of artificial drains rather than restoration of modified natural systems.

If the Mangaheka drainage district is extended over the industrial area to allow levying of targeted rates, then a fund would be available for implementation of the Mangaheka Restoration Vision which describes appropriate restoration options. Without such a fund, enhancement options are limited by the need to obtain funding from other sources, permission for access and implementation from landowners, and the support of the drainage board for the proposed methods.

As a result, specific enhancement projects cannot be identified within the upper catchment that would offset or mitigate effects of catchment modification within HCC boundaries. Figure 6 shows generally where implementation of the Mangaheka Restoration Vision options could occur. As set out in the Vision document, restoration principally includes fencing and riparian planting of short stature indigenous sedgelands on drain banks and shrubland on modified stream margins.

Before development, black mudfish (*Neochanna diversus*) occupied drains within HCC boundaries. The mudfish were translocated into the lower catchment when development occurred. In recognition of the loss of such habitat, there is an opportunity to create mudfish habitat in the upper catchment. The only location with peaty soils suitable for this purpose is shown in Figure 6.

One project proposed in the lower catchment is the Tangirau Wetland Restoration which is the subject of a funding application to the Waikato River Authority. If the application is successful, it would result in the restoration of some 43ha of wetland and riparian habitat. This project is not related to effects of land development in HCC boundaries. I suggest we amend the map to relate directly to the general restoration options per the Mangaheka Restoration Vision.

8.0 Monitoring Programme

The purpose of monitoring to support an ICMP is to:

- Ensure that the assumptions on which objectives were based remain valid, and
- Determine whether implemented measures are effective at achieving the objectives.

The following monitoring parameters are recommended to ensure that discharge quality is as expected and that bank instability does not increase post-development.

1. Downstream of stormwater discharge points for the Rotokauri Structure Plan industrial/employment areas and Waikato Expressway/Koura Drive, within the zone of reasonable mixing, undertake water quality monitoring consistent with the HCC Comprehensive Stormwater Discharge Consent methodology for the analytes set out in Table 2, plus temperature and dissolved oxygen. The purpose of the analysis is to monitor discharge quality to ensure compliance with the Discharge Consent. The contaminant concentrations should be compared against USEPA water quality criteria.
2. At the Te Kowhai Road, Murray farm, and Horotiu Road culverts, undertake water quality monitoring consistent with the HCC Comprehensive Stormwater Discharge Consent methodology for the analytes set out in Table 2, plus temperature and dissolved oxygen. The purpose of the analysis is to monitor post-development changes in baseline stormwater contaminant concentrations and water quality parameters to confirm the contaminant load assessment. The contaminant concentrations should be compared against ANZECC guidelines.
3. Between stormwater discharge points and the Murray farm culvert, undertake a bi-annual drain walkover to observe and measure bank instability extent and severity. Compare the results with the baseline erosion survey information to determine whether observable changes in erosion, scour, and bank instability are occurring. Analysis of scour, erosion and sediment deposition in the tributary from the discharge points to no less than 100m downstream, excluding the reaches of artificial substrates at road crossings. At 10m intervals across a transect, measure the drain depth, bank slope, and channel width at the waterline and bank crest. Compare transects to determine change in channel morphology. Complete a visual assessment of sediment deposition along the same reach. Compare transect cross sections to determine the extent of scour, erosion or deposition.

9.0 Conclusion

Urbanisation within the Mangaheka Stream catchment will continue to occur within the Rotokauri Structure Plan area, which comprises a small proportion of the stream catchment. As a result, increased stormwater volumes will be discharged into the Mangaheka Stream's headwater drains at or near their upstream extent.

The receiving environments are small tributary drains with poor riparian and aquatic habitat, and poor water quality. The upper catchment drains support a tolerant aquatic macroinvertebrate community and a naturally depauperate fish community affected by intermittent flow and poor habitat quality.

Based on the existing water quality, there is a risk that urbanisation has and will continue to decrease water quality due to thermal pollution, even with stormwater treatment devices designed to TP10 standards. Stormwater treatment devices need to maintain existing water chemistry and quality, and densely planted devices are the most appropriate method of achieving this.

Because the drains and downstream modified stream are small watercourses, they are vulnerable to effects from stormwater discharges which will form a disproportionately large part of the post-development flows. There is a risk that such discharges will have adverse effects on bank stability and erosion unless regular monitoring and preventative management is undertaken.

The Mangaheka Stream catchment upstream of Horotiu Road provides existing habitat for shortfin eels and banded kokopu, and threatened longfin eels and black mudfish, conferring ecological significance on the waterway. Eels and mudfish have been found in the upstream drains. Fish habitat and fish passage in upstream habitats must be maintained in proposed road corridors and land development areas, or replaced with equivalent or enhanced habitats.

To reduce potential for stormwater management resulting from urbanisation to have adverse effects, objectives are provided for each of the main risks. On the basis of the information currently available regarding the ecological values of the Mangaheka Stream and the proposed urbanisation for industrial and employment zones, actions have been recommended to prevent or mitigate effects on ecological values. Monitoring is recommended to ensure that the recommended actions have achieved the objectives.

10.0 References

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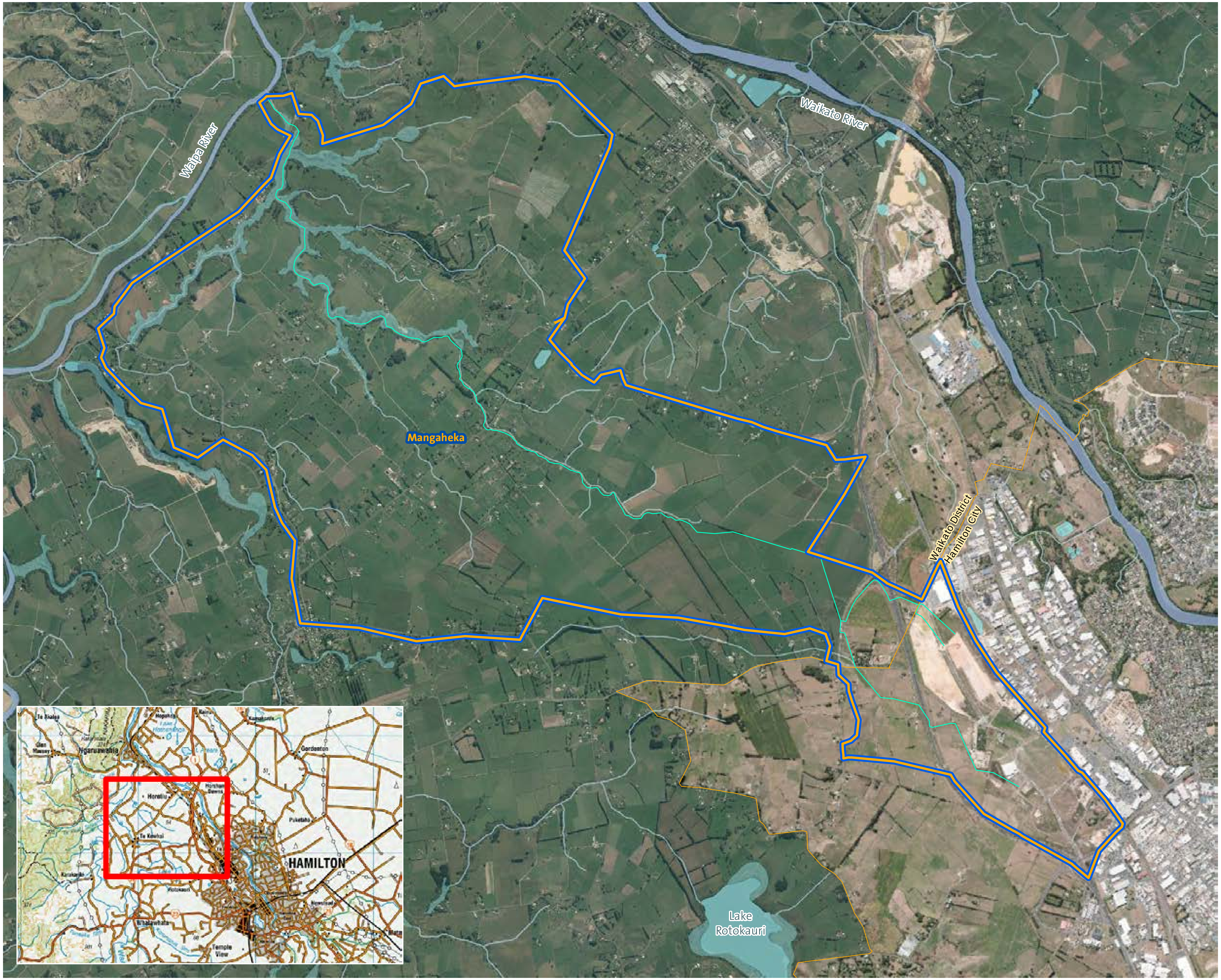
Appendix 1 – Figures

File Ref: T15161_Figure1_CatchmentBoundary.mxd



Legend

Topographic Catchment Boundary

0 1 km

1:30,000 @ A3

Sources: Aerial photography sourced from Waikato Regional Council (WRAPS 2012). Topographic information sourced from Land Information New Zealand.

Sub-catchment data sourced from Lysaght Consultants Ltd, as per plan titled "2012-06-27 - 112196 - BML - Catchment Boundaries.dwg"

Projection: NZGD 2000 New Zealand Transverse Mercator

MANGAHEKA ICMP

Figure 1
Catchment Boundaries

Date: 23 June 2016
Revision: 0

Plan Prepared for the Hamilton City Council by Boffa Miskell Limited
*Project Manager:*Louise.Saunders@boffamiskell.co.nz
Drawn: JWa *Checked:* LSa

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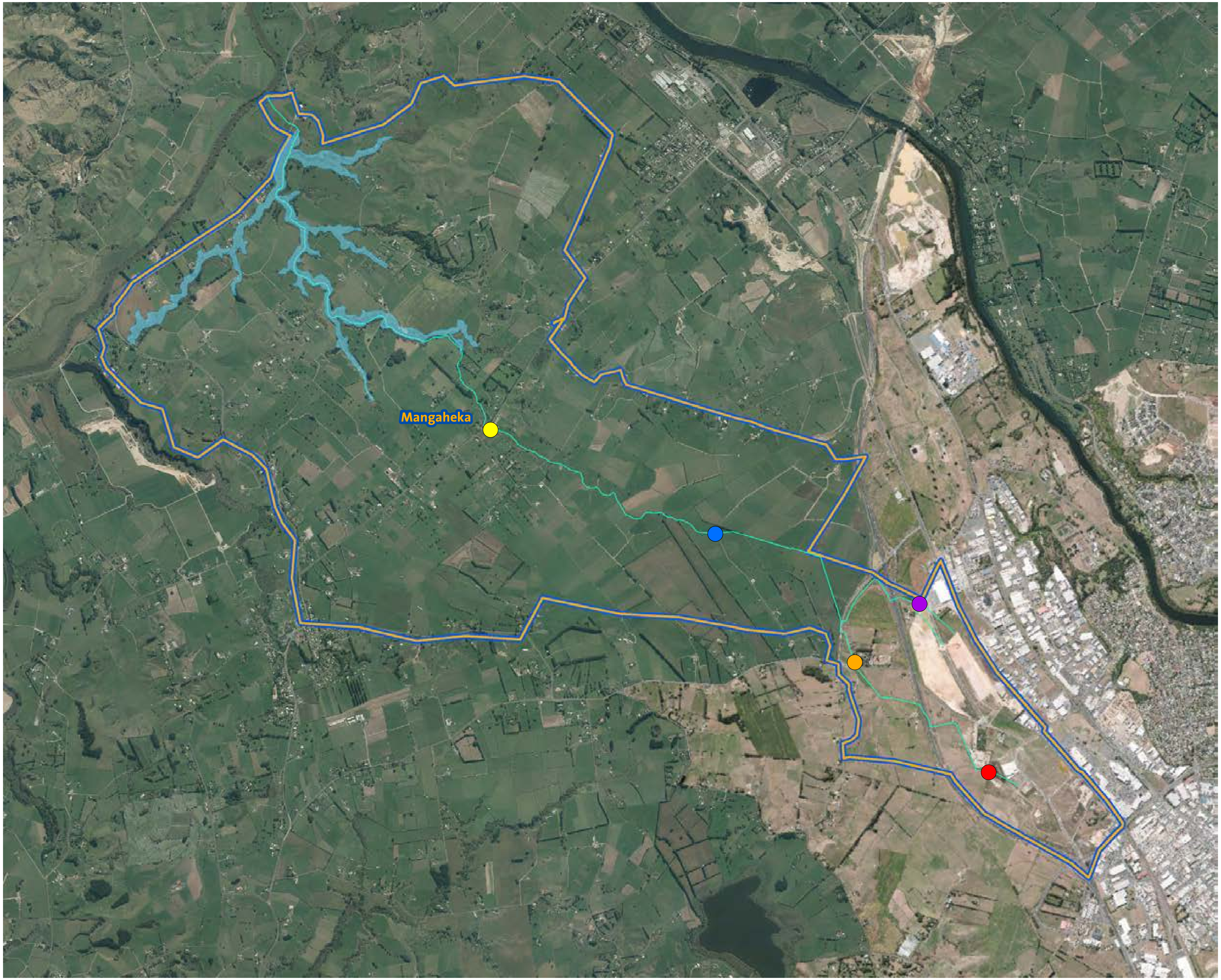
File Ref: T15161_Figure2_SampleSites.mxd



Legend

2016 Sample Site

- Horotiu Road

2012 Sample Sites

- HJV Boundary
- Ruffell Road
- Te Kowhai Road Culvert
- The Farm Culvert
- Wetland
- Waterway
- Topographic Catchment Boundary

0 1 km

1:30,000 @ A3

Sources: Waikato Regional Council (WRAPS 2012), Land Information New Zealand, AECOM Limited.

Projection: NZGD 2000 New Zealand Transverse Mercator

MANGAHEKA ICMP

Figure 2
Sample Sites

Date: 23 June 2016
Revision: 0

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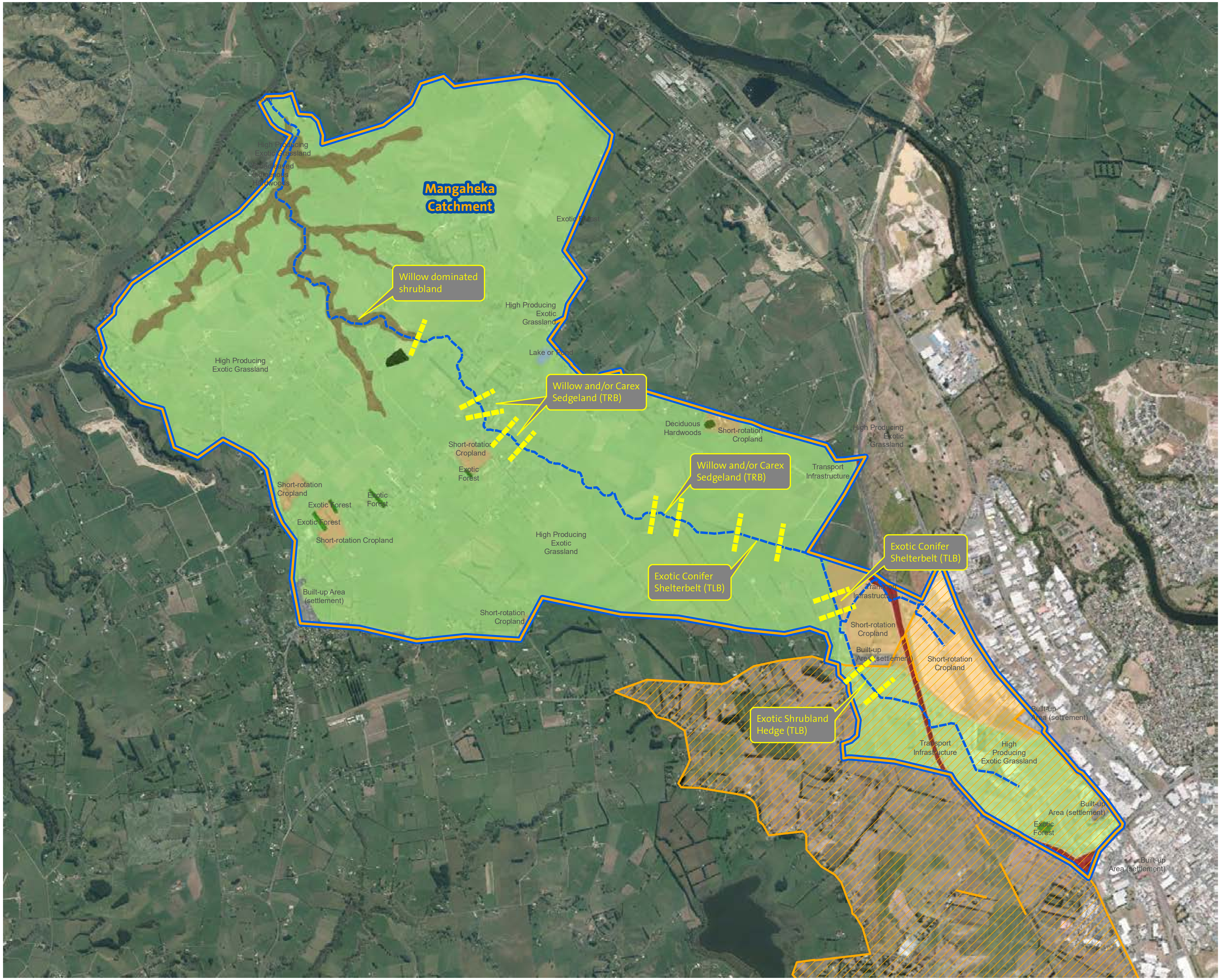
File Ref: T15161_Figure3_Vegetation.mxd



Legend

- Topographic Catchment Boundary
- Stormwater Centreline
- Structure Plan Area
- Built-up Area (settlement)
- Transport Infrastructure
- Lake or Pond
- River
- Short-rotation Cropland
- High Producing Exotic Grassland
- Low Producing Grassland
- Broadleaved Indigenous Hardwoods
- Deciduous Hardwoods
- Indigenous Forest
- Exotic Forest

0 1.2 km

1:30,000 @ A3

Sources: Waikato Regional Council (WRAPS 2012), Land Information New Zealand, Hamilton City Council.

Projection: NZGD 2000 New Zealand Transverse Mercator

MANGAHEKA ICMP

Figure 3
Riparian Vegetation

Date: 23 June 2016
Revision: 0

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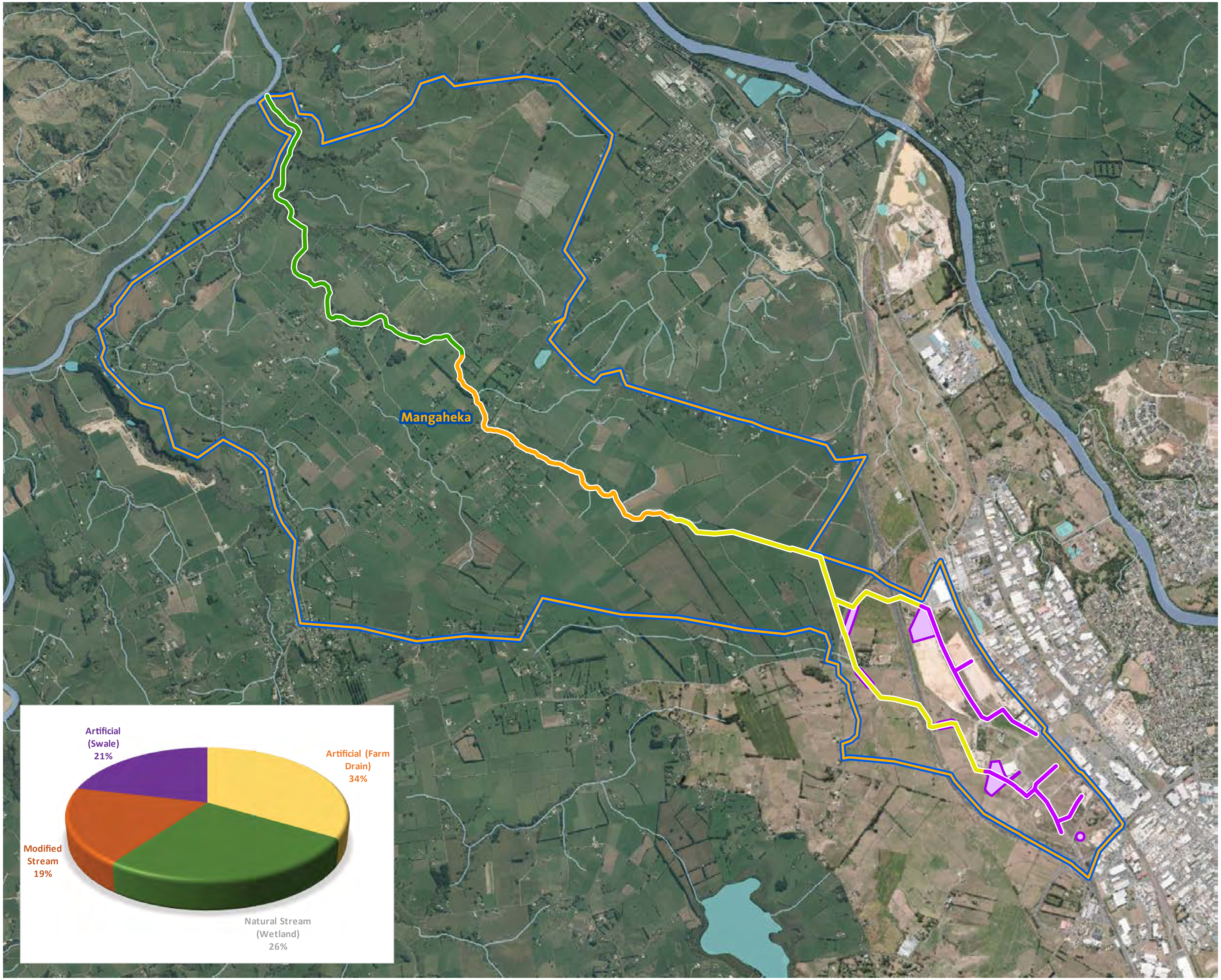
File Ref: T15161_Figure4_Hydrography.mxd



Legend

Stormwater Centreline

- Artificial (Farm Drain)
- Artificial (Swale)
- Modified Stream
- Natural Stream (Wetland)
- Topographic Catchment Boundary
- Artificial Ponds
- River Centreline - NZTopo50
- Lake - NZTopo50
- Pond - NZTopo50
- River - NZTopo50

0 1.2 km

1:30,000 @ A3

Sources: Waikato Regional Council (WRAPS 2012), Land Information New Zealand, AECOM Limited.

Projection: NZGD 2000 New Zealand Transverse Mercator

MANGAHEKA ICMP

Figure 4
Hydrography

Date: 23 June 2016
Revision: 0

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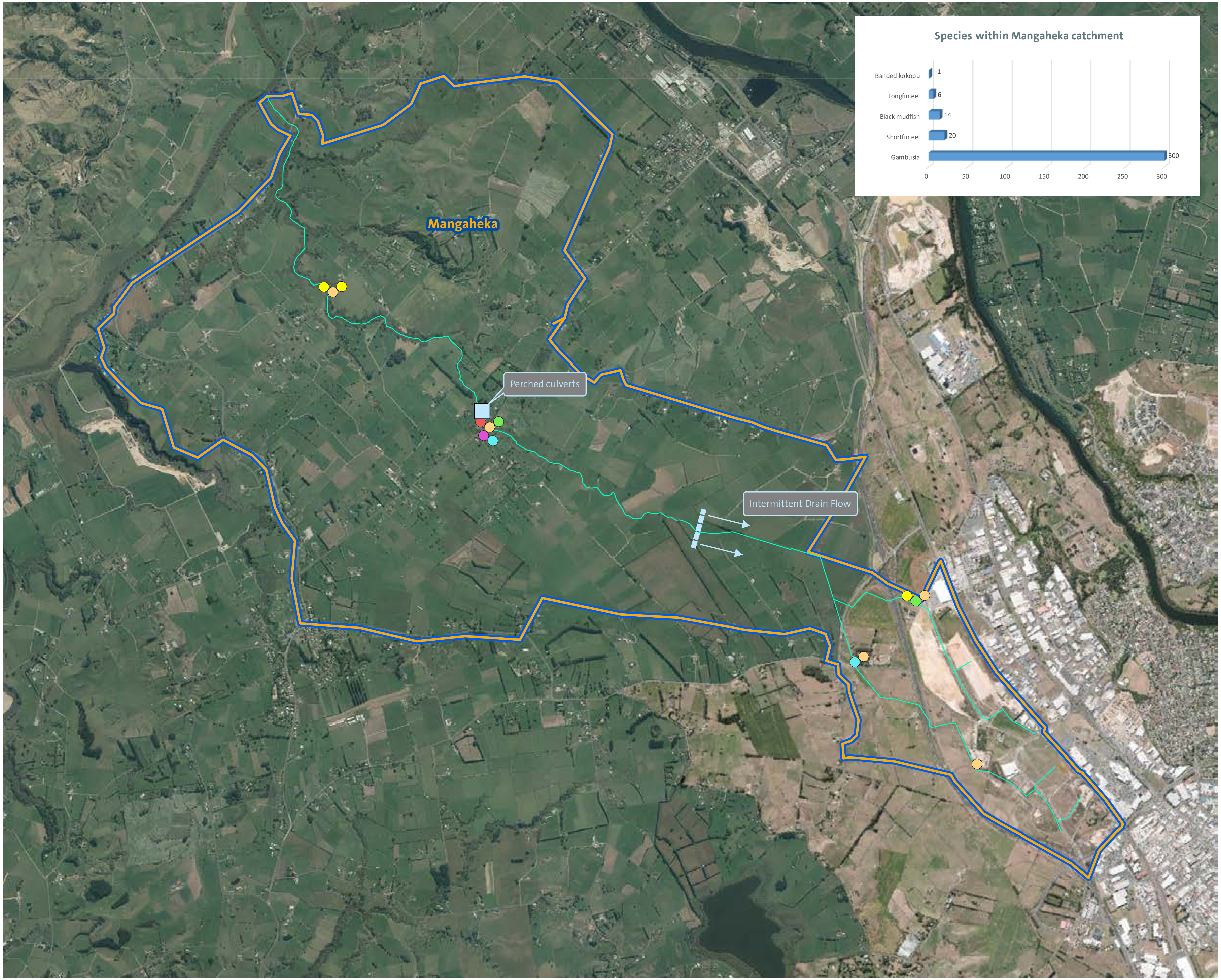
File Ref: T15161_Figure5_Fish.mxd



Legend

Freshwater Fish Database records

- Shortfin eel
- Longfin eel
- Banded kokopu
- Gambusia
- Black mudfish
- No species recorded
- Potential and actual fish passage barrier

0 1.2 km

1:30,000 @ A3

Sources: Waikato Regional Council (WRAPS 2012), Land Information New Zealand, AECOM Limited.

Projection: NZGD 2000 New Zealand Transverse Mercator

MANGAHEKA ICMP

Figure 5
Freshwater Fish

Date: 24 June 2016
Revision: 0

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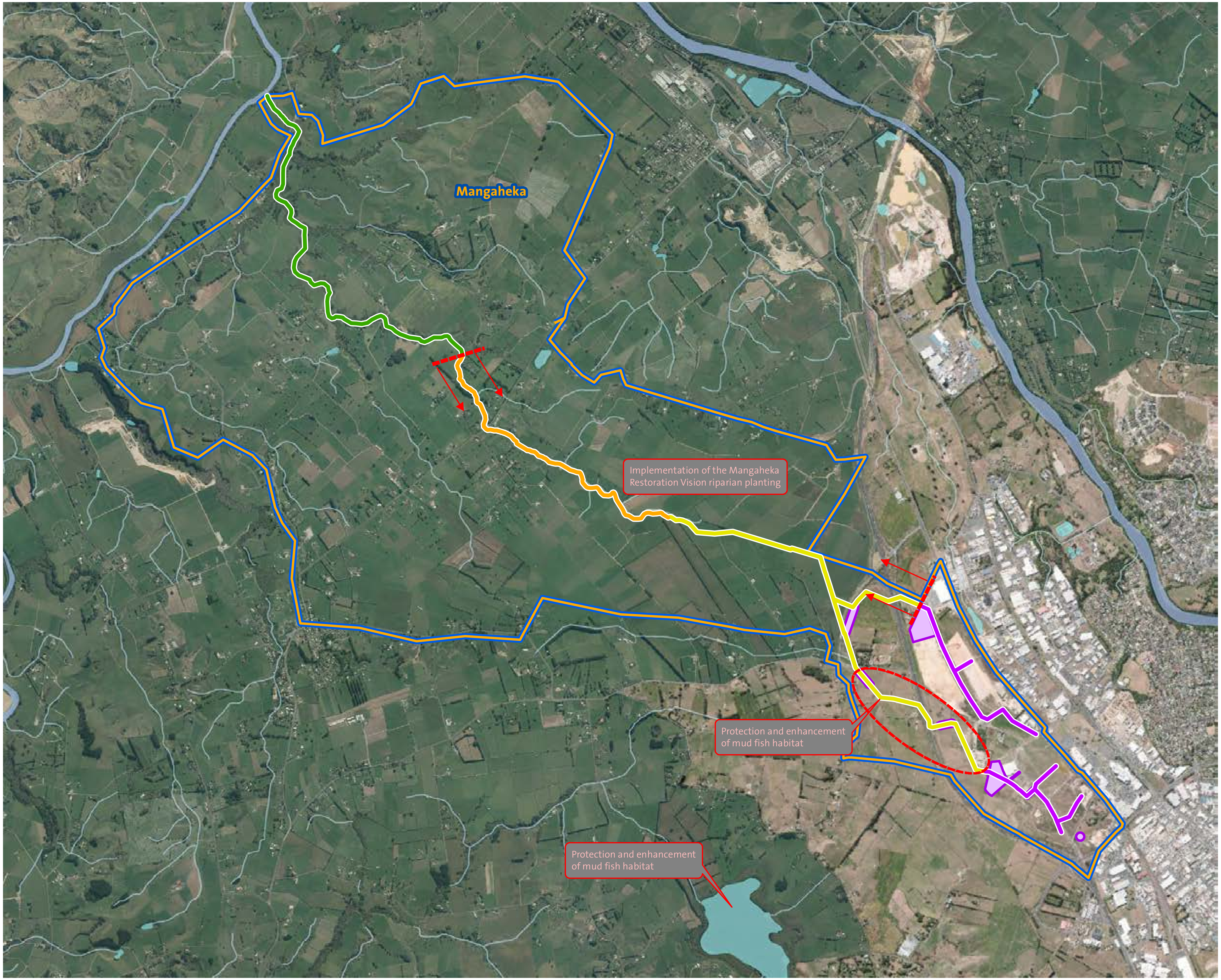
File Ref: T15161_Figure6_EcoEnhanceOps.mxd



Legend

Stormwater Centreline

- Artificial (Farm Drain)
- Artificial (Swale)
- Modified Stream
- Natural Stream (Wetland)
- Topographic Catchment Boundary
- Artificial Ponds
- River Centreline - NZTopo50
- Lake - NZTopo50
- Pond - NZTopo50
- River - NZTopo50

0 1.2 km

1:30,000 @ A3

Sources: Waikato Regional Council (WRAPS 2012), Land Information New Zealand, AECOM Limited.

Projection: NZGD 2000 New Zealand Transverse Mercator

MANGAHEKA ICMP

Figure 6
Ecological Enhancement Opportunities

Date: 23 June 2016
Revision: 0

Plan Prepared for the Hamilton City Council
by Boffa Miskell Limited
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Appendix 2 – Water and Sediment Analysis Reports

Hill Laboratories
BETTER TESTING BETTER RESULTS

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1 Clyde Street
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Hamilton 3240, New Zealand

Tel +64 7 858 2000
Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Boffa Miskell Limited	**Lab No:**	1018512 SPv1
Contact:	S Bathgate	**Date Registered:**	20-Jun-2012
	C/- Boffa Miskell Limited	**Date Reported:**	02-Jul-2012
	PO Box 13373	**Quote No:**	49903
	TAURANGA 3141	**Order No:**	
		Client Reference:	SW and Fresh Water Sedime
		Submitted By:	S Bathgate

Sample Type: Sediment

Sample Name:		Ruffell Rd 1 20-Jun-2012 10:50 am	Te Kowhai Rd 1 20-Jun-2012 11:20 am	Murray Culvert 1 20-Jun-2012 12:00 pm	Clarke Boundary 1 20-Jun-2012 1:00 pm	
Lab Number:		1018512.1	1018512.2	1018512.3	1018512.4	
Individual Tests						
Total Recoverable Iron	mg/kg dry wt	6,100	37,000	16,300	12,300	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	5	20	12	13	-
Total Recoverable Cadmium	mg/kg dry wt	< 0.10	1.05	0.23	0.38	-
Total Recoverable Chromium	mg/kg dry wt	4	10	6	7	-
Total Recoverable Copper	mg/kg dry wt	4	51	9	26	-
Total Recoverable Lead	mg/kg dry wt	4.9	15.7	12.3	14.1	-
Total Recoverable Nickel	mg/kg dry wt	2	7	3	3	-
Total Recoverable Zinc	mg/kg dry wt	28	162	54	33	-

Sample Type: Aqueous

Sample Name:		Ruffell Rd 1 20-Jun-2012 10:50 am	Te Kowhai Rd 1 20-Jun-2012 11:20 am	Murray Culvert 1 20-Jun-2012 12:00 pm	Clarke Boundary 1 20-Jun-2012 1:00 pm	
Lab Number:		1018512.5	1018512.6	1018512.7	1018512.8	
Individual Tests						
Turbidity	NTU	18.2	18.0	23	12.9	-
pH	pH Units	6.5	6.4	6.4	5.8	-
Total Suspended Solids	g/m^3	10	13	13	6	-
Total Copper	g/m^3	0.0022	0.0028	0.0026	0.0025	-
Total Iron	g/m^3	1.04	1.61	1.87	2.1	-
Total Lead	g/m^3	0.00032	< 0.00011	0.00019	0.00024	-
Total Zinc	g/m^3	0.069	0.023	0.033	0.0175	-
Total Nitrogen	g/m^3	4.2	2.5	4.6	1.66	-
Nitrate-N + Nitrite-N	g/m^3	3.1	1.39	3.4	0.52	-
Total Kjeldahl Nitrogen (TKN)	g/m^3	1.08	1.12	1.21	1.14	-
Dissolved Reactive Phosphorus	g/m^3	0.005	0.012	0.007	0.005	-
Total Phosphorus	g/m^3	0.056	0.106	0.077	0.058	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	$g\ O_2/m^3$	< 2	< 2	< 2	< 2	-
Escherichia coli	cfu / 100mL	430	700 #1	900 #1	1,100 #1	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	< 0.15	< 0.15	< 0.10	-
C10 - C14	g/m^3	< 0.2	< 0.4	< 0.4	< 0.2	-
C15 - C36	g/m^3	< 0.4	< 0.8	< 0.8	< 0.4	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	< 1.4	< 1.4	< 0.7	-

Analyst's Comments

Please interpret these microbiological results with caution as the sample temperature was >10 °C on receipt in the lab. Samples are required to be less than 10 °C (but not frozen).

#1 Statistically estimated count based on the theoretical countable range for the stated method.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Samples
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1-4
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	-	1-4
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1-4
Total Recoverable Iron	Dried sample, sieved as specified (if required). Nitric/Hydrochloric acid digestion, ICP-MS, screen level. US EPA 200.2.	40 mg/kg dry wt	1-4

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Samples
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	5-8
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	5-8
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 21st ed. 2005.	-	5-8
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	5-8
Total Phosphorus Digestion	Acid persulphate digestion.	-	5-8
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 21st ed. 2005.	0.05 NTU	5-8
pH	pH meter. APHA 4500-H^+ B 21st ed. 2005.	0.1 pH Units	5-8
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 21st ed. 2005.	3 g/m^3	5-8
Total Copper	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005 / US EPA 200.8.	0.00053 g/m^3	5-8
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.021 g/m^3	5-8
Total Lead	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005 / US EPA 200.8.	0.00011 g/m^3	5-8
Total Zinc	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 21st ed. 2005 / US EPA 200.8.	0.0011 g/m^3	5-8
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N.	0.05 g/m^3	5-8
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I (Modified) 21st ed. 2005.	0.002 g/m^3	5-8
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} C. (modified) 4500 NH_3 F (modified) 21st ed. 2005.	0.10 g/m^3	5-8
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005.	0.004 g/m^3	5-8
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 21st ed. 2005.	0.004 g/m^3	5-8
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. Analysed at Hill Laboratories - Microbiology; 1 Clow Place, Hamilton. APHA 5210 B 21st ed. 2005.	2 g O_2/m^3	5-8
Escherichia coli	Membrane filtration, Count on mFC agar, Incubated at 44.5°C for 22 hours, MUG Confirmation. Analysed at Hill Laboratories - Microbiology; 1 Clow Place, Hamilton. APHA 9222 G, 21st ed. 2005.	1 cfu / 100mL	5-8

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental Division

Hill Laboratories
BETTER TESTING BETTER RESULTS

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Fax +64 7 858 2001
Email mail@hill-labs.co.nz
Web www.hill-labs.co.nz

ANALYSIS REPORT

Client:	Boffa Miskell Limited	**Lab No:**	1570413 SPv1
Contact:	L Saunders	**Date Registered:**	19-Apr-2016
	C/- Boffa Miskell Limited	**Date Reported:**	02-May-2016
	PO Box 13373	**Quote No:**	76181
	Tauranga 3141	**Order No:**	T15161
		Client Reference:	Mangaheka Stream
		Submitted By:	Kieran Miller

Sample Type: Sediment

Sample Name:		Mangaheka 1 (Sed) 19-Apr-2016 11:20 am				
Lab Number:		1570413.1				
Individual Tests						
Total Organic Carbon*	g/100g dry wt	0.70	-	-	-	-
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Recoverable Arsenic	mg/kg dry wt	8	-	-	-	-
Total Recoverable Cadmium	mg/kg dry wt	0.16	-	-	-	-
Total Recoverable Chromium	mg/kg dry wt	3	-	-	-	-
Total Recoverable Copper	mg/kg dry wt	2	-	-	-	-
Total Recoverable Lead	mg/kg dry wt	3.2	-	-	-	-
Total Recoverable Nickel	mg/kg dry wt	< 2	-	-	-	-
Total Recoverable Zinc	mg/kg dry wt	34	-	-	-	-

Sample Type: Aqueous

Sample Name:		Mangaheka 1 (SW) 19-Apr-2016 11:20 am				
Lab Number:		1570413.2				
Individual Tests						
Turbidity	NTU	6.2	-	-	-	-
pH	pH Units	6.9	-	-	-	-
Total Suspended Solids	g/m³	5	-	-	-	-
Dissolved Aluminium	g/m³	0.010	-	-	-	-
Total Aluminium	g/m³	0.022	-	-	-	-
Dissolved Iron	g/m³	0.91	-	-	-	-
Total Iron	g/m³	2.4	-	-	-	-
Total Nitrogen	g/m³	0.44	-	-	-	-
Total Kjeldahl Nitrogen (TKN)	g/m³	0.38	-	-	-	-
Total Phosphorus	g/m³	0.035	-	-	-	-
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	g O_2/m³	< 2	-	-	-	-
Faecal Coliforms	cfu / 100mL	410 #1	-	-	-	-
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Dissolved Arsenic	g/m³	< 0.0010	-	-	-	-
Dissolved Cadmium	g/m³	< 0.00005	-	-	-	-
Dissolved Chromium	g/m³	< 0.0005	-	-	-	-
Dissolved Copper	g/m³	< 0.0005	-	-	-	-
Dissolved Lead	g/m³	< 0.00010	-	-	-	-
Dissolved Nickel	g/m³	< 0.0005	-	-	-	-
Dissolved Zinc	g/m³	< 0.0010	-	-	-	-

Sample Type: Aqueous						
Sample Name:		Mangaheka 1 (SW) 19-Apr-2016 11:20 am				
Lab Number:		1570413.2				
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn						
Total Arsenic	g/m^3	< 0.0011	-	-	-	-
Total Cadmium	g/m^3	< 0.000053	-	-	-	-
Total Chromium	g/m^3	< 0.00053	-	-	-	-
Total Copper	g/m^3	< 0.00053	-	-	-	-
Total Lead	g/m^3	< 0.00011	-	-	-	-
Total Nickel	g/m^3	< 0.00053	-	-	-	-
Total Zinc	g/m^3	0.0012	-	-	-	-
Nutrient Profile						
Total Ammoniacal-N	g/m^3	0.064	-	-	-	-
Nitrite-N	g/m^3	0.004	-	-	-	-
Nitrate-N	g/m^3	0.055	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.058	-	-	-	-
Dissolved Reactive Phosphorus	g/m^3	0.005	-	-	-	-
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq						
Acenaphthene	g/m^3	< 0.00010	-	-	-	-
Acenaphthylene	g/m^3	< 0.00010	-	-	-	-
Anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]anthracene	g/m^3	< 0.00010	-	-	-	-
Benzo[a]pyrene (BAP)	g/m^3	< 0.00010	-	-	-	-
Benzo[b]fluoranthene + Benzo[j] fluoranthene	g/m^3	< 0.00010	-	-	-	-
Benzo[g,h,i]perylene	g/m^3	< 0.00010	-	-	-	-
Benzo[k]fluoranthene	g/m^3	< 0.00010	-	-	-	-
Chrysene	g/m^3	< 0.00010	-	-	-	-
Dibenzo[a,h]anthracene	g/m^3	< 0.00010	-	-	-	-
Fluoranthene	g/m^3	< 0.00010	-	-	-	-
Fluorene	g/m^3	< 0.0002	-	-	-	-
Indeno(1,2,3-c,d)pyrene	g/m^3	< 0.00010	-	-	-	-
Naphthalene	g/m^3	< 0.0005	-	-	-	-
Phenanthrene	g/m^3	< 0.0004	-	-	-	-
Pyrene	g/m^3	< 0.0002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.10	-	-	-	-
C10 - C14	g/m^3	< 0.2	-	-	-	-
C15 - C36	g/m^3	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	-	-	-	-

Analyst's Comments

[#1] Please interpret this result with caution as the sample was > 8 °C on receipt at the lab. The sample temperature is recommended by APHA to be less than 8 °C on receipt at the laboratory (but not frozen). However, it is acknowledged that samples that are transported quickly to the laboratory after sampling, may not have been cooled to this temperature.

SUMMARY OF METHODS

The following table(s) gives a brief description of the methods used to conduct the analyses for this job. The detection limits given below are those attainable in a relatively clean matrix. Detection limits may be higher for individual samples should insufficient sample be available, or if the matrix requires that dilutions be performed during analysis.

Sample Type: Sediment

Test	Method Description	Default Detection Limit	Sample No
Environmental Solids Sample Preparation	Air dried at 35°C and sieved, <2mm fraction. Used for sample preparation. May contain a residual moisture content of 2-5%.	-	1
Heavy metal screen level As,Cd,Cr,Cu,Ni,Pb,Zn	Dried sample, <2mm fraction. Nitric/Hydrochloric acid digestion, ICP-MS, screen level.	0.10 - 4 mg/kg dry wt	1
Total Recoverable digestion	Nitric / hydrochloric acid digestion. US EPA 200.2.	-	1
Total Organic Carbon*	Acid pretreatment to remove carbonates present followed by Catalytic Combustion (900°C, O2), separation, Thermal Conductivity Detector [Elementar Analyser].	0.05 g/100g dry wt	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Heavy metals, dissolved, trace As,Cd,Cr,Cu,Ni,Pb,Zn	0.45µm filtration, ICP-MS, trace level. APHA 3125 B 21st ed. 2005.	0.00005 - 0.0010 g/m^3	2
Heavy metals, totals, trace As,Cd,Cr,Cu,Ni,Pb,Zn	Nitric acid digestion, ICP-MS, trace level	0.000053 - 0.0011 g/m^3	2
Nutrient Profile		0.0010 - 0.010 g/m^3	2
Polycyclic Aromatic Hydrocarbons Screening in Water, By Liq/Liq	Liquid / liquid extraction, SPE (if required), GC-MS SIM analysis [KBIs:4736,2695]	0.00010 - 0.0005 g/m^3	2
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m^3	2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	2
Total Digestion	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	2
Total Kjeldahl Digestion	Sulphuric acid digestion with copper sulphate catalyst.	-	2
Total Phosphorus Digestion	Acid persulphate digestion.	-	2
Turbidity	Analysis using a Hach 2100N, Turbidity meter. APHA 2130 B 22nd ed. 2012.	0.05 NTU	2
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	2
Total Suspended Solids	Filtration using Whatman 934 AH, Advantec GC-50 or equivalent filters (nominal pore size 1.2 - 1.5µm), gravimetric determination. APHA 2540 D 22nd ed. 2012.	3 g/m^3	2
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	2
Dissolved Aluminium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.003 g/m^3	2
Total Aluminium	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012 / US EPA 200.8.	0.0032 g/m^3	2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	2
Total Iron	Nitric acid digestion, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.021 g/m^3	2
Total Nitrogen	Calculation: TKN + Nitrate-N + Nitrite-N. Please note: The Default Detection Limit of 0.05 g/m^3 is only attainable when the TKN has been determined using a trace method utilising duplicate analyses. In cases where the Detection Limit for TKN is 0.10 g/m^3, the Default Detection Limit for Total Nitrogen will be 0.11 g/m^3.	0.05 g/m^3	2
Total Ammoniacal-N	Filtered sample. Phenol/hypochlorite colorimetry. Discrete Analyser. (NH_4-N = NH_4+-N + NH_3-N). APHA 4500-NH_3 F (modified from manual analysis) 22nd ed. 2012.	0.010 g/m^3	2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	2
Total Kjeldahl Nitrogen (TKN)	Total Kjeldahl digestion, phenol/hypochlorite colorimetry. Discrete Analyser. APHA 4500-N_{org} D. (modified) 4500 NH_3 F (modified) 22nd ed. 2012.	0.10 g/m^3	2
Dissolved Reactive Phosphorus	Filtered sample. Molybdenum blue colorimetry. Discrete Analyser. APHA 4500-P E (modified from manual analysis) 22nd ed. 2012.	0.004 g/m^3	2
Total Phosphorus	Total phosphorus digestion, ascorbic acid colorimetry. Discrete Analyser. APHA 4500-P B & E (modified from manual analysis) 22nd ed. 2012. Also modified to include the use of a reductant to eliminate interference from arsenic present in the sample. NWASCA, Water & soil Miscellaneous Publication No. 38, 1982.	0.004 g/m^3	2
Carbonaceous Biochemical Oxygen Demand ($cBOD_5$)	Incubation 5 days, DO meter, nitrification inhibitor added, dilutions, seeded. Analysed at Hill Laboratories - Microbiology; 1 Clow Place, Hamilton. APHA 5210 B (modified) 22nd ed. 2012.	2 g O_2/m^3	2
Faecal Coliforms	Membrane Filtration, Count on mFC agar, Incubated at 44.5°C for 22 hours, Confirmation. Analysed at Hill Laboratories - Microbiology; 1 Clow Place, Hamilton. APHA 9222 D, 22nd ed. 2012.	1 cfu / 100mL	2

These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

This report must not be reproduced, except in full, without the written consent of the signatory.

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental Division

Appendix 3 – Aquatic Macroinvertebrate Results

Rotokauri Structure Plan Industrial Development

Aquatic Invertebrate Assessment

20 June 2012

Boffa Miskell

Document Quality Assurance

<table>
<tr><td colspan="3">Bibliographic reference for citation:
Boffa Miskell Limited 2012. Rotokauri Structure Plan Industrial Development: Aquatic Invertebrate Assessment. Report prepared by Boffa Miskell Limited for Louise Clark (Boffa Miskell Ltd).</td></tr>
<tr><td>Prepared by:</td><td>Sharon De Luca
Principal/Ecologist
Boffa Miskell Limited</td><td></td></tr>
<tr><td>Reviewed by:</td><td>Louise Clark
Associate Principal/Ecologist
Boffa Miskell Limited</td><td></td></tr>
<tr><td>Status: FINAL</td><td>Revision / version: 0</td><td>Issue date: 20 June 2012</td></tr>
<tr><td colspan="3">Use and Reliance
This report has been prepared by Boffa Miskell Limited on the specific instructions of our Client. It is solely for our Client's use for the purpose for which it is intended in accordance with the agreed scope of work. Boffa Miskell does not accept any liability or responsibility in relation to the use of this report contrary to the above, or to any person other than the Client. Any use or reliance by a third party is at that party's own risk. Where information has been supplied by the Client or obtained from other external sources, it has been assumed that it is accurate, without independent verification, unless otherwise indicated. No liability or responsibility is accepted by Boffa Miskell Limited for any errors or omissions to the extent that they arise from inaccurate information provided by the Client or any external source.</td></tr>
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File ref:
T10093_Aquatic_Invertebrate_Report_2012

1.0 Introduction

1.1 Background

Benthic macroinvertebrate samples were collected from soft bottom drains and streams by Stephanie Bathgate of Boffa Miskell on 20 June 2012. Boffa Miskell processed the samples and report below the results of taxonomic composition.

1.2 Objectives

The objectives of this report are to present the methods and results of aquatic macroinvertebrate sample processing.

2.0 Laboratory Analysis

2.1 Macroinvertebrate Samples

2.1.1 Processing

All samples were passed through a 500µm sieve to remove fine material. Contents of the sieve were then placed in a white tray and macroinvertebrates were identified under a dissecting microscope (10-40x) using the keys of Winterbourn *et al.* (2006) and NIWA's online resources.

Macroinvertebrate samples collected quantitatively were processed according to protocol 'P3: Full count with subsampling option' outlined in the Ministry for the Environment's 'Protocols for sampling macroinvertebrates in wadeable streams' (Stark *et al.* 2001).

2.2 Data Summaries and Metric Calculations

For each site, benthic macroinvertebrate community health was assessed by determining the following characteristics:

Number of taxa: Reflects health of the community through a measurement of the variety of the taxa present. Taxonomic richness generally increases with increasing habitat diversity.

Number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa: These insect groups are generally dominated by pollution sensitive taxa. In stony bed rivers, this index usually increases with improved water quality and increased habitat diversity.

Macroinvertebrate Community Index (MCI) for soft-bottomed streams (MCI-sb)(Stark and Maxted 2007): These biotic indices have recently been developed specifically for use in soft-bottomed streams. The original MCI and SQMCI were developed for use in hard-bottomed streams based on sampling macroinvertebrates from riffle or run habitats, however their use has often been extended through a wide range of habitats including soft-bottomed areas. The soft-bottomed indices use the same principles as the hard-bottomed MCI and SQMCI indices, however new taxon-specific tolerance scores (between 1 and 10) have been derived specifically for soft-bottomed streams.

The MCI-sb uses the occurrence of specific macroinvertebrate taxa to determine the level of organic enrichment in a stream. Taxon scores are between 1 and 10, 1 representing species highly tolerant to organic pollution (e.g. worms and some dipteran species) and 10 representing species highly sensitive to organic pollution (e.g. most mayflies and stoneflies). A site score is obtained by summing the scores of individual taxa and dividing this total by the number of taxa present at the site. These scores can be interpreted in comparison with national standards (Table 2). For example, a low site score (e.g. 40) represents 'probable severe pollution' and a high score (e.g. 140) represents very 'clean' conditions.

$$\text{MCI} = \frac{\text{Sum of taxa scores}}{\text{Number of scoring taxa}} \times 20$$

Quantitative Macroinvertebrate Community Index (QMCI) (Stark 1985): The QMCI uses a similar approach as the MCI but weights each taxa score based on how abundant the taxa is within the community. Site scores range between 0 and 10. As for MCI, QMCI scores can be interpreted in the context of national standards (Table 2). QMCI scores were calculated for samples collected quantitatively and processed according to protocol 'P3: Full count with subsampling option'.

$$\text{QMCI} = \sum_{i=1}^{i=S} \frac{(\boldsymbol{n_i} \times \boldsymbol{a_1})}{\boldsymbol{N}}$$

Where S = the total number of taxa in the sample, n_i is the number of invertebrates in the ith taxa, a_i is the score for the *i*th taxa, and N is the total number of invertebrates in the entire sample.

Table 2 *Interpretation of macroinvertebrate community index values from Boothroyd and Stark (2000) (Quality class A) and Stark and Maxted (2007) (Quality class B).*

Quality Class A	Quality Class B	MCI-sb	QMCI-sb, SQMCI-sb
Clean water	Excellent	> 120	> 6.00
Doubtful quality	Good	100 – 119	5.00 – 5.99
Probable moderate pollution	Fair	80 – 99	4.00 – 4.99
Probable severe pollution	Poor	< 80	< 4.00

3.0 Results

3.1 Macroinvertebrate results

The macroinvertebrate results are included below (Tables 4) and have also been forwarded to Louise Clark (Boffa Miskell Ltd) in electronic form.

Table 4 *Macroinvertebrate data.*

Taxon	MCI soft bottom	Murray Culvert			Te Kowhai Road		
COELENTERATA		Abundance	MCI	QMCI	Abundance	MCI	QMCI
Hydra	**1.6**	2	1.6	0.02		0	0.00
PLATYHELMINTHES	**0.9**	1	0.9	0.01	21	0.9	0.04
NEMATODA	**3.1**	1	3.1	0.02		0	0.00
OLIGOCHAETA	**3.8**	69	3.8	1.46	273	3.8	2.21
HIRUDINEA	**1.2**		0	0.00	2	1.2	0.01
CRUSTACEA							
Amphipoda	**5.5**		0	0.00	6	5.5	0.07
Ostracoda	**1.9**	3	1.9	0.03	3	1.9	0.01
INSECTA							
Plecoptera							
Trichoptera							
Hudsonema	**6.5**		0	0.00	1	6.5	0.01
Oxyethira	**1.2**	22	1.2	0.15		0	0.00
Odonata							
Austrolestes	**0.7**	2	0.7	0.01		0	0.00
Xanthocnemis	**1.2**	15	1.2	0.10	1	1.2	0.00
Hemiptera							
Microvelia	**4.6**		0	0.00	1	4.6	0.01
Sigara	**2.4**	18	2.4	0.24	2	2.4	0.01
Coleoptera							
Dytiscidae	**0.4**		0	0.00	1	0.4	0.00
Hydrophilidae	**8**		0	0.00	3	8	0.05
Liodessus	**4.9**		0	0.00	1	4.9	0.01
Diptera							
Ceratopogonidae	**6.2**		0	0.00	1	6.2	0.01
Chironominae	**3.8**	1	3.8	0.02		0	0.00
Chironomus	**3.4**		0	0.00	11	3.4	0.08
Hexatomini	**6.7**	1	6.7	0.04	6	6.7	0.09
Muscidae	**1.6**	1	1.6	0.01		0	0.00
Orthocladiinae	**3.2**		0	0.00	10	3.2	0.07

Stratiomyidae	**4.2**		0	0.00	1	4.2	0.01
Tanypodinae	**6.5**		0	0.00	7	6.5	0.10
Tanytarsus	**-**		0	0.00	23	-	0.00
Zelandotipula	**3.6**		0	0.00	3	3.6	0.02
Lepidoptera							
Collembola	**5.3**	1	5.3	0.03	1	5.3	0.01
ACARINA	**5.2**	1	5.2	0.03	1	5.2	0.01
MOLLUSCA							
Gyraulus	**1.7**	1	1.7	0.01		0	0.00
Physa = Physella	**0.1**	2	0.1	0.00	5	0.1	0.00
Potamopyrgus	**2.1**	38	2.1	0.44	3	2.1	0.01
Sphaeriidae	**2**	1	2	0.01	83	2	0.35

Total Abundance	**180**	**470**
Taxonomic richness	**18**	**25**
No. of Insect Taxa	**8**	**16**
No of EPT Taxa	**1**	**1**
%EPT abundance	**12.2**	**0.2**
MCI-sb	**50.3**	**71.8**
QMCI-sb	**2.6**	**3.2**

4.0 References

Boothroyd, I.G. and Stark, J.D. 2000. *Use of invertebrates in monitoring.* Chapter 14 in Collier, K.J. and Winterbourn, M.J. eds. *New Zealand stream invertebrates: ecology and implications for management.* New Zealand Limnological Society, Christchurch. Pp. 344-373.

Stark, J.D. 1993. *Performance of the Macroinvertebrate Community Index: effects of sampling method, sample replication, water depth, current velocity, and substratum on index values.* New Zealand Journal of Marine and Freshwater Research. 27: 463-478.

Stark J.D. and Maxted, J.R. 2007. *A biotic index for New Zealand's soft-bottomed streams.* New Zealand Journal of Marine and Freshwater Research. 41: 43-61.

Stark, J.D., Boothroyd, I.K.G., Harding, J.S., Maxted, J.R. and Scarsbrook, M.R. 2001. *Protocols for sampling macroinvertebrates in wadeable stream.* New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment.

Winterbourn, M.J., Gregson, K.L.D. and Dolphin, C.H. 2006. *Guide to the aquatic insects of New Zealand.* Bulletin of the Entomological Society of New Zealand. 14.

T15161 (Mangaheka)

Summary of Freshwater Macroinvertebrate Sample Processing & Results

April 2016

ryderconsulting
environment + planning + project management

T15161 (Mangaheka)

Summary of Freshwater Macroinvertebrate Sample Processing & Results

April 2016

prepared for Boffa Miskell by Ryder Consulting Limited

Ben Ludgate, MSc.

Document version: 25/05/16

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Table of Contents

1. Introduction

Preserved benthic macroinvertebrate samples were provided to Ryder Consulting Limited by Boffa Miskell. Boffa Miskell staff collected these samples in April 2016. Ryder Consulting Limited was engaged to process the samples, and report the results of taxonomic composition and abundance.

2. Laboratory Analysis

2.1 Processing

In the laboratory, the samples were passed through a 500 μm sieve to remove fine material. Contents of the sieve were then placed in a white tray and macroinvertebrates were identified under a dissecting microscope (10-40x) using criteria from Winterbourn *et al.* (2006).

2.2 Data summaries and metric calculations

For each site, benthic macroinvertebrate community health was assessed by determining the following characteristics:

Number of invertebrates: The total number of individuals from all taxa groups per sample. Invertebrate abundance gives an indication of benthic production.

Number of taxa: A measurement of the number of taxa present.

Number of Ephemeroptera, Plecoptera and Trichoptera (EPT) taxa, percentage of the total number of taxa comprising EPT taxa (% EPT taxa), and percentage of the total abundance comprising EPT taxa (% EPT abundance): These insect groups are generally dominated by invertebrates that are indicative of higher quality conditions. In stony bed rivers, these indexes usually increase with improved water quality and increased habitat diversity.

Macroinvertebrate Community Index for soft-bottomed streams (MCI-sb) and Quantitative MCI for soft-bottomed streams (QMCI-sb) (Stark and Maxted 2007): These biotic indices have been developed specifically for use in soft-bottomed streams. The original MCI and QMCI were developed for use in hard-bottomed streams based on sampling macroinvertebrates from riffle or run habitats, however their use has often been extended through a wide range of habitats including soft-bottomed areas. The soft-bottomed indices use the same principles as the hard-bottomed MCI and QMCI indices, however new taxon-specific tolerance scores (between 1 and 10) have been derived specifically for soft-bottomed streams (Stark and Maxted 2007).

The MCI-sb site score is obtained by summing the scores of individual taxa and dividing this total by the number of taxa present at the site.

$$\text{MCI-sb} = \left(\frac{\text{Sum of taxa scores}}{\text{Number of scoring taxa}}\right) \times 20$$

The QMCI-sb is calculated as:

$$\text{QMCI-sb} = \sum_{i=1}^{i=S} \frac{(n_i \times a_i)}{N}$$

Where S = the total number of taxa in the sample, n_i is the number of invertebrates in the ith taxa, a_i is the score for the *i*th taxa, and N is the total number of invertebrates for the entire sample.

As for MCI and QMCI, MCI-sb and QMCI-sb scores can be interpreted in the context of national standards (Table 1).

Table 1 *Interpretation of macroinvertebrate community index values from Boothroyd and Stark (2000) (Quality class A) and Stark and Maxted (2007) (Quality class B).*

Quality Class A	Quality Class B	MCI-sb	QMCI-sb
Clean water	Excellent	≥ 120	≥ 6.00
Doubtful quality	Good	100 – 119	5.00 – 5.99
Probable moderate pollution	Fair	80 – 99	4.00 – 4.99
Probable severe pollution	Poor	< 80	< 4.00

3. Results

3.1 Macroinvertebrate results

The macroinvertebrate results are included below and have also been forwarded to Boffa Miskell in electronic form (Excel spreadsheet).

		Mangaheka		
TAXON	**MCI-sb score**	**1A**	**1B**	**1C**
ACARINA	5.2		1	
COLEOPTERA				
Hydraenidae	6.7	1	1	
Hydrophilidae	8.0			1
COLLEMBOLA	5.3	2		
CRUSTACEA				
Cladocera (*Simocephalus*)	0.7			6
Copepoda (Cyclopoida)	2.4			217
Ostracoda	1.9	67	3	19
Paracalliope fluviatilis	5.5	4	12	13
DIPTERA				
Chironomus species	3.4			1
Orthocladiinae	3.2	1		5
HEMIPTERA				
Sigara species	2.4	4		
MOLLUSCA				
Lymnaeidae	1.2	2	3	3
Physa / Physella species	0.1	9		3
Potamopyrgus antipodarum	2.1	22	13	18
Sphaeriidae	2.9	1	1	
ODONATA				
Xanthocnemis zealandica	1.2	1	1	1
OLIGOCHAETA	3.8		4	1
PLATYHELMINTHES	0.9	249	112	47
TRICHOPTERA				
Oxyethira albiceps	1.2	55	39	18
Number of invertebrates		418	190	353
Number of taxa		13	11	14
Number of EPT taxa		1	1	1
% EPT taxa		8	9	7
% EPT abundance		13	21	5
MCI-sb score		53.2	59.3	50.9
QMCI-sb score		1.3	1.5	2.2

4. References

Boothroyd, I.G. and Stark, J.D. 2000. Use of invertebrates in monitoring. Chapter 14 in Collier, K.J. and Winterbourn, M.J. eds. New Zealand stream invertebrates: ecology and implications for management. New Zealand Limnological Society, Christchurch. Pp. 344-373.

Stark, J.D. and Maxted, J.R. 2007. A biotic index for New Zealand's soft-bottomed streams. *New Zealand Journal of Marine and Freshwater Research*. **41**: 43-61.

Winterbourn, M.J., Gregson, K.L.D. and Dolphin, C.H. 2006. Guide to the aquatic insects of New Zealand. *Bulletin of the Entomological Society of New Zealand*. **14**.

Appendix F

Assessment of Environmental Effects

Report

Mangaheka ICMP - Assessment of Environmental Effects

Prepared for Hamilton City Council

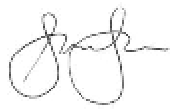
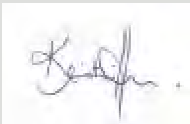
Prepared by CH2M Beca Ltd

31 August 2018

Revision History

Revision Nº	Prepared By	Description	Date
0	**Dominic Adams**	Draft for client review	10 July 2018
1	**Dominic Adams**	Final for Issue	31 August 2018

Document Acceptance

Action	Name	Signed	Date
Prepared by	**Dominic Adams**		24 August 2018
Reviewed by	**Anna Lewis**		31 August 2018
Approved by	**Kristina Hermens**		31 August 2018
on behalf of	CH2M Beca Ltd		

Executive Summary

This Assessment of Environmental Effects ("AEE") assesses the effects on the Mangaheka Stream Catchment ("the Catchment") of the planned stormwater diversion and discharge activities undertaken in accordance with the Mangaheka Integrated Catchment Management Plan ("the ICMP"). This AEE is intended to satisfy the requirements of the following conditions of the Hamilton City Council's Comprehensive Stormwater Discharge Consent ("the CSWDC"):

- Condition 30(g) requires an assessment of the environmental effects of all new stormwater diversion and discharge activities on the catchment in such detail as corresponds with the scale and significance of the effects that these activities will have on the catchment. The headings used below in section 2 are based on the requirements set out in condition 30(g) of the CSWDC on which the effects of the activities are to be assessed
- Condition 30(h) requires an assessment of the cumulative environmental effects of all new stormwater diversion and discharge activities on the catchment over time

This AEE is based on technical assessments undertaken by environmental specialists in support of the development of the ICMP. The AEE also identifies seven objectives of the Waikato River Vision and Strategy which are relevant to the influence of the ICMP. Table 3 in section 3 details the provisions which align the ICMP with the Vision and Strategy.

The Mangaheka catchment straddles the Hamilton City Council (HCC) and Waikato District Council (WDC) boundaries with approximately 86% of the catchment (1,788ha) lying within WDC jurisdiction, with the upper catchment (291ha) upstream of Koura Drive within HCC jurisdiction. The land use within the catchment is predominantly rural in nature (mainly dairy farming or grazing) with commercial / light industrial development in part of the upper catchment. The Mangaheka Stream comprises modified watercourses in the upper catchment as well as in roughly the upper half of the lower catchment, with the Tangirau Wetland present in the lower half. There is little native vegetation in the catchment and the modified watercourses have limited shading. Water quality in the stream is recorded to be moderate to poor quality which is comparable to other urban watercourses in Hamilton (Boffa Miskell, 2018). The upper catchment area is generally flat-lying and represents one of the higher parts of the catchment. From this area the topography slopes generally to the northwest towards the Waipa River which then joins the Waikato River.

On-going development of the upper catchment will replace rural land with light industrial and commercial land uses. Furthermore, this change in land use will result in an increase of impermeable surfaces in the upper catchment and a reduction in soakage potential leading to a greater volume of stormwater runoff being generated. The ICMP includes a number of provisions to manage stormwater generated within the upper catchment and to mitigate any potential effects. Key provisions of the ICMP are:

- Encouragement for developers to reduce impervious areas and provide soakage opportunities within development areas and on-lot
- On-lot pollution reduction measures comprising: gross pollutant traps, water treatment devices (such as swale or raingarden, no exposed copper or zinc building products
- Use of a treatment train approach consisting of on-lot water treatment measures in combination with centralised devices
- Use of centralised wetland devices with greater than 80% vegetation cover
- On-lot water detention tanks
- Watercourse enhancement via riparian planting, protection via stock fencing in rural areas and erosion protection works to reduce suspended sediment in the stream and maintain integrity of stream banks

- Consideration of reconnecting the Te Otamanui catchment to divert some peak stormwater flows away from the Mangaheka Stream
- Monitoring of groundwater to inform wetland design
- Regular water quality monitoring as part of the city-wide monitoring plan
- Maintaining existing modified watercourses and requirement for new watercourses to mimic natural environment
- Requirement for no reticulated stormwater

Considering the ICMP provisions and technical studies, this assessment has identified that stormwater discharge activities in the Mangaheka Catchment, following implementation of the above ICMP provisions may have minor effects on:

- Natural features, surface water bodies and aquifers
  - Reduction in soakage opportunities may lead to reduction in recharge of the underlying aquifer with a potential reduction in baseflow support to the Mangaheka Stream
- Flood risk
  - Increases in peak flows, stormwater discharge volumes and stormwater drainage pathways could potentially lead to increased flooding
- Receiving water hydrology
  - Reduction in soakage opportunities may lead to potential reduction in baseflow support to the Mangaheka Stream
- Sediment and water quality
  - Increase in runoff from a commercial / light industrial area is anticipated to lead to increased contaminant loads in stormwater
- Existing infrastructure
  - Increases in peak flows, stormwater discharge volumes and stormwater drainage pathways could potentially lead to flooding of existing buildings and properties and infrastructure

The above effects are addressed in the ICMP via a combination of monitoring the stream water quality and erosion, monitoring of groundwater levels and detailed modelling of flood risk for individual developments and for the entire catchment.

Less than minor effects are anticipated for:

- Sites of historic and cultural significance
- Effects on fish passage for indigenous and trout fisheries
- Effects on existing authorised resource use activities

Positive effects are anticipated for:

- Public health
- Receiving water habitat, ecology and ecosystem health
- Receiving water riparian vegetation
- The extent and quality of open stream channels
- Natural and amenity values

These positive effects reflect the anticipated overall improvement and enhancement of the catchment following implementation of the ICMP provisions leading to improvement in water quality in the stream, enhancement of habitat for aquatic species and particularly ‘at risk’ species, and riparian planting of native species.

Potential cumulative effects have been identified for:

- Natural features, surface water bodies and aquifers
- Flood risk
- Receiving sediment and water quality
- Receiving water hydrology

Many of the provisions included in the ICMP are anticipated to result in a positive effect for the catchment with improved water quality and increased native planting. The potential minor effects identified are to be managed by the ICMP provisions and these include some future actions identified in the ICMP which are aimed to address any remaining gaps in information and upcoming changes in applicable legislation.

Contents

1 Introduction

1.1 Purpose of this Document

This AEE has been developed in order to determine the actual and potential effects, including the cumulative effects, on the Mangaheka Stream catchment as a result of planned development and associated three waters infrastructure as indicated via the Rotokauri Structure Plan. This AEE is intended to satisfy the requirements of conditions 30(g) and 30(h) of the Hamilton City Council's Comprehensive Stormwater Discharge Consent ("the CSWDC"):

- Condition 30(g) requires an assessment of the environmental effects of all new stormwater diversion and discharge activities on the catchment in such detail as corresponds with the scale and significance of the effects that these activities will have on the catchment. The headings used below in section 2 are based on the requirements set out in condition 30(g) of the CSWDC on which the effects of the activities are to be assessed
- Condition 30(h) requires an assessment of the cumulative environmental effects of all new stormwater diversion and discharge activities on the catchment over time

This AEE also considers how the ICMP aligns with the Waikato regulatory framework including the Vision and Strategy for the Waikato River, the Waikato Regional Policy Statement (WRPS), the Waikato Regional Plan (WRP), and Healthy Rivers Wai Ora. The Vision and Strategy identifies the intent of the Waikato River Authority to improve the quality of the Waikato River water and enhance the relationship of the community with the river to improve the rivers' wellbeing and this influence extends to contributing catchments. Not all of the objectives can be given effect by the ICMP, however, the seven applicable objectives and how these are addressed by the ICMP is detailed in section 3.

This document has been compiled in support of the ICMP utilising a number of technical studies which have been developed for the Mangaheka catchment in the past or commissioned specifically to support the development of the ICMP. The technical studies informing this document include the following:

- Morphum Environmental Ltd, May 2017: Mangaheka Watercourse Assessment and Programme of Works
- Boffa Miskell, July 2018: Mangaheka Stream Assessment of Ecological Values to inform an Integrated Catchment Management Plan
- CH2M Beca, May 2017a: Te Otamanui Fatal Flaw Assessment
- CH2M Beca, June 2017b: Mangaheka Integrated Catchment Management Plan - Stormwater 1D Modelling Report
- CH2M Beca, February 2018a: Mangaheka Water Quality Assessment
- CH2M Beca, July 2018b: Mangaheka ICMP – Addendum to Water Quality Report
- Porters Group Limited and Hamilton Joint Venture Limited, March 2015: Upper Mangaheka Draft Integrated Catchment Management Plan
- Nga Mana Toopu o Kirikiriroa (July 2004) Cultural Investigations Report, prepared for Transit New Zealand for the Te Rapa Bypass Notice of Requirement
- Beca, April 2018, Desktop Hydrogeological Assessment

The above reports have been used to describe the existing environment of the Mangaheka catchment, including any particular sensitivities or existing issues. From this an assessment of potential effects has been conducted associated with currently proposed and projected development. Information contained within these report is summarised within the ICMP and included as appendices to the ICMP.

1.2 Catchment Description

The overall Mangaheka catchment area encompasses approximately 2,080ha of flat to rolling Waikato lowlands in the area generally defined by Onion Road in the north, the North Island Main Trunk (NIMT) railway and Tasman Road in the east, Ngaruawahia Road in the west, and Te Kowhai Road to the south. The Mangaheka Stream is a small tributary of the Waipa River and flows southeast-northwest towards it.

Approximately 86% of the catchment (approximately 1,788ha) lies within Waikato District Council (WDC) jurisdiction, with the upper catchment (291ha) upstream of Koura Drive within Hamilton City Council (HCC) jurisdiction. An overview of the catchment is provided in Figure 1.

Within HCC boundaries, the catchment includes the 177ha Rotokauri Structure Plan industrial area between the Te Rapa bypass and the NMIT railway and an employment zone between the bypass and Burbush Road / Koura Drive. More than 120ha of industrial land in this area has been consented and is under development since 2012. Within this area, modified watercourses have been replaced with stormwater treatment swales and detention basins with discharge points into the downstream watercourse network. The Te Rapa bypass and associated connecting roads were constructed with stormwater treatment swales discharging into existing, new and realigned watercourses within the Mangaheka catchment.

Downstream of Koura Drive within Waikato District, the Mangaheka Stream has a rural catchment (mainly dairy farming or grazing) comprised of artificial, modified watercourse, and an extensive gully wetland. The adjacent catchments are Te Rapa Stream to the east (discharging into the Waikato River) and Lake Rotokauri to the west (discharging to the Waipa River).

The Te Otamanui sub-catchment is located along the south western border of Mangaheka Catchment. This sub-catchment, which also discharges to the Waipa River via a culvert beneath Bedford Road, has an area of approximately 500ha comprising mainly rural land with the Te Otamanui Lagoon located in the western (downstream) part of the catchment. The stream is understood, via anecdotal evidence from local landowners, to have previously been connected to Mangaheka Stream near the Koura Drive / Te Kowhai Road roundabout. The two streams were allegedly disconnected in the 1950's, and reconnection to allow overflow from Mangaheka Stream is currently being investigated by HCC (CH2M Beca, 2017a). The lagoon has been reported in recent times to be drying out and it is considered that reconnection could both help maintain lagoon water levels and reduce peak flows in the Mangaheka Stream.

The upper catchment area is generally flat-lying and represents one of the higher parts of the catchment. From this area the topography slopes generally to the northwest towards the Waipa River. The highest ground is located along much of the northern boundary of the catchment with associated steeper slopes trending south and south west.

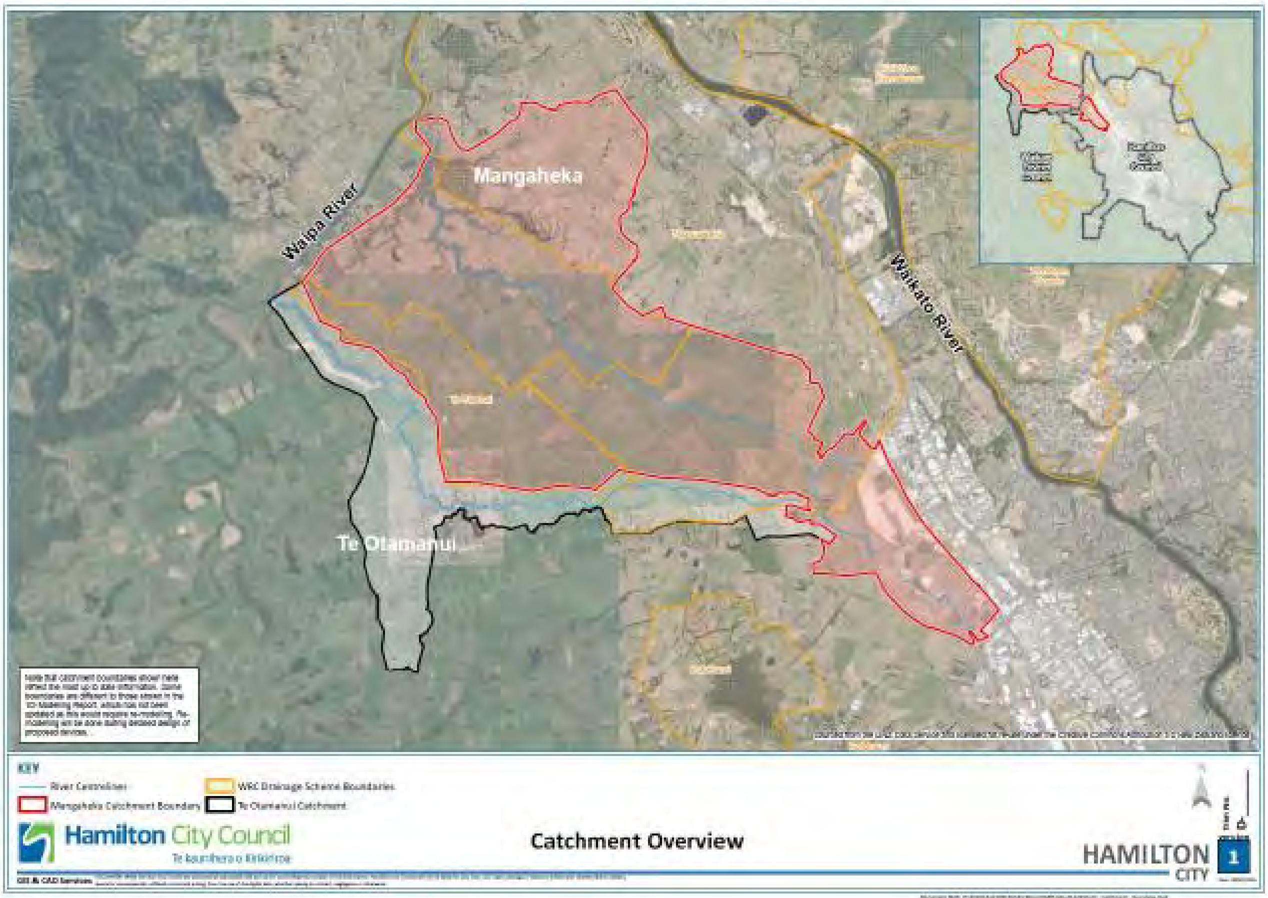


Figure 1: Catchment Overview of Mangaheka and its adjacent sub-catchment Te Otamanui

1.3 Proposed Development and ICMP Provisions

Section 2.2.3 of the ICMP outlines the anticipated development of the upper catchment to be comprised of light industrial / commercial activities with up to 90% impervious surfaces. To mitigate the increase in stormwater runoff and contaminant loadings associated with this type of development, centralised stormwater control devices, namely constructed wetlands, are proposed for each sub catchment within the upper catchment. 1D stormwater modelling has been conducted (CH2MBeca, 2017b) to determine flood volumes allowing for Maximum Probable Development (MPD), the proposed constructed wetlands and the effects of climate change to confirm the device sizing.

No specific development is anticipated within the lower catchment, however on-going erosion that has been occurring along parts of the stream and water quality impacts due to stock access to the stream are proposed to be reduced via a stream protection works programme. This programme includes greater separation of the stream from surrounding agricultural activities via retirement of a 5m corridor either side of the stream, and a fencing and planting programme. Details of the programme are provided within section 3.5 and 6.5 of the ICMP as well as the future actions detailed in section 6.6 of the ICMP.

2 Assessment of Effects

As outlined in section 1 above, this AEE has been prepared in order to address Condition 30(g) of the CSDC. Table 1 below provides an overview of the requirements of Condition 30g), the relevant sections of this report and associated source material. This AEE should be read as a supporting document to the ICMP.

Table 1: Condition 30(g) Requirements, Corresponding AEE Sections and Source Material

Condition 30(g) Requirements	Relevant AEE Section	Associated Technical Reports
i. Natural features, surface water bodies and aquifers	Section 2.1	Upper Mangaheka Draft ICMP, Ecological Assessment, Hydrogeological desk study
ii. Sites of cultural and/or historical significance	Section 2.2	Upper Mangaheka Draft ICMP, Te Rapa Bypass Investigation - Cultural Investigations Report
iii. Public health	Section 2.3	Water Quality Report, Ecological Assessment
iv. Flooding hazards	Section 2.4	Stormwater 1D Modelling Report, Te Otamanui Fatal Flaw Assessment
v. Receiving water hydrology	Section 2.5	Stormwater 1D Modelling Report, Mangaheka Water Quality Assessment & Addendum
vi. Receiving water sediment and water quality	Section 2.6	Mangaheka Water Quality Assessment, Ecological Assessment & Addendum
vii. Receiving water habitat, ecology and ecosystem health	Section 2.7	Ecological Assessment, Watercourse Assessment and Programme of Works
viii. Receiving water riparian vegetation	Section 2.8	Ecological Assessment, Watercourse Assessment and Programme of Works
ix. The extent and quality of open stream channels	Section 2.9	Ecological Assessment, Watercourse Assessment and Programme of Works
x. Fish passage for indigenous trout fisheries	Section 2.10	Ecological Assessment, Watercourse Assessment and Programme of Works
xi. Natural and amenity values	Section 2.11	Ecological Assessment, Watercourse Assessment and Programme of Works
xii. Existing infrastructure	Section 2.12	Stormwater 1D Modelling Report, Mangaheka Water Quality Assessment & Addendum
xiii. Existing authorised resource use activities	Section 2.13	-

2.1 Natural Features, Surface Water Bodies and Aquifers

2.1.1 Natural Features and Surface Water Bodies

Existing Environment

The Mangaheka catchment has been largely modified from its original state with the majority of the catchment comprising agricultural land with little to no native vegetation present (Boffa Miskell 2018). The upper catchment comprises largely urban development and rural landscape zoned as ‘light industrial / commercial’ in the Hamilton District Plan and as indicated in Figure 2.8 of the Rotokauri Structure Plan. In the upper catchment, the land area to the north of the Te Rapa bypass has largely been cleared and landscaped to form initial development platforms (HCC, 2015). Roads and infrastructure associated with the planned development in this area have been constructed.

In the upper catchment, the two main branches of the drainage network meet immediately downstream of Koura Drive. Prior to development, the modified water course networks comprised the stream headwater catchments located within the Rotokauri Structure Plan industrial / employment area, which was originally peat swamps (HCC, 2015). As a result of development of the industrial area and the Te Rapa Bypass, the modified watercourses were replaced with planted swales and detention basins.

Downstream of the industrial area and bypass, modified watercourses flow north and northwest to Koura Drive, where they meet at the streams main stem. The stream then flows as a single modified watercourse, northwest through farmland. Outside the Hamilton City boundary, the catchment is almost entirely rural (mainly dairy farming), with largely modified watercourses draining to the stream, and with very little riparian vegetation (Boffa Miskell 2018). Between Koura Drive and Horotiu Road, the stream develops a more defined floodplain within an increasingly entrenched gully landform as it approaches Horotiu Road.

Between Horotiu and Ngaruawahia Roads, the stream becomes wetland in an entrenched gully network comprising the Tangirau Wetland. Other branches of the stream form arms of the gully network at numerous confluences. The main stem flows northwest through an extensive rural gully system that becomes increasingly deep and wide. The gully system is fully vegetated with willow-dominated trees and indigenous sedge understorey (Boffa Miskell, 2018). The outlet to the Waipa River downstream of Ngaruawahia Road is via a short section of modified watercourse. Boffa Miskell (2018) suggest the wetland was formed following the construction of the Ngaruawahia Road embankment which restricted stream flow.

Existing overland flow paths are also recorded in the upper catchment associated with restrictions to stormwater draining via culverts during high rainfall events. The main overland flow paths that have been identified include flow across the south western upper catchment which originates from the Rotokauri catchment; high flow associated with breaching of the banks of the existing artificial channel downstream of the Porters Pond wetland, flow from Mangaheka catchment into the adjacent Te Otamanui sub-catchment (CH2M Beca, 2017b).

The water quality in the Mangaheka stream has been reported by Boffa Miskell as having water quality and water chemistry that is very similar to other Hamilton waterways and is considered to be moderate to poor quality. The stream receives on-going inputs of suspended sediment, turbidity, nutrients, metals, and faecal pathogens from both upstream industrial development and adjacent rural landuse (Boffa Miskell, 2018).

The strategic intent of land drainage activity is set out in Waikato Regional Council’s Long Term Plan 2012 – 2022. Effective land drainage is provided by maintaining a land drainage network that allows landowners the ability to manage water table on their properties, and that reduces surface flooding resulting from significant rainfall events. Flooding in the catchment has the potential to impact agricultural land via grass die-back if flood ponding cannot drain from paddocks quickly enough and built infrastructure in the event of stream bank breaches and overland flow. Effective land drainage is currently provided by the existing land drainage network which is part of two separately administered drainage areas: the WDC Drainage Area; and the Waikato Central Drainage Area, managed by the Waikato Regional Council (WRC).

The proposed drainage concept for the development area is shown on Plan 2A in Appendix B of the ICMP and described in section 4 of the ICMP. A stormwater network including wetland devices and swales for part of the development area north of the bypass has already been consented to discharge to the Mangaheka Stream (refer Porters / HJV consent).

Assessment of Effects

The proposed development of the upper catchment will have the following actual or potential effects on natural features and water bodies:

- Removal of natural landscape features and conversion to urban landscape
- Increase in impervious area and associated reduction in soakage potential in the sub-catchment will increase stormwater volumes being generated
- A potential increase in scour and erosion within the watercourse as a result of increased peak flows
- An increase in discharges of sediment and contaminants to the Mangaheka Stream and subsequently the Waipa River - thus potentially conflicting with the intention of Waikato Regional Plan Change 1 (healthy rivers) and the Vision and Strategy for the Waikato River

Plan 2A in Appendix B of the ICMP identifies the proposed layout and sizing of centralised devices in the upper catchment. These centralised devices will be wetlands with at least 80% vegetated cover and have been sized to provide detention and treatment of the anticipated volume of stormwater generated within the developed upper catchment, allowing for up to 90% impervious area (as permitted by the HCC Operative District Plan on developed lots (CH2M Beca, 2017b). The 1D stormwater modelling report identifies that the proposed devices will maintain peak flows during close to existing levels (CH2M Beca, 2017b) and hence limit potential for increased erosion. The development of wetlands will facilitate treatment of stormwater runoff to reduce sediment loads and other contaminants such as metals.

Assessment of effects on flooding risks and water quality are addressed in sections 2.4 and 2.6, respectively, of this report.

Erosion protection and stream works in the lower catchment is planned and detailed within section 3.5 and 6.5 of the ICMP. These works will focus on existing areas identified as susceptible to erosion and are planned to be carried out independently of the development of the upper catchment as identified in the Future Actions in section 6.6 of the ICMP.

Management of Effects

The following management techniques are planned to be established in the Mangaheka catchment, in addition to the planned mitigation noted above, to reduce adverse effects from development:

- Sediment controls during construction
- Off-line treatment devices
- Encouragement to reduce impervious areas as far as practical
- Use of a treatment train approach consisting of on-lot water quality measures in combination with centralised devices
- On-lot measures comprise: gross pollutant traps, water treatment device (such as swale or raingarden, no exposed copper or zinc building products
- On-lot water detention tanks
- Encouragement to incorporate soakage opportunities via permeable paving etc
- Watercourse enhancement via riparian planting, protection via stock fencing in rural areas and erosion protection works to reduce suspended sediment in the stream and maintain integrity of stream banks
- Wetlands to include submerged discharge points to capture hydrocarbons and litter
- Consideration of reconnecting the Te Otamanui catchment to divert some peak stormwater flows away from the Mangaheka Stream

The main management technique proposed to address anticipated impacts to water volumes is the proposed centralised stormwater devices comprising planted wetlands to facilitate detention and flood attenuation prior to discharge to the stream. The centralised devices will be supplemented by on-lot requirements for pollution control and rainwater detention. Centralised devices are proposed to have specific features for capturing and separating out hydrocarbons and gross pollutants. The devices are sized for appropriate detention and residence times for particulate (including particulate metals) removal. The size of the devices and 80% vegetated cover requirement is intended to assist in regulating water temperatures before discharge to the stream. 1D modelling of the anticipated increased stormwater volumes taking account of the proposed stormwater devices and the effects of climate change indicate that peak flows will not increase significantly (CH2M Beca, 2017b).

Summary of Effects

It is anticipated that the proposed management techniques provided in the ICMP will maintain peak water flows to as close as possible to pre-development levels (CH2M Beca, 2017b). The proposed erosion protection works is expected to provide enhancement of the Mangaheka Stream environment (Morphum, 2017). Overall this is anticipated to restrict development effects on natural features and water bodies to less than minor adverse.

Cumulative Effects

Attenuation of peak flows and the proposed stream protection works is aimed at reducing the potential for on-going or increased erosion as a result of development. This will aim to help prevent or at least minimise any cumulative effects of erosion associated with any increased stormwater generation. Monitoring of identified areas of the stream currently susceptible to erosion is identified in the Monitoring Plan (section 6.7 of the ICMP) and will be used to determine the adequacy and effectiveness of erosion protection and any requirements for additional works.

2.1.2 Aquifer

Existing Environment

The soil profile within the catchment is expected to be comprised of sands, silts, gravels and peats of the Piako (Hinuera Formation) and underlying Walton Sub-groups, with the latter outcropping and forming the low lying hills along much of the northern boundary of the catchment and some isolated low lying hills in the lower catchment (Beca, 2018). A desk based hydrogeological review of the catchment (Beca, 2018) was conducted and noted that groundwater level monitoring in the adjacent Rotokauri catchment, which is considered to have similar geology to the Mangaheka catchment, indicated a seasonal range typically in the order of 1.5 – 2m but in places as much as 3m or as little as 0.5m. Ground investigations referred to in section 1.3 of the ICMP have previously recorded groundwater levels to range from approximately 0.7 - 1m below ground surface during a winter monitoring period and roughly 1 - 1.5m below this level during a summer monitoring period. This indicates the potential for significant lateral variations in groundwater table, or the presence of perched groundwater locally. Differences in groundwater levels may also potentially be influenced by seasonal variations. No geotechnical investigation reports are available for the lower catchment area, however, based on publicly available soils information, the lower catchment is anticipated to comprise soils of similar limited or poor-drainage capability with shallow groundwater.

Shallow groundwater within superficial deposits is anticipated to be accessed by various bores in the catchment with others extending down to bedrock. Depth to bedrock and hence soil thickness is variable within the catchment.

There are a number of groundwater takes recorded on the WRC website for agricultural use and private water supply in the lower catchment area. The bores in this area are recorded to range from less than 25m in depth to over 100m. Two water take consents, one held by Porter Properties and one by HJV, are recorded in the industrial area of the upper catchment for use in dust suppression and one water take consent for agricultural irrigation is recorded in the currently rural part of the upper catchment south of the bypass.

Assessment of Effects

The proposed development of the upper catchment will have the following actual or potential effects on the groundwater regime and any aquifers underlying the Mangaheka catchment:

- Reduction in soakage opportunities in the upper catchment has the potential to have an adverse effect on contribution to baseflow of the stream and shallow aquifer recharge
- Removal of peat soils may contribute to changes in shallow groundwater flow

Reduction in soakage within the upper catchment could have the potential to impact local groundwater abstractions where these access shallow groundwater.

Management of Effects

The following mitigation measures are proposed to assist management of any changes to the hydrogeological regime as a result of development:

- Monitoring of groundwater to inform wetland design
- Avoidance of reticulated stormwater drainage
- Assessment of the effects of peat removal on groundwater flow

Proposed development in the upper catchment is anticipated to significantly increase annual stormwater flow volume discharging from this area, as a result of the remaining 60ha of undeveloped land being developed up to 90% impervious surfaces. The ICMP specifies that existing natural drainage flows be considered by development and retaining modified watercourses with natural features is required instead of replacement with reticulated drainage.

Due to recorded and anticipated lateral variation in groundwater levels in the upper catchment, the ICMP includes a requirement for groundwater monitoring to be conducted to inform the design of each wetland device (e.g. lined or unlined) to reduce the potential for effects on the local groundwater regime or device performance. The requirements for monitoring are included in section 6.7 of the ICMP.

The requirements for the above management options are provided in the means of compliance table (Table 6.3 in the ICMP).

Summary of Effects

The effect on baseflows and shallow groundwater from the change in soakage pattern is not fully known at present with limited information available on the hydrogeology of the catchment. Current water take consents recorded in the upper catchment relate to dust suppression (during constriction) and agricultural irrigation which are not expected to be impacted as these activities are unlikely to be taking place following development of the upper catchment into an industrial / commercial area. It is assumed that reduction in soakage options will reduce baseflow to the stream which is already recorded to be intermittent in the upper catchment and uppermost part of the lower catchment. Considering the area of the entire catchment is approximately 2,080ha, and the upper catchment is recorded to be 291ha (14% of the total area), a reduction in soakage of this area is anticipated to have an effect mainly on the local, upper catchment area. Considering the above, it is anticipated that the development in the catchment is likely to have a minor adverse effect on the aquifer in terms of recharge. However groundwater monitoring is to be conducted prior to future developments can help build a more accurate picture of the actual effects and help refine any required provisions for future revisions of the ICMP.

Cumulative Effects

The upper catchment has already undergone partial development, with the formation of development platforms and construction of some lots with associated reductions in soakage opportunities and removal of peat soils (HCC, 2015). As development continues in the upper catchment in the future, the reduction in soakage increases therefore resulting in an overall minor adverse effect.

2.2 Sites of Historic and Cultural Significance

Existing Environment

Formal archaeological and cultural assessments of the Mangaheka catchment have not been conducted for the ICMP, however the following sources have been utilised to identify any known sites of historic or cultural significance:

- Waikato District Plan
- Hamilton City Operative District Plan
- Waikato Regional Council Online Maps Viewer
- Waikato District Council Maps Viewer
- Archsite Viewer
- Nga Mana Toopu o Kirikiriroa (July 2004) Cultural Investigations Report, prepared for Transit New Zealand for the Te Rapa Bypass Notice of Requirement

A marae recorded as both Waikeri and Tangirau marae, is located in the western part of the catchment in the vicinity of the Tangirau wetland. This marae is also identified on the WDC Map viewer as within a Pa Zone. The wetland is anticipated to be important for local fishing and cultural practices and the Tangirau Restoration Group has been formed by local iwi and local landowners with the objective to protect and enhance the wetland. The group has received funding from the Waikato River Authority for 'Stage 1' of a planned three stage restoration project including control of pest plant species, planting of native species and fencing.

A review of information available on the Archsite viewer identified the following sites (Table 2) recorded in or immediately adjacent to the Mangaheka catchment.

Table 1 - Archaeological Sites Recorded in Archsite

Site ID	Type / Name	Description	Co-ordinates
S14/124	Wooden artefact	Indigenous pre-1769	E 1789738 N 5825156
S14/362	Borrow pit	A single borrow pit and Maori-made soils on the banks of the Waipa River	E 1789616 N 5825408
S14/361	Borrow pits	Eight borrow pits, and Maori-made soils	E 1789810 N 5825710
S14/122	Whakapuku Pa	The pa site is situated NW of the junction between Bedford Road and the Ngaruawahia Road, between the road and the river	E 1788141 N 5823748
S14/118	Pa	NW of Te Kowhai, on the east bank of Waipa River, bisected by Bedford Road	E 1787830 N 5823364

The sites above are all located on the western boundary of the Mangaheka Catchment beside the Waipa River.

The Te Rapa Bypass Cultural Investigations Report notes that a bush stand of kahikatea named as "Pikihinau" is present near the roundabout joining Te Kowhai Road, Burbush Road and Koura Drive. This has been identified in the report as a site of specific significance in the area, and originally noted for gathering hinau berries and hunting native birds. The size if this stand has reportedly been significantly reduced due to agricultural practices. The report also identifies a further significant area being a swamp area named “Te Maire” which is recorded to be present to the north of Te Kowhai Road within dairy farmland. This geographical extent of this area is not clear in the report, however it is anticipated that the Te Marie area could lie at least partially within the Te Otamanui sub-catchment.

The Hamilton City Plan does not indicate any known sites of historic or cultural significance within the upper catchment. The Waikato District Plan does not identify any known cultural or heritage sites within the lower catchment other than the ‘Pa Zone” recorded in the north western catchment area. However, a ‘heritage site’ associated with a property is recorded within the village of Te Kowhai in the Te Otamanui catchment. The WRC Maps viewer records the marae as the Waikeri Marae. Based on the available information reviewed for this assessment, no other sites of historic or cultural significance are known to be present within the catchment.

Assessment of Effects

Considering the archaeological finds recorded in the western part of the catchment and the important cultural areas identified in the south western part of the catchment it is possible that as yet unidentified archaeological and / or cultural sites are present which could be exposed during construction, or could be exposed due to erosion and scour of the Mangaheka stream banks.

The potential for effects on the use of the Tangirau wetland for cultural practices including fishing are considered further in sections 2.6 (sediment and water quality) and 2.7 (habitat, ecology and ecosystem health) below. The potential for effects on the Pikihinau and Te Marie areas are considered to be low as they do not appear to be in the immediate vicinity of the Mangaheka Stream or the proposed development in the upper catchment. However, the potential for increased water flow in the Te Otamanui Stream as a result of reconnection to Mangaheka will need to be considered within any future detailed feasibility study for the Te Otamanui sub-catchment.

Management of Effects

Based on the information reviewed, it is apparent that there are some historic and cultural sites recorded within the catchment near the western boundary. There are no anticipated effects associated with these particular sites. However the exercise of the stormwater management and discharge activities covered by the ICMP could give rise to the discovery of artefacts or human remains, if the discharge were to result in the erosion or scour of a stream bed and that exposed such items.

The CSWDC is not a consent to carry out earthworks. The construction of future stormwater management devices (swales / wetlands etc) would require separate regional resource consents that would need to consider potential effects on historic and cultural sites, or recommend measures to manage and mitigate construction activities in the even that a site was discovered. Effects on any as yet unknown sites of cultural or historic significance that may be present within the catchment will be minimised by the implementation of the HCC or WDC Accidental Discovery Protocol (ADP) with requirements for notification of iwi representatives and authorities if any artefacts or bones are discovered during development or as a result of erosion.

The project team met with mana whenua representatives of Te Ha o Te Whenua O Kirikiriroa on three occasions to share the outcomes of the technical reports and discuss the particular outcomes to be achieved in the ICMP. Mana whenua are currently updating the cultural impact statement for the wider Rotokauri area and this will supersede historical cultural impact assessments relied on for the ICMP and this AEE. The revised Cultural Impact Statement will be utilised once it has been released and this is captured in the Future Actions section of the ICMP (section 6.6).

Summary of Effects

There are limited development works planned outside of the upper catchment and these mainly comprise erosion protection works associated with the stream and riparian planting. Approximately half of the upper catchment area (on the northern side of the bypass) has already been subject to development works including earthworks therefore the only landscape with limited pre-disturbance is the currently rural area to the south of the bypass (approximately 7% of the total catchment area). Based on the available cultural heritage information reviewed for this assessment, it is anticipated that the effect of the planned development will be less than minor. If any sites are discovered during development, the appropriate ADP will be implemented to manage construction activities and invoke the appropriate procedures to manage the site.

Cumulative Effects

As there are no known sites of historical or cultural significance anticipated to be affected by the proposed development or stream works, there are no cumulative effects.

2.3 Public Health

2.3.1 Potential for Recreational Exposure

Existing Environment

Public access to the Mangaheka Stream is limited largely to the Tangirau Wetland. The majority of the catchment is privately farmed agricultural land and so public access is limited. Potential impacts to public health from the stream are typically associated with inputs from agricultural runoff and stock access to the stream which can introduce pathogens. In the remainder of the catchment any access to the stream is assumed to be limited predominantly to farmers with limited recreational use anticipated with the upper catchment.

The Mangaheka Stream is currently recorded to have generally moderate to poor water quality which is generally consistent with other urban stream in the Hamilton area. It is considered unsuitable for human contact or livestock consumption and the faecal pathogen load is considered to potentially represent a risk to human health via fish and watercress harvesting from the stream (Boffa Miskell, 2018).

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effect on public health via recreational exposure:

- Overall reduction in risks to human health due to reduced pathogen and nutrient loads

Considering the proposed wetlands and the transition of land use from agricultural to light industrial / commercial, discharges from the upper catchment are anticipated to be improved for nutrients and sediment, and maintained or slightly degraded for metals (Boffa Miskell, 2018) compared to the existing conditions. The potential for bioaccumulation of metals within aquatic plants and fish within the stream which may then be used as a food source may remain a potential risk to human health. It is noted in the Boffa Miskell 2018 report, that metals concentrations recorded in the stream currently already exceed Australian and New Zealand Environment and Conservation Council (ANZECC) thresholds for dissolved zinc and copper, however, the report also states that the toxicity of metals is likely to be limited by formation of mineral complexes with phosphorus and organic material, meaning the bioavailable dissolved form of metals in the water column is low.

Management of Effects

The following mitigation measures are proposed to assist management of any changes to the Mangaheka Stream water quality as a result of development:

- On-lot treatment of stormwater comprising a device such as a swale / raingarden
- No exposed copper or zinc building products
- Use of a treatment train approach to increase pollutant removal
- Design of centralised devices to meet the Infrastructure Technical Specifications (ITS)
- Programmed erosion protection stream works including stock fencing and riparian planting
- Regular water quality monitoring as part of the city-wide monitoring plan
- Capture and re-use of rain-water for on-lot non-potable use

The ICMP also encourages:

- Reduction of impermeable areas
- Expansion of the list of activities requiring a pollution plan

On-going monitoring of stream water will be used to establish trends in water quality and determine any potential risks to human health from recreational exposure including consumption of food sourced from the stream. This is addressed in the monitoring plan in section 8 of the ICMP.

Summary of Effects

The centralised stormwater devices will not be publically accessible and will not be utilised for any recreational activities. The main area anticipated to be accessible by the public for recreational activities will be the Tangirau wetland. As noted above, the overall risk to human health as a result of recreational exposure to the stream water is anticipated to be reduced (as per the findings of the Boffa Miskell (2018) report) and in this way, there is no adverse effect associated with human health and the effect is considered to be positive. As noted above, there is no effect currently considered to be associated with bioaccumulation of metals and risks to human health.

Cumulative Effects

As the groundwater quality is not anticipated to change adversely as a result of development, there are no cumulative effects identified to be associated with human health via recreational exposure.

2.3.2 Domestic Water Supplies

Existing Environment

Groundwater quality within the Mangaheka catchment is not fully known at present. Water bore information available on the Waikato Regional Council maps site records observed water quality as ranging between ‘good’, ‘poor’ and ‘unknown’. It is anticipated that, as for the general Hamilton area, groundwater will be influenced by urban and agricultural run off as well as peat and organic soils which can transfer metals and nutrients. There are a number of water takes recorded in the area on the WRC online groundwater map both in the vicinity of the main stream as well as its tributaries. The majority of these are recorded to be less than 25m in depth, with a fewer number recorded as greater than 25m extending up to between 75m and 100m depth. There are also a number of bores that have no details relating to depth assigned to them. In view of this, there may be an existing potential for contamination of water takes, dependant on the concentrations of particular parameters in groundwater, the groundwater flow regime and the depth of water take. Nonetheless, the Boffa Miskell 2018 report notes that while concentrations of copper and zinc recorded in the stream currently exceed ANZECC thresholds, the bioavailable dissolved form of metals in the water column will be low as will be the toxicity.

It is anticipated that the Mangaheka Stream is fed by groundwater. Interactions between groundwater and stream waters, in terms of the potential for streamwater to contribute to groundwater and hence potentially transfer contaminant load to groundwater has not been assessed by the ICMP's technical studies

Assessment of Effects

The proposed development of the upper catchment will have the following actual or potential effect on public health via domestic water supplies:

- Potential impact to domestic water supplies sourced from shallow groundwater

The water quality addendum report (CH2M Beca, 2018b) indicates post development contaminant loadings of the stream will likely include elevated copper and zinc, however, this will mirror existing conditions. The potential for transfer of contaminants from the stream to groundwater is not understood.

Management of Effects

Any effects will be managed by the same ICMP provisions noted above for recreational exposure.

Summary of Effects

The anticipated overall improvement of water quality in the Mangaheka Stream (in terms of nutrients and pathogens) (Boffa Miskell, 2018) reflects the change of upper catchment land use from agricultural to light industrial / commercial as well as proposed riparian planting and stream protection works in the lower catchment reducing inputs to the stream from agricultural activities. Considering this, there is no adverse effect on domestic water supplies expected. Further discussion on water quality is provided in section 2.6 below.

Cumulative Effects

As the groundwater quality is not anticipated to change adversely, there are no cumulative effects identified to be associated with human health via domestic supplies.

2.4 Flood Risk

Existing Environment

No detailed information is currently available on existing flooding within the catchment. The estimated current impervious area of the full catchment is 9.7% which includes farm tracks, hardstands, buildings and roads (Boffa Miskell, 2018). Flooding in the catchment has the potential to impact agricultural land via grass die-back if flood ponding cannot drain from paddocks quickly enough, and built infrastructure in the event of stream bank breaches and overland flow. Effective land drainage is currently provided by the existing land drainage network which is part of two separately administered drainage areas: the WDC Drainage Area; and the Waikato Central Drainage Area, managed by the WRC.

A number of existing overland flow paths (OLFPs) have been identified for the catchment. One comprises the former connection with Te Otamanui sub-catchment while another as a result of culvert capacity. This periodic connection between the streams is considered likely to have occurred more frequently in the past prior to Koura Drive being constructed. However, now, it is anticipated that floodwater would flow up the swale on the west side of Koura Drive and overflow westwards into the path of Te Otamanui Stream.

Anecdotal information has indicated that in the northern part of the upper catchment, a culvert beneath the bypass, immediately downstream of Porter's Wetland, can back up during high rainfall events leading to breaching of the stream banks in the immediate vicinity of the watercourse and localised flooding in this area.

A larger OLFP is recorded to occur from the neighbouring Rotokauri catchment as a result of the culvert below Exelby Road potentially backing up, which would lead to an overflow in the Rotokauri swale approximately halfway between Burbush Road and the bypass. The predicted flow path is visible as an established feature on satellite imagery indicating that this has occurred more than once in the past.

Assessment of Effects

The proposed development of the upper catchment will have the following actual or potential effects on flood risk:

- Potential for increased volume and duration of peak storm flows
- Increased areas subject to flooding and increased flood drain down time leading to grass die back
- Flooding associated with overland flow paths

Under the Operative District Plan light industrial urbanisation is expected to create levels of imperviousness of 90% within the portion of the catchment in the Rotokauri Structure Plan area (within the upper catchment area yet to be developed). The total imperviousness of the entire catchment will increase to around 14.9 %.

Detailed flood modelling has not been conducted, however a 1D stormwater model (CH2M Beca, 2017b) has been developed with the primary objective of assessing the impacts of future developments (assuming Maximum Probable Development – MPD scenario) in the catchment on peak water levels and flows downstream, and to confirm what is required to mitigate these effects. The detailed modelling is provided in the 1D modelling report and is summarised in section 2.6 of the ICMP. The 1D flood modelling which compares flooding based on existing (pre-development) conditions to the post development scenario predicts that the effect on water levels resulting from MPD can be mitigated by using the existing and proposed attenuation basins such that there is limited additional downstream flooding effect.

The drain down times (following MPD and mitigation) for the 1D modelled events in the area of Horotiu Rd, for example, are reported as 11 hours and 5.5 hours for a 100 year and 10 year event respectively. This indicates that grass die back will be avoided.

Management of Effects

The ICMP identifies the following stormwater management techniques for the catchment to aid in reducing peak flow and volume:

- On-lot detention tanks
- Attenuation of stormwater in wetlands prior to discharge to the stream
- Maintaining natural drainage features within development areas
- Consideration of overland flow paths prior to lot development
- Monitoring of groundwater to inform design of centralised devices
- Investigation of the re-connection of the Te Otamanui sub-catchment
- Monitoring of stream bed and bank erosion
- Encouragement for provision of soakage opportunities within development areas and on-lot

The potential for flooding will be reduced further through detailed groundwater investigation and design of proposed devices prior to their final siting and construction. Groundwater investigation will aim to facilitate an understanding of the water table in the area of the device to confirm the most appropriate location (so that the device is not drained or flooded due to incompatibilities with the existing ground water table). Detailed design of the proposed device will allow more up to date and detailed assessment of anticipated stormwater volumes to be managed by the device.

If the reconnection of Te Otamanui sub-catchment is completed, peak flows and total flood volumes will be reduced for Mangaheka, however, modelling has yet to be completed to determine the extent of such reductions.

Summary of Effects

Overall, the 1D modelling indicates that with the stormwater management devices in place, peak flows and volumes will not be significantly different than the pre-development conditions, with drain down times within appropriate timeframes (CH2M Beca, 2017b). Based on this it is anticipated that effects of flooding following development will be less than minor. Implementation of the management provisions noted above will be important to maintain or reduce the anticipated flood risk.

Cumulative Effects

There may be a potential for cumulative effects associated with flooding via overland flow paths from adjacent developments or that have not yet been identified. There may also be the potential for on-going development both within and immediately surrounding the catchment, to alter stormwater runoff patterns and generate new flow paths. Developments within the catchment are required to consider overland flow paths. Detailed flood mapping of the upper catchment and immediate surrounds may be required in the future to maintain understanding of flow paths and flood management requirements as the landscape is developed. This requirement is identified as a future action in the ICMP (Table 6-4).

2.5 Receiving Water Hydrology

2.5.1 Baseflows

Existing Environment

Existing development in the upper catchment includes three consented stormwater devices, two of which (Porters and HJV devices) are intended to be wetlands (to provide water detention and treatment), however, these have been impacted by sediment inflows during construction activities within the sub-catchments and require the completion of remediation works and planting to operate as wetlands. One device (4-Guys pond) is designed for water detention only and relies on the HJV pond for water treatment (CH2M Beca, 2017b).

The upper catchment is currently part-developed with previous earthworks having formed initial building platforms in the areas of the three consented ponds noted above, referred to in the ICMP as areas A, B and F. Limited information is available about the previous earthworks that have taken place in the upper catchment, however it is anticipated that the majority of peat soils in these areas will have been removed and soils reworked, therefore the soakage capacity, and hence the opportunity for generation of base flow in this partially developed area, is not currently clear.

The stream is described as perennial from approximately mid-way between Koura Drive and Horotiu Road with the section upstream of this area noted as intermittent in the Boffa Miskell 2018 report. It is expected that base flow supply of groundwater will be an important recharge mechanism for the watercourse. One of the objectives of the ICMP includes ensuring base flows are maintained to avoid impacts to sensitive ecological habitats downstream. The main area of proposed development is located in the upper catchment area with existing and future discharges to modified watercourses.

Assessment of Effects

The proposed development of the upper catchment will have the following actual or potential effects on receiving water hydrology:

- Potential for alteration of hydrological regime and baseflow supply from centralised devices
- Reduction in soakage opportunities.

The increase in impermeable area and the development of centralised wetlands has the potential to impact baseflow supply to the stream channels in the upper catchment and uppermost section of the lower catchment either by providing more consistent baseflow or a reduction dependent on the hydrological regime as well as wetland design. This has potential effects on stream ecology as discussed further is section 2.7.

Management of Effects

Effects on receiving water hydrology with a particular focus on base flows, will be minimised using the following stormwater management techniques:

- Maintaining existing natural drainage paths
- Monitoring of groundwater to inform design of centralised devices
- Design of new stormwater watercourses to mimic natural features to allow soakage
- Requirement for no reticulated stormwater channels
- Encouragement of reduced impermeable areas
- Encouragement to include soakage opportunities in design via permeable paving etc

Effects relating to peak flows are addressed in section 2.4 above.

Potential adverse effects on the Mangaheka Stream base flow will be managed, in part, via detailed assessment of the hydrogeological regime during design of stormwater management devices (Beca, 2018). Maintaining baseflows to as close to natural conditions as possible will help maintain the existing hydrological regime.

Summary of Effects

Following the implementation of the management measures described above, effects on baseflow may be minimised. The Boffa Miskell (2018) report notes that the groundwater contribution to watercourse baseflow increases rapidly with distance downstream. Based on this it is considered that provided the management provisions above are implemented to maintain the intermittent streams in the upper catchment area (e.g. mimic the natural conditions as closely as possible) the effects of the planned development on hydrology will be less than minor.

Cumulative Effects

Reduction in soakage opportunities in the upper catchment will typically result from the proposed development which is currently on-going. There are no other activities, out with the development of the upper catchment, which will reduce soakage potential within the Mangaheka Catchment. As such there are no cumulative effects identified for receiving hydrology.

2.5.2 Peak Flows and Aquifers

Effects associated with peak flows are addressed in section 2.4 above. Effects on aquifers within the catchment are addressed in section 2.1 above.

2.6 Receiving Sediment and Water Quality

Existing Environment

As reported in the Ecological Assessment report (Boffa Miskell, 2018), limited sediment samples taken from locations in the Mangaheka Stream in 2012 and 2016 were analysed for iron, arsenic, cadmium, chromium, copper, lead, nickel and zinc. The concentrations recorded in the analysis indicated almost all of the samples had concentrations at or below the ANZECC Interim Sediment Quality Guideline (ISQG) low trigger concentrations. Based on the results of the limited sampling recorded to date, there is no evidence of metals concentrations in sediments within the Mangaheka Stream representing a significant risk to biota (Boffa Miskell, 2018).

Water quality is also addressed within the ecological assessment report (Boffa Miskell, 2018), with analysis of samples recovered from five sites within the Mangaheka Stream in 2012 and 2016 (comprising sites at Ruffell Road, Te Kowhai Road, a farm culvert, the HJV development boundary, and Horotiu Road) indicating concentrations of some parameters above the relevant ANZECC trigger value. Due to apparently limited water in the upper reaches of the stream in 2016, a full repeat of the sampling conducted in 2012 could not be completed. The results of the sampling, summarised to indicate the exceedances recorded (in **bold**), are provided in the table below:

Table 2: Water Quality Sample Analysis (2012 & 2016)

Parameter	Ruffell Road	Te Kowhai Road	Farm Culvert	HJV Boundary	Horotiu Road	ANZECC Trigger Value
Faecal Coliforms (cfu/100mL)	**430**	**700**	**900**	**1,100**	**410**	100
Total copper (g/m^3)	**0.0022**	**0.0028**	**0.0026**	**0.0025**	<0.00053	0.0018
Total zinc (g/m^3)	**0.069**	**0.023**	**0.033**	**0.0175**	0.0012	0.015
Total nitrogen (g/m^3)	**4.2**	**2.5**	**4.6**	**1.66**	**0.44**	0.04-0.10
Total kjeldahl nitrogen (g/m^3)	**1.08**	**1.12**	**1.21**	**1.14**	**0.38**	0.04-0.10
Nitrate N	-	-	-	-	**0.055**	0.04-0.10
Nitrate-N + Nitrite-N (g/m^3)	**3.1**	**1.39**	**3.4**	**0.52**	**0.058**	0.04-0.10
Total phosphorus (g/m^3)	**0.056**	**0.106**	**0.077**	**0.058**	**0.035**	0.015-0.03

Based on available sampling and analysis results arsenic, cadmium, chromium, lead, and nickel are generally below ANZECC guidelines, aluminium, copper, and zinc typically exceed ANZECC guidelines, and iron is elevated. Phosphorus can be expected to combine with aluminium, iron, manganese, zinc, copper and other metals forming metal phosphates, increasing turbidity, reducing nutrient availability and limiting metal bioavailability and therefore toxicity in the water column. Concentrations of total copper and total zinc exceed ANZECC guidelines indicating potential for biological harm, however, concentrations of the bioavailable dissolved fraction are anticipated to be below ANZECC thresholds (Boffa Miskell, 2018). As noted in section 2.3 above, the water of the Mangaheka Stream is not considered suitable for human contact due to elevated pathogens.

The results indicate concentrations of total copper and total zinc slightly exceeding the guideline value at all but one location, with the most elevated parameter concentrations associated with nutrients and faecal coliforms. The Boffa Miskell, 2018 report also noted elevated sediment load in the watercourse assumed to be generated from agricultural runoff. This limited sampling indicates water quality being predominantly influenced by discharges from agricultural land, however the source of faecal coliforms at the HJV boundary is not understood. Dissolved metals were not analysed for in 2012 and only limited results are available from the 2016 sampling round. The report suggests that dissolved metals will typically be present in lower concentrations than particulate metals, however relative concentrations of particulate and dissolved metals in stormwater runoff will be largely dependent on the operational activities on each lot and the effectiveness of any stormwater protection / filtering. Water quality of the stream is noted to be generally poor but considered to be similar to the water quality within other catchments in the Hamilton area. From its predominantly rural catchment, the stream receives ongoing inputs of sediment, turbidity, nutrients, metals, and faecal pathogens (Boffa Miskell, 2018).

The Boffa Miskell (2018) report also states that the most important water quality issue associated with the upper catchment is elevated temperature and turbidity resulting from unplanted or sparsely planted watercourses and stormwater devices which has potential effects on aquatic ecology. This is addressed further in section 2.7.

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effect on receiving water sediment and water quality:

- Anticipated increase in stormwater contaminant load associated with the development of the upper catchment
- Reduction in agricultural contaminants from both the upper and lower catchments

The contaminant load used in the addendum water quality report (CH2M Beca, 2018b) included recent monitoring data collected for the HCC Comprehensive Stormwater Discharge Consent (T+T, 2017) which provided up to date Hamilton specific data for an existing industrial area. An analysis of the water quality of Hamilton's rural, semi-urban, and urban waterways, shows that although total contaminant loads may increase following urbanisation, contaminant concentrations can be expected to remain similar to pre-development due to the release of metal loads from historic wetland areas into groundwater (Boffa Miskell, 2018). The expected water quality of the industrial stormwater discharges is likely to be improved for nutrients and sediment, maintained for zinc, and slightly degraded for copper but within the tolerances of the aquatic species present (Boffa Miskell, 2018). This view on the contaminant load generally aligns with the findings of the water quality addendum report.

The reduction of agricultural inputs (due to development of the upper catchment as well as stream works in the lower catchment) is anticipated to reduce nutrient and pathogen loads in the stream and improve the water quality in this regard.

Management of Effects

To avoid or minimise the generation of contaminated stormwater entering the Mangaheka Stream, the following management techniques are included in the ICMP:

- Particular pollution control requirements for sites identified to include 'high risk' activities.
- Expansion of the list of activities considered high risk
- Use of a treatment train approach
- On-lot stormwater treatment via swale or raingarden etc
- Centralised wetland devices designed to reduce metal concentrations and suspended sediment
- Centralised devices to include gross pollutant traps and submerged outlets to trap hydrocarbons
- Regular water quality monitoring at the base of the upper catchment
- On-going monitoring programme for erosion, water and sediment quality
- A programme of stream works including erosion protection, stock fencing and riparian planting

Implementation of the above ICMP requirements will significantly reduce the metals concentrations, however an overall marginal increase in copper and zinc in the stream water is anticipated (CH2M Beca, 2018b).

Summary of Effects

The expected water quality of the industrial stormwater discharges is likely to be improved for nutrients and sediment, maintained for zinc, and slightly degraded for copper but within the tolerances of the aquatic species present (Boffa Miskell, 2018). It is recognised that metals concentrations in the stream water will generally remain no worse than current following development and hence is considered to be a less than minor adverse effect. However, considering the existing levels of faecal coliforms, nutrients and suspended sediment recorded in the stream waters, the ICMP provisions are anticipated to result in an overall enhancement and positive effect on water quality. A key element of this, as noted in Boffa Miskell (2018) is reduction in agricultural inputs to the stream.

Cumulative Effects

The analysis of water quality of Hamilton's rural, semi-urban, and urban waterways, referred to in the Boffa Miskell (2018) report, and noted above, discusses that although total contaminant loads may increase following urbanisation, contaminant concentrations can be expected to remain similar to pre-development even in catchments with large industrial areas. Considering the existing elevated metals in the Mangaheka Stream, further development may be likely to contribute a cumulative effect for metals accumulation, however, based on the findings of the Boffa Miskell report, the effect is anticipated to be less than minor.

2.7 Receiving Water Habitat, Ecology and Ecosystem Health

Existing Environment

The Mangaheka Stream has been identified as having a poor to moderate habitat diversity, with diversity increasing with distance downstream (Boffa Miskell, 2018 & Morphum, 2017) towards the Tangirau Wetland. The Boffa Miskell report identifies the stream to comprise a modified watercourse in the upper and mid-catchment which, downstream from Horotiu Road, transitions into a meandering wetland. The upper section provides poor habitat for fish and aquatic macroinvertebrates with slightly better aquatic habitat associated with localised areas of shelterbelts or dense riparian plant cover. All the modified watercourses, referred to in the report largely as drains, were noted to have poor habitat diversity, with uniform width and depth, few pools, poor water clarity, and minimal stable habitat, shade or riparian vegetation. The absence of, or low flow of stream waters during summer months in the upper parts are anticipated to encourage high temperatures, low dissolved oxygen, and poor water clarity which are likely to present fish passage barriers in this area.

Between 500m and 1km downstream of Horotiu Road, Mangaheka Stream becomes part of a wetland, occasionally within a very steep gully. The stream is recorded to vary considerably depending on the characteristics of the wetland at any given location, with areas of standing water and multiple flowing channels locally. The vegetation around this part of the stream has been observed to be very dense with almost 100% shade over various areas (Boffa Miskell, 2018). The stream is considered to have ecological significance as habitat for a range of threatened species in the middle and downstream part of the catchment (Boffa Miskell, 2018).

Boffa Miskell, 2018 suggests the stream channel in the wetland area is almost entirely natural with little evidence of historic modification. However, the report indicates that partial impoundment of the lower part of the stream channel has occurred in the past as a result of the State Highway39 road embankment construction and culvert invert levels, which has resulted in a wetland environment replacing a former stream environment.

The report also stated that there is a low abundance of sensitive macroinvertebrate taxa and limited fish species identified in the stream, however a fish survey conducted by Boffa Miskell in 2016 identified a total of four native species present within the stream: shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachii*), banded kokopu (*Galaxias fasciatus*), and black mudfish (*Neochanna diversus*); and one exotic species (mosquitofish) which correlates with the findings of surveys recorded by the NIWA Freshwater Fish Database for this stream. It is also noted that prior to development of the industrial land parcels in the upper catchment area in 2011/12, three native species (mudfish (12 individuals), longfin eel (2 individuals) and shortfin eel (16 individuals) were caught and translocated under permit from the upper catchment to the Tangirau Wetland.

The diversity and abundance of fish species is likely to increase substantially with distance downstream, as flows become perennial, channel morphology is less modified, habitat diversity increases, and riparian vegetation cover increases (particularly in the wetland area) including providing shaded areas which helps reduce water temperatures (Boffa Miskell, 2018).

Macroinvertebrate assessments conducted in 2012 and 2016 by Boffa Miskell indicated a range of different macroinvertebrate communities, the stream is characterised by a low Macroinvertebrate Community Index which reflects the low abundance of sensitive taxa, lack of habitat diversity, and indicates probable severe pollution. The instream aquatic community is comprised of pollution tolerant species that can withstand the harsh aquatic environment (Boffa Miskell, 2018).

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effects on receiving water habitat, ecology and ecosystem health:

- Increase in metals loads in stormwater runoff
- Improvement in water quality via reduction in agricultural contaminants from both the upper and lower catchments
- Improvement in water quality via stabilisation of stream banks and reduction of erosion susceptibility
- Improved habitat through reduction in suspended sediment, nutrient and faecal coliform loads via bank stabilisation, riparian planting and stock fencing
- Improved habitat though the development of shaded areas via riparian planting

As noted above, the species currently present in the stream are considered to be pollution tolerant. While the water quality for the stream is anticipated to improve overall, Boffa Miskell (2018) note that enhancement of habitat is an important factor in species protection and in the case of the Mangaheka Stream, is likely to have a greater influence than water quality alone.

Management of Effects

Any potential adverse effects on aquatic habitat, ecology and ecosystem health are planned to be addressed by the following management techniques as detailed in the ICMP:

- Use of centralised wetland devices with greater than 80% vegetation cover to improve water quality, reduce water temperatures and provide new habitats for aquatic species
- Use of a treatment train approach for stormwater pollution reduction
- Maintaining existing watercourses to retain existing habitats and established ecology
- Requirement for new watercourses to mimic natural environment to encourage establishment of habitats
- Requirement for no reticulated stormwater
- Requirement for water treatment devices to be established away from existing watercourses to maintain habitats
- Retain soakage opportunities including within peat soils where practical

- Programme of stream works including erosion protection, stock fencing and riparian planting to improve water quality, provide shade and encourage habitat development
  Monitoring plan including assessment of water quality, temperature, macroinvertebrate communities and fish species

It is anticipated that implementation of the provisions of the ICMP, including the programme of stream works and riparian planting, will provide opportunities for significantly improving water quality and enhancing aquatic habitats within the stream. Subsequently it is anticipated that improvement and expansion of habitats will allow numbers of the native fish species recorded in the stream to increase.

Summary of Effects

Provided that stormwater treatment maintains dissolved contaminant concentrations (particularly metals such as copper and zinc) within the same range as is currently experienced then they will remain within the tolerances of fish species present - as referred to in section 2.6 above. This would require the centralised devices to be designed as indicated (as per the ITS), and therefore development of the Rotokauri Structure Plan industrial and employment areas would be unlikely to affect fish diversity or alter the macroinvertebrate community (Boffa Miskell, 2018). The aquatic macroinvertebrate community diversity on the Mangaheka Stream could be improved with riparian vegetation replanting around the drain networks (Boffa Miskell, 2018). In view of the above it is considered that despite the anticipated contaminant load as detailed in CH2M Beca (2018b), the remaining improvements in water quality and opportunities for habitat enhancement will mean the positive effects of development on aquatic habitat, ecology and ecosystem health, and maintaining of metals loadings, with the ICMP provisions, will overall, represent an improvement.

Cumulative Effects

No cumulative effects on habitat, ecology and ecosystem health have been identified.

2.8 Receiving Water Riparian Vegetation

Existing Environment

In its present condition, there is very limited to no indigenous riparian vegetation present within the catchment. Boffa Miskell (2018) report that the majority of the catchment vegetation has been widely modified over time with historic vegetation cover, including peat bog vegetation, replaced with exotic pasture grasses or crops and with exotic shrubs and trees established as shelterbelts. The report notes that there is generally limited riparian vegetation adjacent to the stream with almost no canopy cover however, some cover is provided from shelterbelt trees. A fair amount of the waterway is fenced at the bank crest and periodically sprayed for weed suppression therefore riparian vegetation is very limited.

However, further downstream, nearing Horotiu Road, there is increasing cover where stock access is more limited. Where the wetland is present, and as noted above, vegetation is reported by both Boffa Miskell (2018) and Morphum (2017) to be very dense around the watercourse with good shading of the stream provided.

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effects on receiving water riparian vegetation:

- Significant increase in native species
- Establishment of a dedicated margin of riparian planting on the stream banks
- Constructed wetlands comprising at least 80% planted vegetation

The ICMP includes specific provisions for increasing riparian planting both within the upper catchment and along the stream within the lower catchment.

Development in the upper catchment does not include development of the existing watercourses and as such there are no impacts such as removal of existing riparian vegetation, changes in channel form, or loss of riparian habitat associated with the proposed development.

Management of Effects

Effects of the planned development on riparian vegetation will be managed by the following methods as detailed in the ICMP:

- Use of centralised wetland devices with greater than 80% vegetation cover
- Maintaining existing watercourses to retain and establish riparian vegetation
- Requirement for new watercourses to mimic natural environment
- Requirement for no reticulated stormwater
- Requirement for water treatment devices to be established away from existing watercourses to maintain habitats
- Land retirement corridor to be established along sections of the stream
- Programme of stream works including erosion protection, stock fencing and riparian planting
- Shift from traditional watercourse management techniques to monitoring and maintenance of native riparian planting

The identified programme of stream works and riparian planting is intended to reduce erosion and increase the area of riparian vegetation in the catchment, enhancing associated habitat values (as discussed in section 2.7 above). Following planting, a monitoring and maintenance programme will be implemented to assist the establishment of the planted species and work towards a self-maintaining system. The combination of this programme and the development of wetland devices in the upper catchment aims to increase the area of native vegetation and improve terrestrial and aquatic habitats throughout the length of the stream.

Summary of Effects

As a result of the above, considering the current absence of riparian vegetation in much of the catchment area, the planned replanting of riparian vegetation cover throughout the modified stream catchment may increase the viable habitat for macroinvertebrate species and fish species such as banded kokopu and giant kokopu further upstream in the catchment (Boffa Miskell, 2018). The planting will have a positive effect on receiving water riparian vegetation and also a positive effect on the stream ecosystem.

Cumulative Effects

No cumulative effects on riparian vegetation have been identified.

2.9 The Extent and Quality of Open Stream Channels

Existing Environment

The existing water channel of the stream from the upper catchment down to the beginning of the Tangirau Wetland comprise modified watercourses. Within the wetland the channel meanders and riparian vegetation provides shading of the stream. In the upper part of the lower catchment (from Koura Drive to the beginning of the wetland) the stream is also fed by channels draining adjacent farm land. The upper and middle sections of the stream together with existing farm drains which feed into it are reported to have limited to no riparian vegetation, with limited shading and a number of areas where the stream banks are eroding and destabilising (Morphum, 2017 & Boffa Miskell, 2018) providing increased suspended sediment to the water column. Morphum (2017) notes that blanket weed spraying of the bank vegetation, poorly located / maintained fencing and stock access are all contributing to the on-going bank destabilisation observed.

In the upper catchment area, the modified watercourses are anticipated to provide habitat for a limited number of aquatic species. The Boffa Miskell (2018) report notes that longfin eels and black mudfish had previously been removed from the area to the north of the Te Rapa Bypass within the upper catchment and relocated to the Tangirau Wetland prior to commencement of pre-development earthworks.

In some areas of the existing development of the upper catchment (areas B and F as indicated in Figure 3-2 of the ICMP), the modified watercourses have been planted in the manner of vegetated swales. Details of any design of these have not been provided, however the dense vegetation in these existing ditches is anticipated to provide some level of attenuation of stormwater contaminants prior to treatment within the HJV and Porters ponds. The general absence of riparian planting and, in particular, the lack of shading is identified in the Boffa Miskell (2018) report as key factors likely to lead to elevated water temperatures and limited habitat for aquatic species.

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effects on open stream channels:

- Significant increase in riparian vegetation including native species
- Shading of watercourses, reducing water temperatures and encouraging aquatic habitat development
- Stabilisation of stream banks
- Preservation of existing open stream channel aquatic environment
- Potential increase in sediment runoff from construction activities

The ICMP provisions of proposed stream works and emphasis on maintaining and enhancing existing watercourses will have direct positive effects on watercourse channel quality.

Management of Effects

As stated above, part of the intent of the ICMP is to improve the condition of existing natural and modified watercourses within the catchment and for the stream habitats and water quality to be enhanced via:

- Use of centralised wetland devices with greater than 80% vegetation cover
- Maintaining existing modified watercourses to retain existing and establish new riparian vegetation
- Requirement for new watercourses to mimic natural environment
- Requirement for no reticulated stormwater
- Requirement for water treatment devices to be established away from existing modified watercourses to maintain existing habitats
- Land retirement corridor to be established along sections of the stream
- Programme of stream works including erosion protection, stock fencing and riparian planting
- Shift from traditional watercourse management techniques to monitoring and maintenance of native riparian planting

The ICMP states that existing modified watercourses and stream channels are not to be altered by development in the upper catchment. However, they will be subject to a programme of works of erosion protection and increase riparian vegetation where necessary.

The ICMP monitoring plan details the programme of on-going assessment of the receiving environment and includes the following elements:

- Visual semi-quantitative assessment of bank and bed stability
- Semi-quantitative assessment of aquatic fauna presence and / or diversity
- Quantitative assessment of stream water quality
- Visual assessment for contaminants

Construction activities will be monitored by both HCC and WRC to avoid sediment laden run off to reach the stream in the upper catchment. Any construction activities in the vicinity of the stream in the lower catchment will be monitored by WRC.

Summary of Effects

The modified watercourses in the catchment are reported in Boffa Miskell (2018) and Morphum (2017) as having limited various areas of unstable banks, lack of riparian vegetation and degradation from stock access. Following the implementation of the ICMP provisions, in particular the programme of stream works including riparian planting, bank stabilisation, and the requirement for new stormwater channels to mimic natural features, it is anticipated that the extent and quality of open stream channels will be improved, representing a positive effect.

Cumulative Effects

No cumulative effects have been identified associated with the extent and quality of open stream channels.

2.10 Fish Passage for Indigenous and Trout Fisheries

Existing Environment

The Boffa Miskell (2018) report states that the NIWA Freshwater Fish Database (FFDB) contains 14 records for fish surveys at 7 sites undertaken from 1984 to 2016 in the Mangaheka Stream. Survey locations included Crawford Road, Horotiu Road, and within the modified watercourses in the upper catchment. No trout were observed during the surveys, however, a total of five species were identified including one exotic species (mosquitofish) and four native species namely shortfin eel (*Anguilla australis*), longfin eel (*Anguilla dieffenbachii*), banded kokopu (*Galaxias fasciatus*), and black mudfish (*Neochanna diversus*). Black mudfish and longfin eels are classified as declining species and are considered to be at risk.

Previously in the upper catchment, the fish populations of the two largest industrial land parcels (B and F) were removed prior to land development in 2011 – 2012 (Boffa Miskell, 2018). The fish were translocated to the Tangirau Wetland at Crawford Road. The species caught and transferred were: black mudfish (12), longfin eel (2) and shortfin eel (16). Anecdotal evidence indicates that giant kokopu, banded kokopu, and koura (*Paranephrops planifrons*) are also present within the wetland near Crawford Road. A fish survey conducted by Boffa Miskell in 2016 generally confirmed previous findings for fish species present.

Existing stormwater management devices are located in the upper catchment. Of these, Porter's pond, the HJV pond and 4 Guys pond are within the channel. These devices are anticipated to represent barriers to fish passage, however it should be noted that there is minimal existing stream channel upstream of 4-Guys pond. The culverts at Ngaruawahia Road and Horotiu Road are considered to represent only a minor barrier to fish passage as the permanent water flow entering the culvert is anticipated to allow capable climbing species such as eels, kokopu and black mudfish passage through the culvert and upstream (Boffa Miskell, 2018).

The Ecological Assessment report (Morphum, 2017) also notes that the diversity and abundance of fish species is likely to increase substantially with distance downstream, as flows become perennial, channel morphology is less modified, habitat diversity increases, and riparian vegetation cover increases. The report points out that the natural and modified watercourses, and wetland areas throughout the catchment with peat-influenced groundwater base flows will provide important habitat for threatened black mudfish and also identifies an environment suitable for black mudfish in one of the southern-most headwaters of the Mangaheka Stream, located directly to the south of the bypass.

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effects on fish passage:

- Construction of wetlands creating barrier to fish movements
- Potential increase in sediment load during construction altering stream bed morphology

One of the proposed wetlands (Device 7), which is located downstream of the existing HJV pond, has been identified as an ‘in-line” device (situated within the existing stream channel) due to existing physical constraints in the area. All other wetlands are proposed to be “off-line”. Once the on-line wetland is established, the wetland discharge structure is anticipated to prevent fish movements either up or downstream at this point. It is noted that the location of Device 7 is within the upstream section of an area identified within the Boffa Miskell (2018) report as potentially suitable for protection and enhancement of mudfish habitat. No other works within the stream channel, other than bank stabilisation and erosion protection works are planned and so no other potential barriers to fish passage are anticipated to be created.

Management of Effects

As noted above, the ICMP includes a number of requirements which will facilitate protection of fish passage. These requirements include:

- Maintaining existing modified watercourses to retain existing habitats and established ecology
- Requirement for new watercourses to mimic natural environment to encourage establishment of habitats
- Requirement for no reticulated stormwater
- Requirement for water treatment devices (other than Device 7) to be established away from existing modified watercourses to maintain habitats
- Encouragement to maintain peat soils, where possible, to support mudfish habitat
- Programme of stream works including erosion protection, stock fencing and riparian planting to improve water quality, provide shade and encourage aquatic habitat development
- Monitoring plan including assessment of water quality, temperature, macroinvertebrate communities and fish species

Should planned development in the upper catchment require watercourse crossings, these will require to be constructed with minimal or no disturbance to the channel.

As noted above, all but one wetland device are proposed to be off-line and hence will not represent a barrier to fish movements. Mudfish and eels were previously relocated from the upper catchment prior to the development of the existing building platforms north of the by-pass (Boffa Miskell, 2018). In view of this, the presence of mudfish and eels is not anticipated in the location of proposed Device 7. It should be noted that any future discovery and disturbance of habitat for black mudfish in the catchment will require a wildlife permit from the Department of Conservation and will be subject to a detailed management plan. Identification of mudfish habitat as well as other habitats and the presence of particular species will be monitored via on-going monitoring as per the monitoring plan in section 8 of the ICMP as well as potentially via development-specific monitoring where identified within development consent requirements issued by HCC.

The area identified by Boffa Miskell to be potentially suitable for protection and enhancement of mudfish habitat includes an area to the south of the bypass which would be downstream of Device 7. The ICMP encourages maintaining and enhancing habitats for black mudfish and this will be encouraged in this area and this may provide some level of mitigation for any effects associated with the development of Device 7.

Summary of Effects

As noted above, Device 7 is proposed to be developed within the existing stream channel while other devices are to be off-line. Device 7 represents a potential barrier to fish movement, however, upstream of this is the HJV pond which is also an in-line device and hence represents an existing barrier to fish passage. In view of this, while the development of off-line devices will not restrict fish movements in the stream, Device 7 is likely to. Nonetheless, due to the existing barrier associated with the HJV pond, the limited length of stream channel, the presence of potentially suitable habitat downstream of the device (as identified by Boffa Miskell, 2018) and the provisions in the ICMP, the adverse effects on fish passage associated with Device 7 is anticipated be minor. The Boffa Miskell (2018) report notes that high temperatures, low dissolved oxygen, and very poor water clarity in the existing stream channels are likely to present fish passage barriers. The provisions of the ICMP aim to improve water quality and reduce water temperatures via provision of shading from riparian planting and development of wetlands and hence improve conditions for fish within the stream channels throughout the catchment.

Cumulative Effects

The existing stormwater management devices (Porters pond, HJV pond and 4 Guys pond) are in-line and are considered to represent barriers to fish passage. The development of Device 7 will represent and additional barrier to fish passage albeit further downstream than the upstream devices that impede fish access. Considering the above, and that the other main headwater of the Mangaheka Stream will not be affected, overall the cumulative effect is anticipated to be minor.

2.11 Natural and Amenity Values

Existing Environment

As noted above, the upper catchment is planned to be developed as a light industrial / commercial area and as such will significantly reduce any natural landscape forms and values in that area. The underlying land use zoning anticipates effects associated with light industrial / commercial areas therefore this section considers only the natural and amenity effects associated with the Mangaheka Stream.

Morphum (2017) notes that existing stream management practices such as blanket weed spraying of stream bank vegetation, poorly located / maintained fencing and stock access are all contributing to the on-going bank destabilisation and limited aquatic habitat. In the lower catchment the landscape mainly comprises agricultural land with very limited, if any, native vegetation present. Downstream of Horotiu Road, the Tangirau Wetland is present. The Boffa Miskell (2018) report indicates that this wetland has, in part, been created previously through natural processes following the partial impoundment of the stream channel as a result of the State Highway 39 road embankment construction and culvert invert levels, which has resulted in a wetland environment replacing the former stream environment. The report anticipates that this wetland will be an important habitat for a range of fish, aquatic species and riparian vegetation.

A group (the Tangirau Restoration Group) has been formed which includes local iwi and local landowners which intends to protect and enhance the wetland. A marae is present in the vicinity of the wetland and it is expected that the wetland will be accessed for cultural and recreational use by local communities, therefore the wetland has cultural and recreational, as well as ecological importance.

Assessment of Effects

The proposed development of the upper catchment and stream works in the lower catchment will have the following actual or potential effects on natural and amenity values:

- Removal of rural landscape in the upper catchment
- Introduction of wetlands in the upper catchment
- Enhancement of aquatic ecosystems and overall water quality within the stream

The most significant effect is anticipated to be the removal of rural landscape in the upper catchment and replacement with light industrial / commercial development. It is noted that this area is zoned for industrial and commercial use within the Rotokauri Structure Plan.

Management of Effects

Management of effects of the proposed development on natural and amenity values is intended to be managed via the following methods:

- Improvement of water quality in the stream through use of centralised wetland devices with greater than 80% vegetation cover to improve water quality, reduce water temperatures and provide new habitats for aquatic species
- Use of a treatment train approach for stormwater pollution reduction
- Maintaining existing modified watercourses to retain existing habitats and established ecology in the upper catchment
- Requirement for new watercourses in the upper catchment to mimic natural environment to encourage establishment of habitats
- Requirement for water treatment devices to be established away from existing modified watercourses to maintain habitats in the upper catchment
- Programme of stream works including erosion protection, stock fencing and riparian planting to improve water quality, provide shade and encourage aquatic habitat development in the lower catchment
- Catchment monitoring planned to include assessment of water quality, temperature, macroinvertebrate communities and fish species

Development in the upper catchment is already underway and the ICMP includes a number of provisions to minimise effects on the stream, retain and protect existing watercourses and enhance the aquatic environment via riparian planting, erosion protection works and back stabilisation.

Summary of Effects

No detailed technical assessment of amenity values has been conducted for the ICMP development. It is considered in the ICMP that construction of wetlands in the upper catchment and improvement of water quality and aquatic habitat throughout the catchment, as noted above in sections 2.6 and 2.7 respectively, will provide some offset to the change in landscape in the upper catchment. The improvement of water quality is anticipated to provide an increase in amenity value for people accessing the Tangirau Wetland area for fishing and recreation, and the enhancement of aquatic habitats along the stream length via riparian planting with native species and the constructed wetlands in the upper catchment is planned to increase natural value within the catchment which at present has very limited native vegetation and low ecological value (Boffa Miskell 2018).

Overall, considering the existing environment and the proposed improvements in environmental conditions associated with the watercourses and planned increase in ecological value, it is anticipated that the effects will be positive.

Cumulative Effects

Urbanisation of rural land has been considered through the implementation of the underlying zoning in the catchment. The ICMP for the Mangaheka catchment, includes a number of provisions, noted above, which are aimed to improve the aquatic environment of the catchment and increase natural and amenity value. In view of the current low ecological value of the catchment and ongoing non-enhancing stream management practices, intended future enhancement of ecological value of the stream environment is not considered to represent a cumulative effect.

2.12 Existing Infrastructure

Existing Environment

The majority of the catchment comprises rural land of mainly agricultural use with localised residential settlements. Existing infrastructure in the catchment comprises:

- Public roads and culverts
- Private roads and culverts
- Residential dwellings and other buildings (farm building, businesses)
- Existing stormwater devices and vegetated watercourses in the upper catchment

Planned expansion of infrastructure in the catchment is detailed in section 2.5 of the ICMP and is further detailed in the Rotokauri Structure Plan.

Assessment of Effects

The proposed development of the upper catchment will have the following actual or potential effects on existing infrastructure:

- Potential flooding of roads and properties due to increased peak flows
- Potential backing up of culverts leading to flooding / new overland flow paths

Development of the upper catchment will increase the volume of stormwater runoff generated from this area. While detailed flood modelling has not been conducted, the 1D stormwater modelling (CH2M Beca, 2017b), discussed in section 2.4 above, and in section 2.6 of the ICMP, details the potential effects of MPD and indicates that implementing all proposed mitigation techniques, stormwater runoff from MPD can be accommodated to allow a no more than minor increase in peak flows downstream.

It is therefore concluded that developments implemented in accordance with the ICMP are unlikely to cause flooding of any existing buildings or infrastructure within the catchment that would not already be prone to flooding in the same recurrence interval storm (CH2M Beca, 2017b).

Management of Effects

The management techniques discussed in section 2.4 above and included within the ICMP are anticipated to avoid any adverse effects on existing properties or infrastructure. Specific methods for managing effects include:

- Detailed flood modelling for individual developments
- Consideration of overland flow paths during development design
- Catchment wide detailed flood hazard modelling by HCC following future LiDAR survey
- Investigation of reconnecting the Te Otamanui sub catchment to help reduce peak flows in Mangaheka Stream

The detailed flood modelling and investigation of Te Otamanui reconnection as noted above are identified as future actions in section 6.6 of the ICMP. Consultation conducted as part of the ICMP development process (reported in section 7 of the ICMP) has identified strong support for the Te Otamanui reconnection and this will require further assessment which is outside the scope of the ICMP.

Summary of Effects

The 1D modelling carried out has shown that the effects on water levels resulting from MPD can be mitigated by using attenuation basins such that the downstream flooding effects are less than minor. This mitigation also results in peak flows which are at or below existing development water levels - except where increases have been deemed appropriate and acceptable (CH2M Beca, 2017b).

Cumulative Effects

Cumulative effects are difficult to determine at the present time and assessment of this will require inputs from detailed flood modelling for both Mangaheka catchment and the Te Otamanui sub-catchment considering proposed development.

2.13 Existing Authorised Resource Use Activities

Existing Consents and Permitted Activities

Authorised resource use activities include permitted activities allowed under the Waikato Regional Plan and activities for which resource consents have been granted. Waikato Regional Council has issued resource consents for the activities listed in the following sub-headings:

- Authorised diversion and discharge
- Consents to discharge farm effluent
- Authorised surface water takes
- Authorised groundwater takes
- Earthworks
- Works over, on, in, or under the bed of a stream

The potential effects on each of these are discussed individually below.

Assessment of Effects

Authorised Diversion and Discharge

There are four permitted discharge consents in the upper catchment. Two of these relate to stormwater discharge to the Mangaheka Stream from plots within the partially developed commercial / light industrial area. One relates to wastewater discharge from a retirement home and one from a business – both of these latter consents are located on the southern side of the bypass.

As discussed in section 2.4 above, 1D stormwater modelling indicates similarity between pre and post development which can largely be attributed to the design of the proposed stormwater devices, which have been sized to attenuate predicted increased stormwater volumes. This means that implementation of the ICMP will assist in maintaining the stormwater capacity within the catchment to allow for authorised diversion and discharges at other locations within the catchment.

Consents to Discharge Farm Effluent

There are currently two consents for discharge of agricultural effluent to land recorded in the upper catchment on the southern side of the bypass. There are another three similar consents in the lower catchment. It is noted that in the upper catchment, following MPD, the discharge of agricultural effluent will no longer be taking place.

The proposed stormwater devices and the implementation of the ICMP will not affect the exercise of existing consents to discharge effluent onto land in the lower catchment.

Authorised Surface Water Takes

Based on the water quality results reported in the Boffa Miskell 2018 report, it is considered unlikely that the Mangaheka Stream is relied upon for surface water takes due to its poor water quality. The WRC maps site indicates a number of farms in the lower catchment with consented ground water takes. There are no surface water takes recorded. As a result, the activities provided for under the ICMP will not affect any surface water takes from within the catchment area.

Authorised Ground Water Takes

There are a number of groundwater takes recorded on the Waikato Regional Council website including for agricultural use and private water supply in the lower catchment area. The bores in this area are recorded to range from less than 25m in depth to over 100m. Water takes in the lower catchment are typically recorded to be for agricultural use and, in the upper catchment, two water takes are recorded to be used for dust suppression and to support construction activities as noted in section 2.1.

Reduction in soakage potential within the upper catchment is anticipated, as noted in section 2.1, to have an effect mainly on the local, upper catchment area, and considering the large area of the lower catchment, any reduction in soakage in this area is unlikely to impact groundwater recharge beyond the limited influence of the upper catchment.

Earthworks

The ICMP is not expected to have any adverse effects on existing consented earthworks activities. The conditions of these consents will require the management of sediment discharge from the earthworks sites, which is consistent with the requirements of the ICMP.

Works Over, On, In, or Under the Bed of a Stream

There are no known consents for works in the bed of a stream in the catchment. The 1D flood modelling has indicated that peak flows will not be increased above existing hence this is not anticipated to represent a particular adverse effect for any future works over and above existing effects. The implementation of any bank or stream bed works will be subject to the requirements of the Waikato Regional Plan, which will require that any associated risks are appropriately avoided, remedied or mitigated.

Management Effects

The ICMP provisions that manage the effects of stormwater discharge activities on peak, base flows, water quality including contaminant loads, scour and erosion will limit any adverse effects of development activities on existing authorised resource consents issued within the catchment.

Summary of Effects

Based on the above, the development of the upper catchment and programme of works planned for the lower catchment are anticipated to have a less than minor effect on existing resource use activities.

Cumulative Effects

No cumulative effects identified.

3 Waikato Regulatory Framework

The following sections outline how provisions of the ICMP align with Waikato-specific guidance and regulatory requirements. The Future Actions section of the ICMP (section 6.6) includes actions to help address any changes in the regulatory framework either currently in process (e.g. Plan Change 1) or to be identified in the future.

3.1 Vision and Strategy for the Waikato River

The Vision and Strategy for the Waikato River has been developed by the Waikato River Authority and lays out a set of objectives aimed to prevent further degradation of the Waikato River and improve water quality, associated environmental conditions and wellbeing of the river. The ICMP is committed to aligning with the values of the vision and strategy and pursuing its objectives where these are appropriate to the ICMP. Of the thirteen objectives (a – m) in the Vision and Strategy, the following table (Table 3) details the elements of the ICMP which address the relevant objectives of the Vision and Strategy.

Table 3: Relevant Objectives of the Vision and Strategy for the Waikato River as Addressed by the ICMP

Relevant Vision and Strategy Objective	ICMP Provisions
a. The restoration and protection of the health and wellbeing of the Waikato River.	▪ The ICMP anticipated overall improved water quality in the Mangaheka Stream via use of planted wetlands, stream protection works and riparian planting leading to reduction in nutrient loads, pathogens and suspended sediment as detailed in sections 4 and 6 of the ICMP. The Mangaheka Stream directly contributes to Waikato River and improvements to the water quality of the stream is consistent with Objective A.
d. The restoration and protection of the relationship of the Waikato region's communities with the Waikato River including their economic, social, cultural and spiritual relationships.	▪ Enhancement of the Mangaheka Stream including riparian planting and habitat creation to encourage and support populations of aquatic species including threatened species as detailed in sections 4 and 6 of the ICMP. ▪ Catchment-specific objective to ensure the Tangirau Wetland function and health is protected. Consultation with local groups including the Tangirau Wetland Restoration Group during development of the ICMP and detailed in section 7 of the ICMP.
g. The recognition and avoidance of adverse cumulative effects, and potential cumulative effects, of activities undertaken both on the Waikato River and within its catchments on the health and wellbeing of the Waikato River.	▪ Potential cumulative effects are considered in the ICMP. A key potential cumulative effect from flooding is addressed via proposed detailed modelling as detailed in section 6.6 of the ICMP.
h. The recognition that the Waikato River is degraded and should not be required to absorb further degradation as a result of human activities.	▪ Planned development of centralised wetlands combined with on-lot protection measures to reduce contaminant loads as far as possible. ▪ Programme for stream protection and riparian planting to enhance aquatic habitats in the Mangaheka Stream,
i. The protection and enhancement of significant sites, fisheries, flora and fauna.	

Relevant Vision and Strategy Objective	ICMP Provisions
j. The recognition that the strategic importance of the Waikato River to New Zealand's social, cultural, environmental and economic wellbeing is subject to the restoration and protection of the health and wellbeing of the Waikato River.	and reduce influence of agricultural activities on stream water quality as detailed in sections 4 and 6 of the ICMP. Monitoring of ICMP provisions to confirm effectiveness and remaining/ emerging issues is detailed in section 6.7 of the ICMP.
k. The restoration of water quality within the Waikato River so that it is safe for people to swim in and take food from over its entire length.	

3.2 Waikato Regional Policy Statement

The purpose of the WRPS is to achieve the purpose of the Resource Management Act by providing an overview of the resource management issues of the region, and policies and methods to achieve integrated management of the natural and physical resources. The following table indicates key policy provisions that relate to stormwater and an indication of how these are addressed by the ICMP.

WRPS Policies	ICMP Provisions
Policy 6.1 makes provision for planned and coordinated subdivision, use and development. The implementation methods associated with this policy include: ■ The requirement for district plan zoning for new urban development (and redevelopment), subdivision and consent decisions to be supported by information which identifies how stormwater will be managed having regard to a total catchment management approach and low impact design methods.	■ The ICMP identifies a range of stormwater management techniques considering effects on the entire catchment. Details of the provisions are provided in the Means of Compliance table in section 6.5 of the ICMP
Section 6A outlines general development principles, with the expectation that new development should: ■ Avoid as far as practicable adverse effects on natural hydrological characteristics and processes (including aquifer recharge and flooding patterns), soil stability, water quality and aquatic ecosystems including through methods such as low impact urban design and development (LIUDD). ■ Adopt sustainable design technologies, such as the incorporation of rain gardens, rainwater harvesting and grey water recycling techniques where appropriate.	■ The ICMP includes requirements for groundwater monitoring in advance of wetland development to assess and minimise potential effects on the hydrogeological regime and provide appropriate inputs for effective wetland design (ICMP section 6.3) ■ Maintaining and enhancing existing aquatic habitats is included as a requirement for new development in the catchment together with a planned programme of stream erosion protection works and riparian planting to improve and enhance existing conditions (ICMP sections 4 & 6) ■ Rain gardens, water detention and re-use tanks and encouragement for developers to reduce impervious areas, are included in the Means of Compliance table (Table 6.3)
Policy 8.3 seeks to maintain or enhance water quality by reducing sediment that is derived from human based activities and by reducing microbial, nutrient and other identified contaminants. A range of implementation methods support the policy including those which require	■ The ICMPO includes planned development of centralised wetlands combined with on-lot protection measures to reduce contaminant loads as far as possible

WRPS Policies	ICMP Provisions
regional plans to control point source discharges of contaminants. The implementation methods associated with this policy include: ■ Management of the adverse effects of land use and activities on fresh water bodies from non-point source discharges of nutrients and other contaminants. ■ Promotion of land-based mitigation of stormwater, including the use of wetlands and low-impact options.	■ Requirements for operational sites to identify potential high risk activities and implement a pollution plan

3.3 Waikato Regional Plan

The Waikato Regional Plan recognises the importance of effectively managing discharges to land and water. Stormwater discharges are addressed in section 3.5 of the Plan. Key policies of the Waikato Regional Plan and how they are addressed in the ICMP is outlined in the table below.

WRP Policies	ICMP Provisions
Policy 1 aims to minimise any adverse effects of contaminants and sediment from operational discharges on aquatic habitats	■ The Means of Compliance Table (Table 6.3 in the ICMP) details a range of requirements that aim to minimise stormwater contaminant loadings and improve water quality and enhance aquatic habitats
Policy 2 aims to ensure that any discharge to water does not result in significant flooding, erosion or siltation.	■ Section 2.6 of the ICMP provides an assessment of flood modelling for the catchment and details provisions for minimising the potential for flooding and associated impacts
Policy 3 promotes land-based treatment systems where soil type and drainage will allow and where adverse effects are minor or are less than those from a direct discharge to water.	■ Section 2.6 and section 6 discuss stormwater treatment devices and promote the use of a treatment train approach, and provision of soakage options
Policy 7 encourages at-source management and treatment of stormwater discharges to reduce adverse water quality and water quantity effects of discharges on receiving waters.	■ Sections 6.3 and 6.5 of the ICMP refer to the use of on-lot treatment as part of an overall treatment train

3.4 Healthy Rivers Wai Ora

The Healthy Rivers proposed Waikato Regional Plan Change 1 seeks to reduce the amount of contaminants entering into the Waikato and Waipā catchments to achieve our Vision and Strategy / Te Ture Whaimana o Te Awa o Waikato of making the river swimmable and viable for food collection along the entire length of the river.

The proposed plan has an emphasis on rural land use and includes new rules for inclusion in the Waikato Regional Plan relating to nutrient levels and point source discharges. The proposed plan change is not currently in place, however the ICMP includes specific provisions that address contaminant load reduction, reduction of erosion and suspended sediment loads; as well as a programme of stream protection and riparian planting works aimed at reducing impacts from agricultural activities within the catchment and improving water quality and aquatic habitats. In view of this it is considered that the ICMP aligns with the anticipated requirements of Plan Change 1 when it comes into effect. The ICMP is subject to periodic review and revision (typically every five years) which allows any changes in regulatory requirements to be incorporated in subsequent versions.

4 Conclusions

This assessment has determined that following implementation of the provisions of the ICMP, the environmental effects of stormwater discharge activities undertaken in the Mangaheka catchment will be as below:

Adverse effects considered less than minor / minor:

- Effects on natural features, surface water bodies and aquifers
- Effects on sites of historic and cultural significance
- Effects on flood risk
- Effects on the receiving water hydrology
- Effects on the receiving sediment and water quality
- Effects on fish passage for indigenous and trout fisheries
- Effects on existing infrastructure
- Effects on existing authorised resource use activities

Positive effects:

- Effects on public health
- Effects on the receiving water habitat, ecology and ecosystem health
- Effects on the receiving water riparian vegetation
- Effects on the extent and quality of open stream channels
- Effects on natural and amenity values

There are no elements of the catchment where "no effects" have been determined.

Cumulative Effects

In addition to the above, there is a potential for cumulative effects for the following:

- Effects on natural features, surface water bodies and aquifers
- Effects on flood risk
- Effects on the receiving sediment and water quality
- Effects on the receiving water hydrology

5 References

- Morphum Environmental Ltd, May 2017: Mangaheka Watercourse Assessment and Programme of Works
- CH2M Beca, June 2017: Mangaheka Integrated Catchment Management Plan - Stormwater 1D Modelling Report
- Boffa Miskell, June 2018: Mangaheka Stream Assessment of Ecological Values to inform Integrated Catchment Management Plan
- CH2M Beca, February 2018a: Mangaheka Water Quality Assessment
- CH2M Beca, July 2018b: Mangaheka ICMP – Addendum to Water Quality Report
- Hamilton City Council, March 2015: Upper Mangaheka Draft Integrated Catchment Management Plan
- Waikato River Authority, July 2011: Vison and Strategy for the Waikato River
- Hamilton City Council, Comprehensive Stormwater Discharge consent 105279, (granted by Waikato Regional Council – expires 30th June 2036)
- Nga Mana Toopu o Kirikiriroa (July 2004) Cultural Investigations Report, prepared for Transit New Zealand for the Te Rapa Bypass Notice of Requirement.

Appendix G

Hydrogeology Assessment

File Note

By:	James Botting	**Date:**	13 April 2018
Subject:	Mangaheka ICMP - Desktop Hydro Assessment	**Our Ref:**	3208842

A desktop review of available information for the Mangaheka catchment (geological maps, Beca site investigation database, New Zealand Geotechnical Database (NZGD) and the WRC GIS Groundwater database) indicates that the geology for the Mangaheka catchment is broadly similar to the Rotokauri catchment. The soil profile is expected to be comprised of sands, silts, gravels and peats of the Piako (Hinuera Formation) and underlying Walton Sub-groups, with the latter outcropping and forming the low lying hills along much of the northern boundary of the catchment and some isolated low lying hills in the lower catchment.

The similarity in geology allows some parallels to be drawn to Rotokauri work; however, it is recognised that the inherent variability of the Hinuera Formation (due to the laterally migrating river system) can result in variability in profile and lateral extent of the geology over short distances. This will have implications for site specific design of structures and stormwater devices. From the borelogs reviewed, it appears surface and subsurface peat or organic silt deposits may be more prevalent in the Mangaheka catchment than in the Rotokauri catchment.

A more significant gap in understanding relates to groundwater levels which in the upper catchment is generally expected to be at a depth of 1 m to 2 m below ground level (bgl). We note that these levels are based on hand augered holes and test pits which provide one-off measurements (during winter) and which do not provide any indication of seasonal range. Groundwater level monitoring at Rotokauri indicates a seasonal range typically in the order of 1.5 – 2 m but in places as much as 3 m or as little as 0.5 m. This variability in water level presents some risk in terms of design water levels for wetlands and stormwater devices. Generally, HCC will require wetlands to be lined to mitigate the risk of not having a permanently wet base; however, this may not always be the case.

Implications for design of devices include:

- If devices are unlined, there will be a need to understand summer groundwater level to provide some level of certainty that the wetland remains wet, and, winter levels to understand the potential groundwater inflows to the wetland and any impact on storage capacity
- If unlined and below summer groundwater level, there will be a need to understand drawdown and effects such as risk of consolidation settlement, impacts on existing devices such as Porters Pond which is unlined, or effects on surface water bodies
- If lined and below the groundwater level there will be a need to consider uplift pressures on the base and also any drawdown effects that might occur during construction (such as those observed during construction of the Far Western Interceptor at Rotokauri)

For these reasons, groundwater level monitoring is recommended in order to better understand the seasonal range and implications for design and assessment of effects. Noting that development could be in 30 years' time and that the specific location of devices is not presently known, this is a future action for developers. The Means of Compliance (for sub-catchments not yet developed) outlines that the developer will undertake groundwater level monitoring for a minimum of 1 year, and, that the design will need to use this data to consider design implications and effects. We note 1 year of monitoring is a minimum and that design will also need to consider drought and peak conditions.

Means of Compliance Table

Sub-Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
Summary for sub-catchments				
All sub-catchments (not yet developed)	**Depth to groundwater** at the location of each ***lined*** stormwater device to be determined through groundwater level monitoring for a minimum of 3 readings over a period of 3 to 4 months sufficient to assess the **winter groundwater level**, at a minimum of 1 groundwater monitoring well(s) / piezometer(s)location. Monitoring wells should be of suitable depth and construction to monitor the near-surface groundwater table only (e.g. screened response zone 2 – 5 m below ground level).	To be assessed at time of resource consent	As required by development	Developer
All sub-catchments (not yet developed)	**Depth to groundwater** at the location of each ***unlined*** stormwater device to be determined through groundwater level monitoring for a minimum of monthly readings over 9 months at a minimum of 1 groundwater monitoring well(s) / piezometer(s) location. Monitoring wells should be of suitable depth and construction to monitor the near-surface groundwater table only (e.g. screened response zone 2 – 5 m below ground level).	To be assessed at time of resource consent	As required by development	Developer

It is expected that peat will likely be removed by developers. Where peat is to be removed, the implications for groundwater flow will need to be considered (i.e. removal of an extensive, thick deposit supporting a perched groundwater level and replacement with sand may result in discharge of the perched level and change in direction and flow of shallow water table). We note that there are ecological benefits to keeping peat (e.g. mud-fish habitat) thus it is encouraged that where peat is outside of the development footprint, it should be maintained. Where in the development footprint, the Means of Compliance will require the developer to:

- Identify if peat to be removed (and over what extent and depth);
- Advise if being replaced (and if so, with what); and
- Provide an assessment that this does not change shallow groundwater flows sufficient to cause any adverse effects (including but not limited to consolidation settlement, drawdown of surface water bodies etc.)

Means of Compliance Table

Sub-Catchment (where)	Requirement (what & why)	Assessment Timing (Key Approvals) (how)	Priority / Staging (when)	Funding (who)
Summary for sub-catchments				
All sub-catchments (not yet developed)	Where present in the development footprint and scheduled for removal**,** the volume of **Peat to be removed shall be identified** (and over what extent and depth removal is to occur). The developer will be required to advise if peat is being replaced (and if so, with what). A groundwater / geotechnical assessment is required that demonstrates that this does not change shallow groundwater flows sufficient to cause any adverse effects (including but not limited to consolidation settlement, drawdown of surface water bodies etc.)	To be assessed at time of resource consent	As required by development	Developer

James Botting

Appendix H

Assessment of ICMP against Tai Tumu Tai Pari Tai Ao – Waikato Tainui Environmental Plan

<table>
<tr><th>Tai Tumu Tai Pari Tai Ao</th><th>Comments</th></tr>
<tr><td colspan="2">Engagement

6.1.3 It is important that a relationship is formed between Waikato-Tainui, as kaitiaki, and the applicant, developer, and local authorities during the planning and initial stages of development, construction, operation, and through to completion. The key to this relationship is tikanga, transparency, good faith, patience and understanding. Consultation with Waikato-Tainui members is not achieved by merely having a discussion about resource consents, plans, and policies. How the concerns, interests and intentions put forward by Waikato-Tainui are considered should be reflected in any outcomes, plans, conditions and policies produced.

6.1.4 Early involvement of Waikato-Tainui in major projects may be accomplished by participation in pre-application meetings, through meetings with the project applicant and local authorities and through the review of draft or initial documents prepared by the applicant. Early involvement will often prevent later delays as potential problems can be eliminated and concerns about conflicting uses can be resolved earlier in the process. Ideally consultation and engagement with Waikato-Tainui should be completed prior to formally filing a consent application or plan.

6.1.5 Waikato-Tainui considers that pre-application consultation on a proposed resource use or activity is best practice to ensure that appropriate consideration is given to matters of importance to Waikato-Tainui. Waikato-Tainui also believes that undertaking a best practice consultation and engagement process will, in the longer run, be more beneficial than the cost of managing a poor process or not engaging in any process.</td></tr>
<tr><td>Objective – collaboration and consistency</td><td>Comment</td></tr>
<tr><td>10.5.1 Resource management, use and activities within the Waikato-Tainui rohe are consistent with the vision, mission, values and strategic objectives of Whakatupuranga 2050.

Policy – collaboration and consistency

10.5.1.1 To ensure that resource management, use and activities within the Waikato-Tainui rohe are consistent with the vision, mission, values and strategic objectives of Whakatupuranga 2050.</td><td rowspan="3">Although HCC initiated engagement with mana-whenua in the later stages of the development of this ICMP, the engagement has been undertaken with tikanga, transparency, good faith, patience and understanding. The parties have listened and engaged openly and have shared their concerns and views.

A collaborative approach to achieving the objectives of Whakatupuranga 2050, Te Ture Whaimana and the ICMP outcomes has been discussed and intended to be progressed through the methods of implementation (in particular the means of compliance and future actions tables).</td></tr>
<tr><td>Objective – Te Ture Whaimana prevails</td></tr>
<tr><td>11.7.1 Te Ture Whaimana prevails in any resource management, use and activity within the Waikato River catchment in the Waikato-Tainui rohe.

Policy – Te Ture Whaimana prevails

11.7.1.1 To ensure that Te Ture Whaimana prevails in any resource management, use and activity within the Waikato River catchment in the Waikato-Tainui rohe</td></tr>
<tr><td>Objective – Waikato-Tainui able to access and</td><td>Comment</td></tr>
</table>

undertake customary activities	
14.3.1 Waikato-Tainui access to and ability to undertake customary activities and resource use, including along the margins of waterways, is protected and enhanced. ***Policy – access is provided*** **14.3.1.1** To ensure that Waikato-Tainui is provided access to regionally, spiritually, and culturally significant sites to undertake customary activities and resource use.	Mana whenua expressed concern during the site visit that their ability to undertake customary activities and resources use has been restricted due to the private ownership of much of the land in the catchment. The centralised devices will be vested in Council and there is more opportunity for these areas to be publicly accessible (to harvest harakeke and other resources). While it is important to note much of the vegetation in the waterways is intended to remove pollutants and contaminants, it would be desirable for adjacent areas to be landscaped with locally sourced harakeke and other traditional plants to be accessible for customary use.
Objective – Waikato-Tainui customary activities are protected and enhanced	**Comment**
14.3.2 The ability of Waikato-Tainui to undertake customary activities is protected and enhanced within the rohe, particularly on, in, and around waterways and their margins, including wetlands and reserves. ***Policy – permitting customary activities*** **14.3.2.3** To recognise and provide for recognised Waikato-Tainui customary activities. ***Policy – restore, protect and enhance customary activities and resource uses*** **14.3.2.4** To restore, protect and enhance customary activities and resource uses.	As stated above, the wetland devices and treatment swales are primarily removing residual contaminants from adjacent industrial sites, before discharging cleaned water into the Mangaheka stream. It is expected the downstream environment will benefit from this additional contaminant removal, which would have an accrued benefit in the Tangirau Wetland and Waipa/Waikato river receiving environments.
Objective – Indigenous Biodiversity	**Comment**
15.3.1 The full range of Waikato ecosystem types found throughout the Waikato-Tainui rohe are robust and support representative native flora and fauna. ***Policy – Indigenous biodiversity*** **15.3.1.1** To ensure that the full range of Waikato ecosystem types found throughout the Waikato-Tainui rohe are robust and support representative native flora and fauna	Council has a list of preferred wetland and landscaping species that reflect the unique Waikato conditions. Council reviews this list when new information is available to achieve successful plant and landscape environments within these highly modified and developed urban areas.
Objective – Site Management Protocols	**Comment**
16.3.1 Site management protocols exist to ensure a	Council actively includes site management protocols

precautionary approach to site works to manage the potential for waahi tapu and taonga tuku iho discovery. ***Policy – Site Management Protocols*** **16.3.2** The Project Manager for a project or consented activities incorporates site management protocols and other protocols in this chapter into the site management plan so as to ensure a precautionary approach to site works to manage the potential discover of waahi tapu and taonga tuku iho. ***Policy – Active Engagement*** **16.3.3.2** Waikato-Tainui marae are actively engaged to ensure the appropriate management of waahi tapu and waahi tuupuna	on resource consent applications. Where insufficient information is available to identify particular sites of interest, these site management protocols seek to alert the relevant developers to the potential for discovery of waahi tapu and taonga tuku iho when earthworks and re-development of rural land is consented.
Objective – The relationship between Waikato-Tainui and Water	**Comment**
19.4.1 Waikato-Tainui engage and participate in the highest level of decision-making on matters that affect waters in the Waikato-Tainui rohe. ***Policy – decision making*** **19.4.1.1** To ensure that Waikato-Tainui engage and participate in the highest level of decision-making on matters that affect waters in the Waikato-Tainui rohe.	Council is engaging with Waikato-Tainui and mana whenua representatives on the wider ICMP programme across the City, to increase awareness of the various stormwater management and treatment initiatives Council is embarking on to give effect to Whakatupuranga 2050 and Te Ture Whaimana in a genuine way.
Objective – water quality	**Comment**
19.4.2 Water quality is such that fresh waters within the rohe of Waikato-Tainui are drinkable, swimmable and fishable in all places (with water quality to the level that Kiingi Taawhiao could have expected in his time). ***Policy – water quality*** **19.4.2.1** Regulators to set clearer and higher water quality targets, and to develop and incentivise methods to achieve these targets.	It is anticipated that the various measures for removing heavy metal and 'at-source' contaminants from industrial sites included in the outcomes of the ICMP will contribute to an overall improvement in the water quality of the Mangaheka Stream and the Waipa and Waikato Rivers.
Objective – Water Quality (integrated catchment management)	**Comment**
19.4.3 An integrated and holistic approach to management of water is achieved.	Through improved water quality measures, 'at-source' and treatment train contaminant removal methods and volume control, the ICMP seeks to develop an

Policy – integrated catchment management **19.4.3.1** To ensure that there is an integrated and holistic approach to catchment management that is effective and informative and the scope of planning is broad.	integrated 'whole of catchment' approach to the management of stormwater from the development of the upper catchment, through to the potential recharge of the Te Otamanui sub-catchment and restoration of the Tangirau Wetland and receiving environments.
Objective – Wetland mauri and condition, hauanga kai, habitat	**Comment**
20.3.1 Existing wetlands are protected and enhanced ***Policy – improvement to the condition of existing wetlands*** **20.3.1.1** To encourage improvements to local hydrology (where possible) to support healthy wetland function, and restoration of locally appropriate wetland biodiversity within local planning and land management practice. ***Policy – land use planning and management adjacent to wetlands*** **20.3.1.2** To ensure that all land use practices that have the potential to impact on wetlands have efficient sediment, drainage, discharge, fertiliser application, and riparian buffer control practices in place to ensure that adverse impacts on wetlands are prevented. ***Policy – land development*** **21.3.1.2** A ll major excavation works that have the potential to impact on waterways shall have sufficient erosion and sediment control measures in place to ensure that adverse effects on water bodies are managed ***Policy – riverbank erosion*** **21.3.1.3** To ensure that riverbank erosion, including the erosion of river islands is effectively managed.	As above, the development of on-lot measures, reduced stormwater volume, and a treatment train approach to the removal of contaminants, it is anticipated existing wetlands (like the Tangirau Wetland) will be improved, and new wetlands will be created in the existing environment (which existed historically before pastoral land drainage practices in the area). Stormwater discharge consents will still be required for all site development (in excess of 1 hectare), and a programme of downstream erosion works has been identified in Council's long term plan, to undertaken erosion protection works in the Mangaheka Stream to address the potential erosion effects resulting from the increased stormwater volume up-stream.
Objective – achieve integrated catchment management, including floodplain and drainage management	**Comment**
21.3.4 Integrated catchment management occurs across the entire rohe of Waikato-Tainui, including in catchments that impact on, or flow into the Waikato-Tainui rohe. Integrated catchment management	Council will continue to develop integrated catchment management plans (for the three waters it manages) in collaboration with the Waikato Regional Council and Waikato-Tainui. All catchments within the City

includes the effective and sustainable management of floodplains and drainage areas to promote natural habitat enhancement. ***Policy – achieve integrated catchment management including flood plan and drainage management*** **21.3.4.1** To promote the development and use of integrated catchment management plans that adequately considers land use, floodplain and drainage management and that promotes habitat restoration.	are affected by Council's existing comprehensive discharge consent conditions and Te Ture Whaimana. Some of the surrounding rural catchments are in a transitional phase of management by regional land drainage committees, and as areas of rural land become urbanised, may no longer be appropriate.

Appendix I

Hamilton City Council Mangaheka ICMP Communication Plan

Communication plan

Mangaheka ICMP

14/12/2017

Background

Hamilton City Council is required to develop Integrated Catchment Management Plans (ICMPs) for the 16 hydrological catchments extending into the city boundary. The requirement for ICMPs comes from condition 30 of the *Comprehensive Stormwater Discharge Consent #105279* from Waikato Regional Council, which authorises the diversion and discharge of urban stormwater runoff. The development of the Mangaheka ICMP is supported by the ICMP Business Case (Hamilton City Council, March 2016) and the Rotokauri Structure Plan (Hamilton City Operative District Plan 2017).

Current Situation

There are various different ICMPs managed by different project managers within the Council, this communication plan will act as a 'live template' for all ICMP projects.

Hamilton city council's vision

Be a high performance organisation; respected by all.

Hamilton city council's purpose

To improve the wellbeing of Hamiltonians by advocating for Hamilton and providing quality infrastructure, public services and regulatory functions.

An ICMP's Purpose

The purpose of an ICMP is as follows:

- To provide guidance to developers, District Plan regulators, Regional Council regulators, and Asset Managers, on how water, wastewater and stormwater, in a catchment, will be managed in an cohesive way and in accordance with proposed new land uses that occur with development. This includes provision of conceptual network service plans and flood hazard maps.
- To ensure the three waters networks, in the catchment(s), can accommodate growth while avoiding treating or mitigating adverse effects that can occur from land use change. This includes effects of flooding and erosion, ad-hoc stormwater discharges and unreasonable increase in water demand and wastewater generation.
- To ensure the existing three water networks are not compromised and any future networks, to accommodate growth, complies with RMA requirements, Hamilton Urban Growth Strategy (HUGS), the Council's Level of Service, the Council's Comprehensive Stormwater Discharge Consent, water conservation and demand management objective.

- To provide a platform (means of compliance) for requiring the implementation of water sensitive devices including the re-use of stormwater and greywater to reduce demand of water, minimise wastewater generation and minimise need for three water infrastructure.
- To provide a platform (means of compliance) for requiring the treatment of on-lot stormwater prior to entering the receiving environment, which may include on-lot treatment devices, centralised devices and a network of swales in between where appropriate and necessary.

The purpose of the Mangaheka ICMP is to:

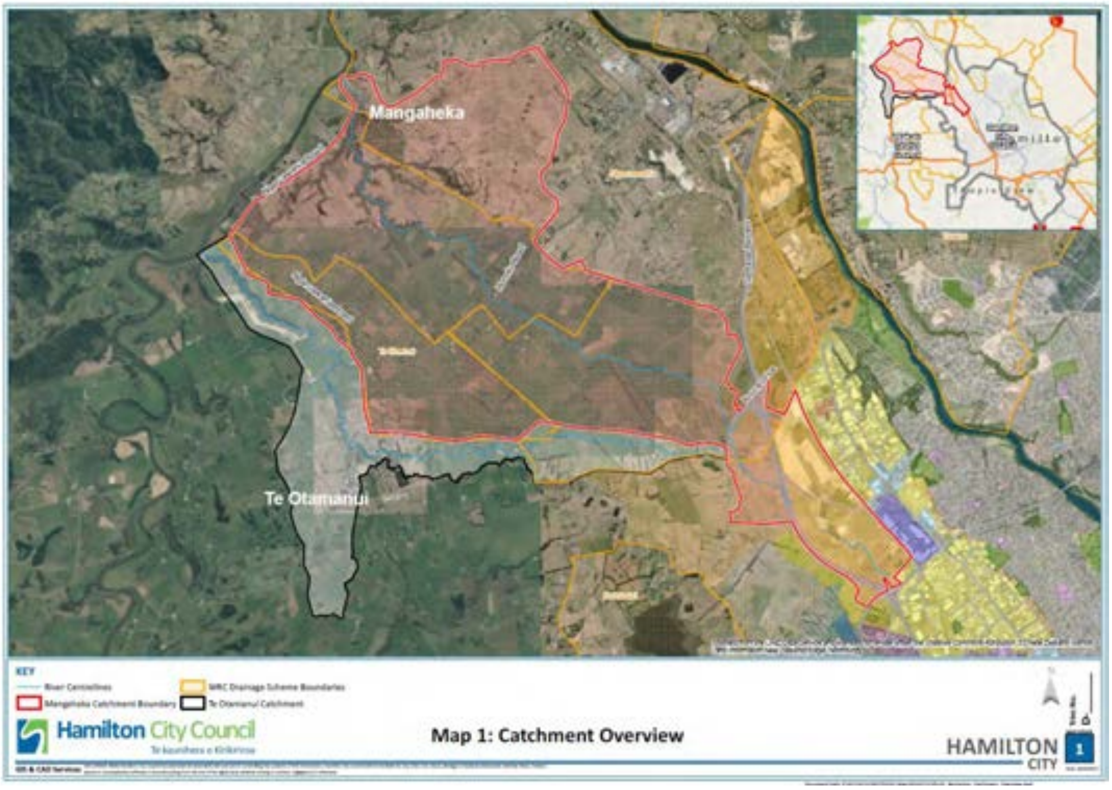
- Effectively manage the natural and physical resources in the catchment including, land-use water resources and infrastructure.
- Inform the implementation of the Rotokauri Structure Plan.
- To accommodate growth by planning for three waters infrastructure and considering the effect on social, cultural and environmental values.

CATCHMENT SUMMARY

The greater Mangaheka catchment covers an area of approximately 2,080ha with around 86% of the catchment being within the Waikato District Council boundaries in rural pastoral production, and the remaining 14% being within Hamilton City Council boundaries, and features a mixture of industrial and rural landuses, to be fully urbanised in the future. It is bound to the west by the Rotokauri and Te Otamanui catchments, and Te Rapa catchment to east.

Within Hamilton City Council boundaries, the catchment includes the 177ha Rotokauri Structure Plan industrial area between the Waikato Expressway and the North Island Main Trunk railway and an employment zone between the Expressway and Burbush Road/Koura Drive. More than 120ha of industrial land in this area has been developed since 2012. Farm drains have been replaced with stormwater treatment swales and detention basins with discharge points into the downstream drain network. The Waikato Expressway and connecting roads was constructed with stormwater treatment swales discharging into existing, new and realigned drains within the Mangaheka catchment.

Downstream of Koura Drive within Waikato District, the Mangaheka Stream has a rural catchment (mainly dairy farming or grazing) comprised of artificial drains, modified stream, and an extensive gully wetland. The adjacent catchments are Te Rapa Stream to the east (discharging into the Waikato River) and Lake Rotokauri to the west (discharging to the Waipa River).



Project Goal

External

- To clearly communicate with the public about what we plan to do and why we are doing the Mangaheka ICMP.
- To gather views from landowners and key stakeholders about the ICMP issues, outcomes and mitigation measures

Internal

- To have clear and concise internal communication with all Council units that are involved on the project.
- To gather the views from internal staff about different aspects that might affect them with this ICMP.

Communication Goal/Objectives

- Ensure key stakeholders and internal/external audiences are aware of the ICMP.
- Help the community have sense of pride and ownership of the Mangaheka ICMP.
- Ensure background information is available and accessible for people seeking more information on the ICMP process.
- Manage media enquiries and, where possible, proactively use media to promote the ICMP development.
- Promote the Council’s key messaging through the communication of this project.

Audiences

*Stakeholder spreadsheet can be found at **D-2536336**, stakeholders to be updated as and when needed.*

Internal audiences	Key Stakeholders	General external audiences
Elected Members	Landowners within HCC boundary. • with a proposed centralized device on their property, • within a stormwater sub-catchment discharging to that device • Within a sub-catchment discharging direct to the stream.	Hamilton residents
Senior Leadership Team	Landowners within WDC boundary where Mangaheka Stream bounds their property (including those properties affected by erosion mitigation works)	Waikato District residents
Infrastructure team	Major Developers (Porters, Hamilton Joint Venture) refer stakeholder database	Media local
Parks and Open Spaces	Mangaheka Drainage Catchment landowners not captured by above	Media regional
City Growth	Local Iwi (THaWK, Waikato Tainui)	
	Local Govt (Waipa DC, WRC)	
	Central Govt (NZTA)	

**Note: Landowners (in this instance) are classed as anyone who has proposed strategic infrastructure on their land*

KEY MESSAGES

Visionary

Hamilton City Council is improving the wellbeing of Hamiltonians by advocating for Hamilton and providing quality infrastructure, public services and regulatory functions.

The development of this ICMP aligns with our strategic imperatives of embracing growth, building a great river city and being best in business.

Specific (plain English, suitable for quotes)

- An Integrated Catchment Management Plan (ICMP) identifies how waters, stormwater, water and wastewater are managed in line with growth projected in the catchment, while giving effect to Council’s comprehensive stormwater discharge consent conditions, and the Vision and Strategy for the Waikato River.
- When completed, this ICMP will enable growth and property development within the Structure Plan area to proceed in a managed way, while allowing us to understand the effects on existing infrastructure, waterways and the wider environment, including discharges to the Waipa and Waikato Rivers.
- Landowners, special interest groups, property developers and other local residents will have the opportunity to provide feedback on the plan as it is developed.

- This catchment includes most of the Industrial/employment areas of the Rotokauri Structure Plan in the north west of Hamilton. The remaining 86% of the catchment is rural and lies within the Waikato District.
- Each catchment is unique and requires significant investigation to understand how stormwater flows through the catchment, the values of the receiving environment (gullies, streams and lakes) and the best way to manage the adverse effects of growth.
- The Mangaheka ICMP will provide specific requirements for on-lot and centralized device contaminant removal, which will result in better environmental and flood storage outcomes for the downstream receiving environment.

Communication risks

Risk	Mitigation
People are unaware of the ICMP	Direct contact to stakeholders where we have their contact details Wider publicity to people in the affected area via elected members and the media Supporting and joint communication with Waikato District Council
People don't understand what the purpose of the ICMP is.	Establish clear communication documents for direct mail. Establish a page on the Council website which will act as a base page for information on the Mangaheka ICMP and all ICMPs. This page should include a draft timeline on the process and 'where we are now'
Internal stakeholders are unaware or don't understand the process.	Utilise executive update to keep elected members informed. Ensure customer services have background info and FAQs for calls to call centre
Developers may consider the draft requirements of the ICMP are onerous and unnecessary.	Key messages will focus on the strategic ICMP and CSWDC outcomes, particularly improving the downstream receiving environment quality and managing stormwater discharge flows. This will require mandatory on-lot water re-use, on-lot contaminant removal, and management of flood flows on-lot or via centralized devices.
Waikato District landowners may not be happy to retire up to 5m of land adjacent to the watercourse and then fence and plant these riparian edges	Communicate MoU intent between WDC/ WRC and HCC, together with funding initiatives such as Project Watershed and WRA funding to improve the receiving environment.

Spokespeople/media strategy

Operational: Chris Allen
Operational: Andrew Parsons

Operational: Andrea Phillips
Operational: Melissa Slatter

Political: Mayor Andrew King
Political: Cr Dave Macpherson, Chair of Growth and Infrastructure Committee

Potential Communication Channels

	Date	**Responsibility**
Create email list for stakeholders and interested parties as the process continues	Ongoing	Melissa
Create anticipated timeline of process and update stakeholders at each stage.	Ongoing	Melissa
Project Sponsor approvals	Ongoing	Melissa
Establishment of dedicated webpage on 'Strategies and Plans' section of the Council website		Sam/ Melissa
Draft letter to residents and stakeholders	December	Sam/ Melissa
Send executive update prior to letters.	December	Sam
Send letter to residents and stakeholders	January	Melissa
Public Notice (should be published at the same time as letters are sent).	January	Sam
Develop FAQs about where the process is up to now	December	Sam
FAQs on website and distribute to customer services and teleops	January	Sam
Media release	January	Sam

Key dates and communication phases:

ITEMS (links to SOP number)	KEY MILESTONES (align with SOP heading)	PURPOSE (insert TRIM link to additional documents if applicable)	TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)	TACTIC	ESTIMATED DATE	ACTUAL DATE (TRIM LINK)	RESPONSIBILITY
1	INITIATION						
	a. Inform key stakeholders	• To inform that the ICMP has been drafted • That an open day will be coming up so you can 'have your say' • The project will likely take a further 6 months so let us know if you want to be kept informed	Key internal and external stakeholders **(D-2536336).** Developers and landowners within HCC boundary • with a proposed centralized device on their property, • within a stormwater sub-catchment discharging to that device • Within a sub-catchment discharging direct to the stream. Landowners within Waikato DC boundary • where Mangaheka	• Email (internal) • Letters to residents • FAQs sent with letter Executive Update			Sam/ Melissa

ITEMS (links to SOP number)	**KEY MILESTONES** (align with SOP heading)	**PURPOSE** (insert TRIM link to additional documents if applicable)	**TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)**	**TACTIC**	**ESTIMATED DATE**	**ACTUAL DATE (TRIM LINK)**	**RESPONSIBILITY**
			Stream bounds their property (including those properties affected by erosion mitigation works) • Internal • Key external				
	b. Letter informing of updates requesting owners/residents contact us with issues	• We will be directly in touch if there is a need relating to a technical assessment • Provide their email address for future communication		• Letter			Sam / Melissa
2	PROJECT PLAN & SCOPE						
	a. ICMP Open Day	• Communicate date to key stakeholders		• Letter, emails and website	Feb 2018		Melissa/Andrea, support from Dominic & Angela

ITEMS (links to SOP number)	**KEY MILESTONES** (align with SOP heading)	**PURPOSE** (insert TRIM link to additional documents if applicable)	**TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)**	**TACTIC**	**ESTIMATED DATE**	**ACTUAL DATE (TRIM LINK)**	**RESPONSIBILITY**
	b. Key stakeholder presentation	• Presentation to internal and external stakeholders (if any)		• emails and website	Feb 2018		Melissa/Andrea, support from Dominic & Angela
	c. Project Sponsor approval		D-2561051	• Memo			Melissa
3	TECHNICAL WORK						
	a. General updates over the course of the project	• To keep communication up with our key stakeholders			Ongoing	Ongoing	Melissa
4	WRITE ICMP						
	a. Liaison with key internal and external stakeholders who may be effected (if required)	• no surprises for the stakeholders when it comes to targeted consultation			Ongoing		Melissa/Andrea/ DE's
5	TARGETED CONSULTATION						
	a. Key internal and		WRC, WDC further	• PGU	January - Feb		Melissa/Andrea,

ITEMS (links to SOP number)	**KEY MILESTONES** (align with SOP heading)	**PURPOSE** (insert TRIM link to additional documents if applicable)	**TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)**	**TACTIC**	**ESTIMATED DATE**	**ACTUAL DATE (TRIM LINK)**	**RESPONSIBILITY**
	external (if any) stakeholder meetings to gain acceptance of draft ICMP		engagement (meeting with each)	• Letter, emails and website	2018		support from Dominic & Angela
	b. Project Sponsor approval for targeted consultation (may be elevated level if flood hazard mapping involved)		D-2561051	• Memo	Dec 2017		Melissa
	c. Letters/email to targeted landowners		D-2561050	Public notice Developers and landowners within HCC boundary • with a proposed centralized device on their property, • within a stormwater sub-catchment	Jan 2018 advising of Open Day & Developer Forum in Feb 2018 and		

ITEMS (links to SOP number)	**KEY MILESTONES** (align with SOP heading)	**PURPOSE** (insert TRIM link to additional documents if applicable)	**TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)**	**TACTIC**	**ESTIMATED DATE**	**ACTUAL DATE (TRIM LINK)**	**RESPONSIBILITY**
				discharging to that device • Within a sub-catchment discharging direct to the stream. Landowners within Waikato DC boundary • where Mangaheka Stream bounds their property (including those properties affected by erosion mitigation works)			
	d. Feedback acknowledgement						

ITEMS (links to SOP number)	**KEY MILESTONES** (align with SOP heading)	**PURPOSE** (insert TRIM link to additional documents if applicable)	**TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)**	**TACTIC**	**ESTIMATED DATE**	**ACTUAL DATE (TRIM LINK)**	**RESPONSIBILITY**
	e. Feedback response (if significant risk identified from feedback received)						
6	APPROVALS						
	a. Waikato Regional Council b. Project Steering Group c. Project Governance Group d. Senior Leadership Team				26 March 2018 June 2018		
7	IMPLEMENTATION						
	a. Project Sponsor approval	• Confirming SOP approvals	Key internal and external stakeholders	• Email • memo	June		
	b. Inform key stakeholders that the ICMP is approved			• letter • email	July 2018		
	c. Load on website				July 2018		

ITEMS (links to SOP number)	**KEY MILESTONES** (align with SOP heading)	**PURPOSE** (insert TRIM link to additional documents if applicable)	**TARGET AUDIENCE (Ensure key stakeholders are agreed by ICMP working group)**	**TACTIC**	**ESTIMATED DATE**	**ACTUAL DATE (TRIM LINK)**	**RESPONSIBILITY**
	(Hamilton City Council and other Territorial Authorities pages as appropriate)						
	d. Workshops with key staff regarding risks, mitigations and outcomes.			• Memo • Workshop	July 2018		

Appendix J

Comprehensive Stormwater Discharge Consent 105279 (Conditions)

Resource Consent Schedule

Resource Consent: 105279

Consent Type: Discharge permit

Consent Subtype: Discharge to water

Pursuant to the Resource Management Act 1991, the Waikato Regional Council hereby grants consent to:

Hamilton City Council (Water & Waste Services)
Private Bag 3010
Waikato Mail Centre
Hamilton 3240

(hereinafter referred to as the Consent Holder)

Activity authorised: Divert and discharge urban stormwater runoff and associated contaminants at multiple locations to land, the Waikato River, Lake Rotoroa, Lake Rotokaeo, Lake Waiwhakareke, Lake Rotokauri, Mangaonua Stream, Mangakotukutuku Stream, Waitawhiriwhiri Stream, Kirikiriroa Stream, Te Awa o Katapaki Stream, other unspecified tributaries of the Waikato River and such other locations as may be covered by this consent in the future in accordance with the conditions of this consent, and use discharge structures within the general vicinity of Hamilton Urban Area which is reticulated by the Hamilton City Council municipal stormwater network

Location: Hamilton Urban Area

Map Reference: NZTopo50 BD33:007:154

Consent Duration: This consent will commence on the date of decision notification and expire on 30th June 2036

Subject to the conditions overleaf:

Glossary of terms

Act:	Resource Management Act 1991
Best Practicable Option:	(Refer to RMA, Part 1 – Interpretation and application)
Catchment Management Plan:	Pertains to all new stormwater diversion and discharge activities in developing catchments. Catchment Management Plans are pre-development planning tools which determine and adopt an integrated catchment management approach based upon the BPO, to avoid as far as practicable and otherwise minimise the cumulative adverse effects of new stormwater diversion and discharge activities in developing catchments. A Catchment Management Plan may apply to a developing catchment or to a number of developing catchments in a Growth Cell
Consent Holder:	The Hamilton City Council
Contaminant:	As defined in section 2 (1) of the RMA
Developing catchment:	A catchment or part of a catchment which is either undergoing urban development, identified for urban development or may in the future be identified for urban development. At the time of consent decision, developing catchments in Hamilton City include catchments, and parts of catchments, within the Rotokauri, Rototuna, Ruakura and Peacock Growth Cells
Gross pollutants:	Litter items such as plastic bottles, bags, takeaway wrappers and leaves
Hazardous substance:	As defined in section 2 (1) of the RMA
High Risk Catchments:	Urbanised catchments which are exposed to high concentrations of routine contaminants, or which are deemed to be more at risk to non-routine contaminant discharge incidents
Illicit wastewater connections:	Wastewater connections to the stormwater network which should be connected to the wastewater network. These primarily relate to private wastewater connections and do not include HCC wastewater network emergency overflow connections
Integrated catchment management approach:	In respect to Catchment Management Plans, an 'Integrated catchment management approach' is derived from assessments of available stormwater management options and their associated environmental impacts. An integrated catchment management approach will likely combine several stormwater management options and be based upon the Best Practicable Option
Low Impact Urban Design:	LIUD comprises design and development practices that utilise natural systems and low-impact technologies. Key elements include working with natural site features, avoiding or minimising impervious surfaces, minimising earthworks in construction, and utilising vegetation to assist in trapping sediment and pollutants
Non-routine contaminant discharge:	An unauthorised discharge (accidental or deliberate) of contaminants directly to the stormwater network or to land where it may then enter the municipal stormwater network
Routine contaminant discharge:	The discharge of stormwater containing contaminants that run off impervious surfaces and enter the stormwater network during rain events, where the types and concentrations of the contaminants are consistent with the contributing catchment
Stormwater management devices:	Structural stormwater management devices which are applied in

	stormwater quantity and quality management. These generally include water quantity and water quality ponds, wetlands, filtration practices, infiltration practices, biofiltration practices and various proprietary devices
Stormwater Management Plan:	Pertains to existing stormwater diversion and discharge activities in urbanised catchments. The Stormwater Management Plan records the way in which the stormwater network is operated and includes various management measures to avoid, remedy or mitigate the adverse effects of stormwater diversion and discharge activities on the environment
Stormwater network:	The Hamilton City Council's municipal stormwater network, including all structural management components associated with the conveyance, soakage, detention storage and contaminant treatment of stormwater
Urbanised catchment:	A catchment which is predominantly urbanised and has limited scope or opportunity for further development

General

Stormwater diversion and discharge activities

1) The stormwater diversion and discharge activities authorised by this consent shall be designed, operated and maintained in general accordance with the application for this consent and the Stormwater Management Plan required by Condition 35 of this consent, except where otherwise required in the resource consent conditions below. Where there is any discrepancy between the application documents, the Stormwater Management Plan and the resource consent conditions, then the conditions below shall prevail.

Scope of the stormwater diversion and discharge activities authorised

2) Except as provided for by Condition 3 of this consent, the stormwater diversion and discharge activities authorised by this consent relate to the Hamilton City Council municipal stormwater network ("stormwater network") as constructed at the commencement of this consent, and as generally shown on the Hamilton City Council Drawing MW/MAP-014. All new stormwater diversion and discharge activities which are established after the commencement of this consent shall meet the technical certification requirements of Condition 3 of this consent, and be shown on an updated version of the Hamilton City Council Drawing MW/MAP-014. This drawing shall be provided to the Waikato Regional Council in accordance with the Municipal Stormwater Network Operation Annual Report, required by Condition 39 of this consent.

Technical certification requirements for new stormwater diversion and discharge activities

3) All new stormwater diversion and discharge activities which are established after the commencement of this consent shall be authorised by this consent when this is confirmed in writing by the Waikato Regional Council in a technical certification capacity. This shall occur on receipt of information from the Consent Holder, showing to the satisfaction of the Waikato Regional Council that:

    a) The new stormwater diversion and discharge activities are consistent with the conditions of this consent; and

    b) For new stormwater diversion and discharge activities established in urbanised catchments - the new activities do not increase peak discharge rates to, or flow volumes in, stormwater receiving water bodies above those that would occur at the time of granting this consent, unless it is demonstrated that there are no additional adverse effects on the environment or downstream properties as a result of such increase; or

    c) For new stormwater diversion and discharge activities established in developing catchments - the new activities are consistent with Catchment Management Plans which have been prepared in accordance with Condition 30 of this consent, prior to the establishment of new activities within these catchments.

Advice Note: Condition 3(c) requires Catchment Management Plans as a prerequisite to new stormwater diversion and discharge activities established in developing catchments. For new activities established in catchments which are not guided by Catchment Management Plans, these activities will not be authorised by the CSDC and will retain respective single site resource consents.

Exemption to Condition 3(c) requirements

4) All new stormwater diversion and discharge activities which are established after the commencement of this consent and located within the Rotokauri, Rototuna, Ruakura and Peacockes Growth Cells as shown on the Hamilton City Council Drawing MW/MAP-020, shall be authorised by this consent if:

   a) The Consent Holder has completed or adopted Catchment Management Plans for the developing catchments within these Growth Cells and submitted them to the Waikato Regional Council for approval in a technical certification capacity by 1 December 2012 (Rotokauri and Rototuna), 1 December 2014 (Ruakura and Peacock), or such later date that may be approved in writing by the Waikato Regional Council in a technical certification capacity;

   b) The Catchment Management Plans include all of the information required by Condition 30 of this consent;

   c) The Waikato Regional Council has approved the Catchment Management Plans and confirmed in writing that the new stormwater diversion and discharge activities are consistent with the Catchment Management Plans and the conditions of this consent; and

   d) Any single site resource consents which are associated with the new stormwater diversion and discharge activities and held by the Consent Holder, shall be surrendered by the Consent Holder in accordance with section 138 of the RMA or amendments thereof.

   The Catchment Management Plans for these catchments shall determine and adopt integrated catchment management approaches which are based upon achieving at least an equivalent outcome (in terms of avoiding as far as practicable and otherwise minimising cumulative adverse effects) to what could have been achieved by the Best Practicable Option for these catchments prior to any development.

Design, structural integrity and maintenance of the stormwater network

5) The Consent Holder shall be responsible for the design, structural integrity and maintenance of the stormwater network, and shall operate and maintain the stormwater network to avoid, remedy or mitigate the actual and potential adverse effects of the stormwater diversion and discharge activities authorised by this consent on the environment.

Changes to the stormwater network

6) The Consent Holder shall not undertake any changes to the stormwater network which would increase the scale or intensity of the actual and potential adverse effects of the stormwater diversion and discharge activities authorised by this consent on the environment.

Best Practicable Option

7) The Consent Holder shall seek to implement the Best Practicable Option to avoid, remedy or mitigate the actual and potential adverse effects of the stormwater diversion and discharge activities authorised by this consent on the environment. To this end, the Best Practicable Option shall be informed by the Stormwater Management Review Report required by Condition 40 of this consent, and implemented through the Stormwater Management Plan required by Condition 35 of this consent.

Consent Holder asset management activities

8) All Consent Holder asset management activities, including those relating to:

   a) Stormwater network activities;

   b) Water and wastewater network activities;

   c) Roading and footpath activities;

   d) Parks and gardens activities;

   e) Refuse collection activities; and

   f) Building maintenance activities

   shall, as far as practicable, be managed to assist the Consent Holder in meeting the conditions of this consent. In this regard the Consent Holder shall provide a copy of this consent to all units of the Hamilton City Council that undertake activities which are relevant to compliance with the consent conditions, and take all reasonable steps to ensure that the appropriate personnel within those units are familiar with the consent conditions to manage activities accordingly. In addition, the Consent Holder shall provide copies of the Stormwater Management Plan (Condition 35), Municipal Stormwater Network Operation Annual Report (Condition 39) and the Stormwater Management Review Report (Condition 40) to these same units of the Hamilton City Council.

Stormwater Quantity & Receiving Environment

Adverse stormwater quantity effects

9) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, the following stormwater quantity effects:

   a) Adverse scour, erosion and sediment deposition on land, property and the beds of stormwater receiving water bodies;

   b) Adverse flooding of land, property and stormwater receiving water bodies;

   c) Adverse effects on aquatic ecosystems.

   All such adverse effects that are more than minor shall be addressed in the manner provided for in Condition 10 hereof, where they have been caused by the stormwater diversion and discharge activities authorised by this consent.

   Advice Note: *Municipal stormwater diversion and discharge activities in conjunction with urban land-use, can adversely affect flood potential by either limiting the rate at which stormwater drains from a catchment, or by increasing the rate and volume of discharge to downstream catchments. Whilst such effects are the subject of this consent, it is also recognised that 'levels of service' for flood alleviation in existing urban catchments are established by the Consent Holder through separate statutory procedures and community consultation. The 'levels of service' that are established between the Consent Holder and the community are not the subject of this consent.*

Procedure for addressing adverse stormwater quantity effects

10) As soon as practicable after becoming aware of any of the adverse effects of the nature specified in Condition 9 that are more than minor, the Consent Holder shall submit a report to the Waikato Regional Council in relation to the adverse effects. As a minimum, the report shall include:

   a) A description of the adverse effects;

b) A description of the cause of the adverse effects;

c) An explanation of any measures taken to remedy or mitigate the adverse effects, the outcome of those measures, and whether further measures are necessary and reasonably practicable;

d) If no measures have been taken in accordance with (c), a description of any reasonably practicable measures that could be taken to remedy or mitigate the adverse effects and a recommendation as to whether those measures are necessary.

The Consent Holder shall liaise with the Waikato Regional Council with a view to determining any reasonably practicable measures which should be taken to remedy or mitigate the adverse effects.

Advice Note: *Separate resource consents may be required to undertake remedial or mitigation works. The Consent Holder is advised to obtain all such consents at its sole expense, prior to any works being undertaken.*

Fish passage

11) The Consent Holder shall undertake a review of municipal stormwater management structures that have been placed in, on, under or over the beds of receiving water bodies to enable the stormwater diversion and discharge activities authorised by this consent. The purpose of the review will be to assess the extent to which stormwater management structures impede or facilitate the upstream and downstream movement of fish with a view to:

a) Assessing whether measures to remedy or mitigate the effects of stormwater management structures on fish movement are warranted having regard to all relevant factors, including engineering difficulties, costs and environmental benefits; and

b) Liaising with the Waikato Regional Council to determine any reasonably practicable measures which should be taken to remedy or mitigate the effects of stormwater management structures on fish movement, where these are considered necessary or desirable by the Waikato Regional Council after having had regard to all relevant factors.

The remedial and mitigation measures which are determined through the review process shall be designed and constructed by the Consent Holder to the satisfaction of the Waikato Regional Council acting in a technical certification capacity, and shall be implemented through the Stormwater Management Plan required by Condition 35 of this consent.

Advice Note: *When acting on this condition the Consent Holder is advised to consult with the Department of Conservation, in accordance with Part VI of the Freshwater Fisheries Regulations 1983.*

Stormwater management devices

12) All stormwater management devices which connect to the stormwater network and are designed to control stormwater volumes and/or peak rates of discharge, shall be operated and maintained by the Consent Holder to provide best practicable stormwater management efficiency at all times.

Stream channel works

13) When carrying out stream channel works for the purpose of maintaining stormwater flows in stormwater receiving water bodies, the Consent Holder shall have due regard to the ecosystem and habitat values that these receiving water bodies support. To this end the Consent Holder shall develop its own activity specific guidelines for stream channel works, and shall implement these guidelines through the Stormwater Management Plan required by Condition 35 of this consent.

Advice Note: *Separate resource consents may be required to undertake stream channel works for the purpose of maintaining stormwater flows in receiving water stream channels. The Consent Holder is advised to obtain all such consents at its sole expense, prior to any works being undertaken.*

Stormwater Quality & Receiving Environment

Floatable contaminants

14) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, the discharge of any substance that is likely to cause the production of conspicuous oil, or grease films, scums or foams, or floatable suspended materials in stormwater receiving water bodies after reasonable mixing.

Suspended solids

15) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, the discharge of suspended solids and any other substances that are likely to cause the following effects in stormwater receiving water bodies after reasonable mixing:

a) Conspicuous changes in colour or visual clarity;

b) Smothering of benthic organisms by sediment;

c) Make the water in the Waikato River unsuitable for contact recreation.

Hazardous substances

16) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, the discharge of hazardous substances in concentrations that are likely to adversely affect aquatic life, or the suitability of water for human consumption after treatment. Where a question arises as to whether the concentration of any particular hazardous substance is causing these effects, it shall be determined through the application of the United States Environmental Protection Agency National Recommended Water Quality Criteria (USEPA, 2009) – Criteria Maximum Concentration, or any other technical publication approved in advance by the Waikato Regional Council in a technical certification capacity.

Micro-organisms

17) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, the discharge of micro-organisms in concentrations that are likely to adversely affect human health. Where a question arises as to whether the concentration of micro-organisms is adversely affecting human health, it shall be determined through the application of the Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas (MfE, 2003), or any other technical publication approved in advance by the Waikato Regional Council in a technical certification capacity.

Adverse effects on aquatic ecosystems

18) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, discharges that are likely to adversely affect aquatic ecosystems and cause the following effects in stormwater receiving water bodies after reasonable mixing:

a) Dissolved oxygen levels to fall below 80% of saturation;

b) pH to fall below 6 or exceed 9;

c) Suspended sediments to smother benthic organisms;

d) Undesirable biological growths;

e) Water temperature to change by more than 3°C or exceed 25°C;

f) Turbidity levels to exceed 25 NTU between the months of August and December;

g) Ammoniacal nitrogen concentrations to exceed 0.88 grams of nitrogen per cubic metre; and

h) Other contaminant concentrations to exceed the United States Environmental Protection Agency National Recommended Water Quality Criteria (USEPA, 2009) – Criteria Maximum Concentration.

Advice Note: *Conditions 9, 14, 15, 16, 17 and 18 identify various adverse effects that this consent is seeking to avoid or minimise through improvements in the management of the stormwater network and the stormwater diversion and discharge activities authorised by this consent. Compliance with these conditions will therefore be determined through the establishment and implementation of best practicable stormwater management measures that are adopted by, and implemented through, the Stormwater Management Plan required by Condition 35 of this consent.*

Street and stormwater catchpit cleaning operations

19) The Consent Holder shall carry out regular street and stormwater catchpit cleaning operations to minimise the volume of stormwater contaminants entering the stormwater network and discharging to the receiving environment. When considering the frequency of street and stormwater catchpit cleaning operations, the Consent Holder shall take account of the land use characteristics within respective stormwater sub-catchments, the intensity of the various land use activities taking place, and any means other than street and stormwater catchpit cleaning operations that are being utilised to control and/or treat contaminated stormwater.

Stormwater catchpits

20) All stormwater catchpits which connect to the stormwater network shall be capable of capturing and retaining the majority of gross pollutants. New, replacement and/or upgraded stormwater catchpits shall, when constructed, be further capable of capturing and retaining the majority of floatable contaminants such as oil and grease, unless any discharges of floatable contaminants from the catchpits to the receiving environment would have no more than negligible adverse effects.

Advice Note: *It may not be necessary for all new, replacement and/or upgraded stormwater catchpits to be capable of retaining the majority of floatable contaminants. Whether this is necessary or not depends on whether floatable contaminants such as oil and grease are being discharged into catchpits and, if they are, in what concentrations. The concentrations, the nature of the receiving environment, and any dilution available in receiving water bodies are all factors that should be taken into account on a case by case basis.*

Stormwater management devices

21) All stormwater management devices which connect to the stormwater network and are designed to treat contaminated stormwater, shall be operated and maintained by the Consent Holder to provide best practicable stormwater treatment efficiency at all times.

Illicit wastewater connections to the stormwater network

22) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, illicit wastewater connections to the stormwater network. On becoming aware of such connections the Consent Holder shall instigate remedial works to remove these connections as soon as practicable.

Advice Note: *This resource consent does not authorise any wastewater connections, illicit or otherwise, to the stormwater network.*

Routine contaminant discharges into the stormwater network

23) The Consent Holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, routine contaminant discharges into the stormwater network, particularly in High Risk Catchments where there is greater potential for stormwater to become contaminated.

Non-routine contaminant discharges to/from the stormwater network

24) On becoming aware of a non-routine contaminant discharge incident, the Consent Holder shall make all reasonable endeavours to avoid contaminants entering the stormwater network, or discharging from the stormwater network to the environment. Standard Operating Procedures to achieve compliance with this condition shall be included in the Stormwater Management

Plan required by Condition 35 of this consent and, as a minimum, those procedures shall address the following matters:

a) The Consent Holders response to non-routine contaminant discharge incidents, including the availability of spill response equipment and HCC staff to assist with such incidents;

b) Notifying the Waikato Regional Council of non-routine contaminant discharge incidents;

c) The assistance to be provided by the Consent Holder to the Waikato Regional Council and other emergency response agencies in undertaking their respective response roles.

Advice Note: *Requirements of the Fire Service Act and other legislative requirements may override the requirements of this condition in certain circumstances.*

New or replacement connections to the stormwater network

25) When assessing applications and engineering approvals for new or replacement connections to the stormwater network, the Consent Holder shall, to the extent that it lawfully can, ensure that stormwater management devices are required and/or in place to avoid as far as practicable and otherwise minimise routine contaminant discharges to the stormwater network.

Domestic water supplies

26) The consent holder shall manage the stormwater network to avoid as far as practicable and otherwise minimise, the discharge of any contaminant that may affect the suitability of water for human consumption after treatment.

27) The Consent Holder shall as soon as practicable but no longer than 3 hours after it comes to its attention, notify the Waikato District Council, Watercare Services Ltd and the Waikato Regional Council of an event that may in itself, or as a consequence of the event, have a significant adverse effect on the quality of water at any downstream drinking water supply abstraction point. The Consent Holder shall record the reasons for the event, the actions taken by the Consent Holder to avoid and/or mitigate issues relating to the event, and undertake an assessment of what measures can be adopted in the future to minimise such events. Upon the written request of the Waikato Regional Council, the Consent Holder shall report this information to the Waikato Regional Council and the Medical Officer of Health.

Stormwater Quality Improvement Programme

28) The Consent Holder shall prepare a Stormwater Quality Improvement Programme, designed to improve the quality of stormwater network discharges and assist the Consent Holder in meeting the conditions of this consent. The Stormwater Quality Improvement Programme shall form part of the Stormwater Management Plan required by Condition 35 of this consent, and be implemented by the Consent Holder progressively over the duration of this consent. As a minimum, the Stormwater Quality Improvement Programme shall include the following:

a) Education programmes which raise the general public's awareness of stormwater quality issues and the ways in which individuals can avoid as far as practicable and otherwise minimise the contamination of stormwater;

b) To the extent that the Consent Holder is authorised to do so, proposed site inspections and stormwater contamination audits of industrial and commercial properties that connect to the stormwater network in High Risk Catchments, along with education and promotion of at-source stormwater management measures to the owners/operators of these properties;

c) Investigative and remedial works programmes to remove illicit wastewater connections to the stormwater network;

d) Stormwater catchpit upgrade programmes which retrofit best practicable outlet devices (for example baffles, siphons, filter bags) to stormwater catchpits in existing urban catchments;

e) Stormwater network upgrade programmes which retrofit best practicable stormwater management devices to the stormwater network in High Risk Catchments.

f) How the Consent Holder proposes to use its regulatory powers and exercise its functions through, for example, consent requirements, engineering approvals, design specifications and guidelines and the introduction of a Stormwater Bylaw to avoid, remedy, and mitigate the adverse effects of stormwater discharges.

Complaints Register

29) The Consent Holder shall keep a Complaints Register for all formal complaints received about the stormwater diversion and discharge activities authorised by this consent. The Complaints Register shall record:

a) The date, time and duration of any alleged event/incident that has resulted in the complaint;

b) The location of the complainant when the alleged event/incident was detected;

c) The possible cause of the alleged event/incident;

d) Any corrective action taken by the Consent Holder in response to the complaint.

The Complaints Register shall be available to the Waikato Regional Council at all reasonable times. Details of complaints about significant events/incidents shall be forwarded to the Waikato Regional Council in writing within 5 working days of such complaints being received, unless otherwise authorised by the Waikato Regional Council.

Urban Growth and Development

Catchment Management Plans

30) In accordance with Condition 3(c) of this consent, Catchment Management Plans which are prepared to guide new stormwater diversion and discharge activities in developing catchments shall be to a standard acceptable to the Waikato Regional Council, and shall be submitted to the Waikato Regional Council for written approval in a technical certification capacity, prior to the establishment of these activities.

Catchment Management Plans shall determine and recommend an integrated catchment management approach which is 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.

As a minimum, Catchment Management Plans shall include the following information:

a) Catchment maps/drawings of the catchment delineating the catchment boundary, catchment topography, natural features, surface water bodies, existing drainage systems and infrastructure (if any) and current land uses;

b) Classification of the surface water bodies within the catchment as detailed in the Waikato Regional Plan;

c) A description of the social, economic, ecological, amenity and cultural objectives being sought for the catchment (likely to stem from a concurrent structure planning process);

d) A description of proposed urban growth, development and land use intensification within the catchment;

e) A list of the key stakeholders associated with the catchment, and details of their respective views on providing for new stormwater diversion and discharge activities within the catchment;

f) An assessment of the current status of the catchment and its environs, together with a description of the geological, hydrological, ecological and existing infrastructural characteristics of the catchment, including any existing resource use authorisations within the catchment;

g) An assessment of the environmental effects of all new stormwater diversion and discharge activities on the catchment, in such detail as corresponds with the scale and significance of the effects that these activities will have on the catchment, including but not limited to, effects on:
    i) Natural features, surface water bodies and aquifers,
    ii) Sites of cultural and/or historical significance,
    iii) Public health,
    iv) Flooding hazards,
    v) Receiving water hydrology, including base flows and peak flows in rivers and streams and long-term aquifer levels,
    vi) Receiving water sediment and water quality,
    vii) Receiving water habitat, ecology and ecosystem health,
    viii) Receiving water riparian vegetation,
    ix) The extent and quality of open stream channels,
    x) Fish passage for indigenous and trout fisheries (refer to the Waikato Regional Plan Water Management Classes for applicability),
    xi) Natural and amenity values,
    xii) Existing infrastructure,
    xiii) Existing authorised resource use activities;

h) An assessment of the cumulative environmental effects of all new stormwater diversion and discharge activities on the catchment over time;

i) In response to the environmental effects assessment information, an assessment of the available management options (including Low Impact Urban Design measures and stormwater management devices), for all new stormwater diversion and discharge activities within the catchment; followed by

j) Recommendations on an integrated catchment management approach which is based upon the Best Practicable Option to avoid as far as practicable and otherwise minimise actual and potential adverse effects of all new stormwater diversion and discharge activities on the catchment;

k) A description of proposed education and promotion initiatives to be carried out by the Consent Holder to support the integrated catchment management approach recommended by the Catchment Management Plan;

l) A description of key infrastructure works to be carried out by the Consent Holder to support the integrated catchment management approach recommended by the Catchment Management Plan;

m) A prioritised infrastructure works schedule for implementing the integrated catchment management approach recommended by the Catchment Management Plan;

n) A list of performance measures by which the implementation of the integrated catchment management approach recommended by the Catchment Management Plan will be gauged.

Any approved Catchment Management Plan that needs to be updated following changes to the integrated catchment management approach recommended by the Catchment Management Plan, shall be reviewed, updated and submitted to the Waikato Regional Council for approval in a technical certification capacity, prior to any such changes being implemented within the associated catchment.

Advice Note: It is recognised that Catchment Management Plans may also include information that provides for the integration of municipal water and wastewater services. Such information and the integration of these services are generally encouraged by the Waikato Regional Council, particularly where they result in environmentally sustainable catchment management outcomes.

Implementation of Catchment Management Plans

31) The Consent Holder shall coordinate and oversee the implementation of approved Catchment Management Plans as required by Condition 3(c) of this consent, and shall ensure as far as practicable, that all relevant stormwater management devices are constructed and operational prior to the development of impervious surfaces within developing catchments.

Waikato Regional Council guidelines for sustainable subdivision development

32) For all new stormwater diversion and discharge activities in developing catchments, the Consent Holder shall promote consideration of the Waikato Regional Council publication titled "Sustainable Subdivision Development – An Environment Waikato Perspective" (WRC, 2006), or any other technical publication approved in advance by the Waikato Regional Council in a technical certification capacity.

Low Impact Urban Design measures and stormwater management devices

33) In addition to the requirements of Conditions 30 - 32 of this consent, the Consent Holder shall promote the implementation of Low Impact Urban Design measures and stormwater management devices in all reticulated catchments, to avoid as far as practicable and otherwise minimise the actual and potential adverse effects of the stormwater diversion and discharge activities authorised by this consent on the environment.

Register of stormwater management devices

34) As the Consent Holder and/or private developers progressively construct new stormwater management devices that become part of the stormwater network, the Consent Holder shall maintain a register of these devices in the Stormwater Management Plan required by Condition 35 of this consent, including details of their location, catchment area, operational procedures and maintenance requirements.

Stormwater Management Planning

Stormwater Management Plan

35) The Consent Holder shall prepare a Stormwater Management Plan for its stormwater network and the existing stormwater diversion and discharge activities that are authorised by this consent. The Stormwater Management Plan shall record the way in which the stormwater network is operated, and shall include best practicable stormwater measures to avoid, remedy or mitigate adverse effects on the environment.

The operational procedures, management initiatives and implementation methods that are adopted by, and implemented through, the Stormwater Management Plan shall assist the Consent Holder in meeting the conditions of this consent.

As a minimum, the Stormwater Management Plan shall include the following information:

a) A plan or drawing or series thereof which shows the Hamilton City Council administrative area, main hydrological catchments, main stormwater network (including sites of key stormwater management devices), major secondary overland flow-paths and stormwater receiving water bodies;

b) A description of the relationship and integration of the Stormwater Management Plan with other key planning instruments and regulatory/non-regulatory processes, including all those utilised in the management of the stormwater network;

c) A description of the stormwater network in relation to the contributing catchments, existing land uses within these catchments, Low Impact Urban Design measures, stormwater management devices and main pipe reticulation;

d) A description of all stormwater receiving water bodies, including their locations, key characteristics (for example water quality, ecological and hydrological characteristics), existing uses and values;

e) A list of the key stakeholders who have an interest in the stormwater diversion and discharge activities authorised by this consent, and their respective views on managing these activities;

f) A description of all stormwater network operation and maintenance procedures, including those associated with land use (for example street and catchpit cleaning), stormwater management devices, pipe reticulation and stormwater receiving water bodies;

g) A description of other Consent Holder asset management activity initiatives that will assist the Consent Holder in meeting the conditions of this consent, or are otherwise complimentary to stormwater management;

h) A description of the management initiatives and implementation methods to avoid as far as practicable and otherwise minimise:
   i) Adverse scour, erosion and sedimentation deposition on land, property and the beds of stormwater receiving water bodies,
   ii) Adverse flooding of land, property and stormwater receiving water bodies,
   iii) Adverse effects on aquatic ecosystems;

i) A list of the municipal stormwater management structures that require reasonably practicable measures to be undertaken to remedy or mitigate the effects of these structures on fish movement, in accordance with Condition 11. Also a description of the specific measures to be undertaken and a programme of works to implement these measures.

j) A set of guidelines for undertaking stream channel works in stormwater receiving water bodies;

k) A description of all potential sources of stormwater contaminants within reticulated catchments (including all potential sources of routine and non-routine contaminant discharges to the stormwater network);

l) Standard Operating Procedures for managing non-routine contaminant discharge events, including the notification procedures described in Condition 27 of this consent;

m) A Stormwater Quality Improvement Programme which, as a minimum includes:
   i) All of the activities listed in the Stormwater Quality Improvement Programme required under Condition 28; and
   ii) A prioritised schedule for implementing the Stormwater Quality Improvement Programme progressively over the duration of this consent;

n) A description of the management initiatives to promote developer consideration of the Waikato Regional Council publication titled "Sustainable Subdivision Development – An Environment Waikato Perspective" (WRC, 2006), or any other technical publication approved in advance by the Waikato Regional Council in a technical certification capacity;

o) A description of the management initiatives to promote the implementation of Low Impact Urban Design measures and stormwater management devices in reticulated catchments;

p) A register of all stormwater management devices associated with the stormwater network, including their location, catchment area, operational procedures and maintenance requirements;

q) A prioritised works schedule for implementing the operational procedures, management initiatives and implementation methods that are adopted by, and implemented through, the Stormwater Management Plan;

r) A list of performance measures by which the implementation of the operational procedures, management initiatives and implementation methods adopted by the Stormwater Management Plan will be gauged.

The Stormwater Management Plan shall be to a standard acceptable to the Waikato Regional Council and shall be submitted to the Waikato Regional Council for written approval in a technical certification capacity, by 30th September 2011 or such later date that may be approved in writing by the Waikato Regional Council in a technical certification capacity. Thereafter, the Stormwater Management Plan shall be reviewed, updated and submitted to the Waikato Regional Council for approval in a technical certification capacity, by 30th September every third year.

(The Consent Holder may update the Stormwater Management Plan at other times and submit it to the Waikato Regional Council in a technical certification capacity. The Waikato Regional Council may waive the requirement for the Stormwater Management Plan update in any three year period if it has been updated and approved before that three year period expires, in which case it shall be updated and submitted to the Waikato Regional Council for approval in a certification capacity, by 30th September in the next three year period.)

Implementation of the Stormwater Management Plan

36) The Consent Holder shall implement the operational procedures, management initiatives and implementation methods adopted by the Stormwater Management Plan, in accordance with that plan as required by Condition 35 of this consent.

Monitoring

Monitoring Programme

37) The Consent Holder shall retain appropriately qualified and experienced persons to prepare a Monitoring Programme. The objectives of the Monitoring Programme are to:

- Investigate the actual and potential adverse effects of municipal stormwater diversion and discharge activities on the environment;

- Provide information to refine Best Practicable Option stormwater management measures that assist the Consent Holder in avoiding, remedying or mitigating actual and potential adverse effects on the environment;

- Assess the performance of utilised stormwater management devices to determine their overall effectiveness in managing and/or treating stormwater, and to guide the best practicable application of these devices in respective catchments;

- Provide guidance on the ongoing and necessary changes to the Stormwater Management Plan to address any shortcomings with the operational procedures, management initiatives and implementation measures adopted by the Stormwater Management Plan;

- Review the level of subdivision and development that is occurring in developing catchments, relative to the land use assumptions underlying the integrated catchment management approaches recommended by approved Catchment Management Plans;

- Determine overall compliance with the conditions of this consent.

As a minimum, the Monitoring Programme shall include:

a) Monitoring to identify any adverse stormwater quantity and quality effects on aquatic ecosystems. This shall include stormwater receiving water body monitoring at targeted stream, lake and river locations, and comprise combinations of the following activities:

   i) Visual assessments of general habitat quality and sensitivity to stormwater inputs,
   ii) Stormwater quality sampling and analyses of key stormwater contaminants and physio-chemical parameters that aid data interpretation,
   iii) Sediment quality sampling and analyses of key stormwater contaminants and sediment characteristics that aid data interpretation, and
   iv) Biological sampling and analyses of macroinvertebrate communities and fish populations;

b) Monitoring to identify any visual signs of contaminants in stormwater (conspicuous oil or grease films, scums or foams, floatable suspended materials, conspicuous change in colour or visual clarity);

c) Monitoring to identify any adverse scour, erosion and sediment deposition on land, property and the beds of stormwater receiving water bodies;

d) Monitoring to identify any adverse flooding of land, property and stormwater receiving water bodies;

e) Monitoring to identify any stormwater management structures that are impeding the upstream and downstream movement of fish;

f) Monitoring to determine the performance of utilised stormwater management devices in managing and/or treating stormwater;

g) Monitoring to gauge the level of subdivision and development that is occurring in developing catchments, relative to the land use assumptions underlying the integrated catchment management approaches recommended by approved Catchment Management Plans;

h) Monitoring to ensure that all stormwater management devices are maintained in good working order, and providing best practicable stormwater management and/or treatment efficiency at all times;

i) Monitoring to determine best practicable street and stormwater catchpit cleaning operations to minimise the volume of stormwater contaminants entering the stormwater network and discharging to the receiving environment;

The Monitoring Programme shall be to a standard acceptable to the Waikato Regional Council and shall be submitted to the Waikato Regional Council for written approval in a technical certification capacity, by 30th September 2011 or such later date that may be approved in writing by the Waikato Regional Council in a technical certification capacity. Thereafter, the Monitoring Programme shall be reviewed, updated and submitted to the Waikato Regional Council for approval in a technical certification capacity, by 30th September every third year. The Waikato Regional Council will review and may alter the Monitoring Programme (in scale and/or method and/or location) after having had regard to the consistency and significance of the monitoring data collected, or any other information relating to the stormwater diversion and discharge activities authorised by this consent.

38) The Consent Holder shall undertake all monitoring in accordance with the Monitoring Programme required by Condition 37 of this consent, and the results of the monitoring shall, as a minimum, be summarised in the Municipal Stormwater Network Operation Annual Report required by Condition 39 of this consent.

Reporting

Municipal Stormwater Network Operation Annual Report

39) The Consent Holder shall compile an annual report entitled "Municipal Stormwater Network Operation Annual Report", for the year ending 31st March each year, and shall submit this report to the Waikato Regional Council by 1st July each year or such later date that may be approved in writing by the Waikato Regional Council in a technical certification capacity. As a minimum the report shall contain:

a) A summary of the operational procedures, management initiatives and implementation methods adopted by the Stormwater Management Plan which have been implemented during the year, along with the results of these initiatives (where relevant). Also a summary of the operational procedures, management initiatives and implementation methods which are proposed to be implemented over the coming year, along with any proposed changes or review updates to the Stormwater Management Plan that provide for the ongoing implementation of best practicable stormwater management measures;

b) A summary of the main stormwater infrastructure works undertaken during the year, particularly the works undertaken in developing catchments in accordance with approved Catchment Management Plans. Also a summary of the main stormwater infrastructure works proposed for the coming year, along with any proposed changes to approved Catchment Management Plans (where deemed by the Consent Holder to be necessary);

c) A summary of other Consent Holder asset management activity initiatives which are complimentary to stormwater management and have been undertaken during the year, along with a summary of similar type initiatives proposed for the coming year;

d) A summary of the information gathered and analysed through the Monitoring Programme required by Condition 37 of this consent. Any proposed refinements to the Monitoring Programme in response to the monitoring information gathered, or particular issues arising, should also be provided;

e) Details of all non-routine contaminant discharge incidents which have been responded to by the Consent Holder, along with a summary of the outcomes of these incidents. Any proposed changes to the Standard Operating Procedures for non-routine contaminant discharge incidents, should also be provided;

f) A summary of the level of compliance achieved with the conditions of this consent, including any reasons for non-compliance or difficulties in achieving compliance;

g) A summary of all formal complaints received in regard to the stormwater diversion and discharge activities authorised by this consent, as recorded in the Complaints Register required by Condition 29 of this consent;

h) An updated version of the Hamilton City Council Drawing MW/MAP-014, showing all new stormwater diversion and discharge activities which have been certified as authorised by the Waikato Regional Council in accordance with Condition 3 of this consent;

i) General comment on the functioning of the Hamilton City – Waikato-Tainui Stormwater Steering Group;

j) A summary of the actions and/or stormwater management measures to be implemented over the coming year to remedy any non-compliance with the conditions of this consent;

k) Details of any other matters considered relevant to this consent.

Stormwater Management Review Report

40) By 30th September 2012 and every third year thereafter, the Consent Holder shall submit a report to the Waikato Regional Council entitled "Stormwater Management Review Report". The report shall address issues relevant to the adoption by the Consent Holder of best practicable measures for avoiding, remedying or mitigating actual and potential adverse effects on the environment as a result of the stormwater diversion and discharge activities authorised by this consent. As a minimum the report shall contain:

a) A literature review of the latest developments in stormwater management best practice with particular emphasis on:
   i. Catchment management planning;
   ii. Application of Low Impact Urban Design measures in developing catchments;
   iii. At source stormwater management practices including regulatory, educational, specific trade and industry, and general land-use management practices,
   iv. Advancements in stormwater treatment technologies and management devices,
   v. Contingency planning for non-routine contaminant discharge incidents,
   vi. Remedial and mitigation measures available to stormwater network operators;

b) An assessment of the extent to which the Consent Holder is implementing the Best Practicable Option to avoid, remedy or mitigate the actual and potential adverse effects of the stormwater diversion and discharge activities authorised by this consent on the environment in accordance with Condition 7 of this consent;

c) In the event that the Consent Holder is not implementing the Best Practicable Option to avoid, remedy or mitigate the actual and potential adverse effects of the stormwater diversion and discharge activities authorised by this consent on the environment, recommendations on the measures to be adopted by the Consent Holder to achieve the Best Practicable Option. These measures shall be adopted by, and implemented through, the Stormwater Management Plan required by Condition 35 of this consent;

d) An assessment of the effectiveness of the District Plan provisions, along with other planning provisions (such as those within the Hamilton City Council Development Manual), to implement the integrated catchment management approach recommended by Catchment Management Plans; and

e) If considered necessary by the Consent Holder, suggestions on changes to the District Plan provisions, and/or other Consent Holder planning document provisions where appropriate, that will assist in achieving the integrated catchment management approach recommended by Catchment Management Plans;

f) A review of any stakeholder concerns raised during the period covered by the Stormwater Management Review Report, and any measures taken or proposed to be taken to address those concerns.

Hamilton City – Waikato-Tainui Stormwater Steering Group

41) The Consent Holder shall invite the Waikato Tainui Te Kauhanganui Inc (or replacement body) to establish in association with the Consent Holder a group to be entitled the Hamilton City Council - Waikato-Tainui Stormwater Steering Group. If established, the Consent Holder shall provide organisation and administrative support to facilitate the development and ongoing role of the Steering Group for the duration of this consent. If established, membership of the Steering Group shall comprise an equal number of Waikato Tainui Te Kauhanganui Inc (or replacement body) and Hamilton City Council representatives appointed respectively by each of those parties. As a minimum:

a) The Steering Group shall be invited to meet at least annually to exercise the functions set out in sub-condition (c) of this condition;

b) The Steering Group shall establish its own meeting protocols having regard to the customary practices of Waikato-Tainui, and shall operate in accordance with the principles of the Treaty of Waitangi, especially the principles of consultation, active participation and partnership;

c) The functions of the Steering Group shall include, but not be limited to, the following activities:
   i. Identify ways to improve stormwater quality, receiving environs and fish passage,

   ii. Receipt of and comments on, the Municipal Stormwater Network Operation Annual Report as required by Condition 39 of this consent,

   iii. Receipt of and comments on, the Stormwater Management Plan and review updates to this plan as required by Condition 35 of this consent,

   iv. Receipt of and comments on, the Stormwater Management Review Report as required by Condition 40 of this consent,

   v. Based on the information in the Municipal Stormwater Network Operation Annual Report, the Stormwater Management Plan, the Stormwater Management Review Report and other relevant information, review the effects of municipal stormwater diversion and discharge activities on stormwater receiving water bodies, and make recommendations to the Consent Holder and/or the Waikato Regional Council as to any management measures and initiatives further needed to address actual and/or potential effects of these activities,

   vi. Recommend to the Consent Holder the commissioning of research and technical reports to assist the Steering Group with its functions,

   vii. At least one month prior to the opportunities for review provided for in Condition 44 of this consent, to make recommendations to the Waikato Regional Council on issues raised by the Steering Group in relation to, amongst other matters, the Stormwater Management Plan, the Municipal Stormwater Network Operation Annual Report, the Stormwater Management Review Report, and how such issues were addressed by the Consent Holder; and

   viii. Consideration of other matters raised by the Steering Group.

This condition shall cease to have any effect if the Consent Holder and the duly authorised representative(s) of Waikato-Tainui advise the Waikato Regional Council in writing that the functions of any Steering Group that is established are to be exercised in accordance with a joint management agreement prepared pursuant to section 41 of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010.

***Advice Note:** Subject to agreement between the Consent Holder and the Waikato Tainui Te Kauhanganui Inc (or replacement body), the Hamilton City – Waikato Tainui Stormwater Steering Group may establish itself as a broad based steering group, focussed on the management of Hamilton's municipal water, wastewater and stormwater activities.*

Administrative

Consent Holder's representative

42) The Consent Holder shall appoint a representative who shall be the Waikato Regional Council's principal contact person in regard to matters relating to this consent. The Consent Holder shall forward contact details of its representative to the Waikato Regional Council. The Consent Holder shall inform the Waikato Regional Council in writing of any change in its representative as soon as practicable.

Waikato-Tainui Raupatu Claims Waikato River Settlement Act

43) Within 12 months of all of the provisions of the Waikato-Tainui Raupatu Claims Waikato River Settlement Act 2010 commencing the Waikato Regional Council may, following service of

notice on the consent holder, commence a review of the conditions of this consent pursuant to section 128(1) of the Resource Management Act 1991, for the purpose of ensuring that the conditions of this consent are not inconsistent with the provisions of the Act; and

Within the six month period following 1st December 2012 and the six month period following the 1st December every five years thereafter, the Waikato Regional Council may, following service of notice on the consent holder, commence a review of the conditions of this consent pursuant to section 128(1) of the Resource Management Act 1991, for the purpose of ensuring that the conditions of this consent are not inconsistent with the Vision and Strategy of the Waikato-Tainui Raupatu Claims Waikato River Settlement Act 2010 (Schedule 2 – Vision and Strategy for Waikato River), and if necessary to address any such inconsistencies by way of further or amended conditions.

Review clause

44) The Waikato Regional Council may within the six month period following 1st July 2014 and the six month period following 1st July every three years thereafter, serve notice on the Consent Holder under section 128(1) of the Resource Management Act 1991, and commence a review of the conditions of this consent for the following purposes:

a) To review the effectiveness of the conditions of this consent in avoiding, remedying or mitigating any adverse effects on the environment from the exercise of this consent, and if necessary to avoid, remedy or mitigate such effects by way of further or amended conditions;

b) In view of the findings of the Stormwater Management Review Report required by Condition 40, or the Monitoring Programme required by Condition 37 of this consent, to require the Consent Holder to adopt the Best Practicable Option or other specific measures to avoid, remedy or mitigate any adverse effects on the environment that result from the exercise of this consent;

c) To review the adequacy of and necessity for the monitoring undertaken by the Consent Holder, and, if necessary, to amend and/or introduce new conditions to monitor any adverse effects on the environment that result from the exercise of this consent;

d) To respond to concerns raised by the Hamilton City Council – Waikato-Tainui Stormwater Steering Group;

e) To achieve consistency with any future changes to the Waikato Regional Council's Regional Plans or policies in regard to catchment management planning and stormwater management.

Costs associated with any review of the conditions of this consent will be recovered from the Consent Holder in accordance with the provisions of section 36 of the Resource Management Act 1991.

Administrative charges

45) The Consent Holder shall pay to the Waikato Regional Council any administrative charge fixed in accordance with section 36 of the Resource Management Act 1991, or any charge prescribed in accordance with regulations made under section 360 of the Resource Management Act.

For and on behalf of the
Waikato Regional Council

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General Advice Notes

1) *This resource consent does not give any right of access over private or public property. Arrangements for access must be made between the Consent Holder and the property owner.*

2) *The reasonable costs incurred by the Waikato Regional Council arising from supervision and monitoring of this consent will be charged to the Consent Holder. This may include but not be limited to routine inspection of the site by Waikato Regional Council officers or agents, liaison with the Consent Holder, responding to complaints or enquiries relating to the site, and review and assessment of compliance with the conditions of consent.*

3) *This consent does not authorise any stormwater diversion or discharge activities derived from privately owned stormwater networks, nor any other stormwater diversion or discharge activities that do not result from the operation of the Hamilton City Council's municipal stormwater network.*

4) *This consent does not authorise any works in a watercourse, nor any other activity for which further consents may be required under sections 13, 14 and 15 of the RMA, or the provisions of the Waikato Regional Plan.*

5) *The Consent Holder is responsible for compliance with the conditions of this consent, except where statutory defences pursuant to section 341 of the RMA apply.*

6) *Pursuant to section 332 of the RMA 1991, enforcement officers may at all reasonable times go onto the property that is the subject of this consent, for the purpose of carrying out inspections, surveys, investigations, tests, measurements or taking samples.*

Appendix to Resource Consent Schedule - 105279

Condition 30 (Catchment Management Plans) and Condition 35 (Stormwater Management Plan) refer to 'key stakeholders'. In this regard 'key stakeholders' include but are not limited to, the following parties and/or their successors:

1. Waikato Regional Council – P O Box 4010, Hamilton East
2. Waikato Tainui Te Kauhanganui Inc / Waikato Raupatu River Trust – Private Bag 3344, Hamilton
3. Waikato District Council – Private Bag 544, Ngaruawahia
4. Waikato District Health Board – Public Health Unit, P O Box 505, Hamilton
5. Department of Conservation – Private Bag 3072, Hamilton
6. Watercare Services Limited – Private Bag 92521, Wellesley Street, Auckland
7. Te Kotuku Whenua Consultants – C/- Maree Pene, 96 Insol Avenue, Hamilton
8. Tui 2000 – C/- Mairi Jay, 43 MacFarlane Street, Hamilton
9. Lake Rotokauri Management Committee – C/- 17 Wynvale Lane, RD9, Hamilton
10. The University of Waikato - Centre for Biodiversity & Ecology Research – Private Bag 3105, Hamilton
11. Mangaiti Gully Restoration Group – C/- Mr Robin Holdsworth, 13 Sexton Road, Rototuna Park, Hamilton
12. Mr Bruce MacKay 1A Wymer Terrace, Hamilton
13. CDL Lands New Zealand Ltd – C/- McPherson Goodwin Surveyors Ltd, P O Box 9379, Hamilton

In terms of Condition 30 (Catchment Management Plans), 'key stakeholders' shall be limited to those parties who are associated with a particular catchment, not the wider Hamilton Urban Area.

In terms of Condition 35 (Stormwater Management Plan), all parties shall be consulted in the development of the Stormwater Management Plan before the Stormwater Management Plan is submitted to the Waikato Regional Council for approval. Thereafter the appropriate party/s shall be consulted as relevant to the stormwater management activity under review.

ATTACHMENT B

Consultation letter

Hamilton City Council
Te kaunihera o Kirikiriroa

Private Bag 3010
Hamilton 3240
New Zealand

Phone 07 838 6699
Fax 07 838 6599

info@hcc.govt.nz
www.hamilton.co.nz

5 February 2014

To stakeholder

We have developed an Integrated Catchment Management Plan (ICMP) for the Ruakura area and are seeking your feedback as you have been identified as having an interest in the area.

An ICMP outlines how Council services such as water supply, wastewater and stormwater can be managed together for future development within the Ruakura area. While our District Plan sets out the rules for what we allow in certain areas, the ICMP is a tailored plan which provides more detail specific to the area.

As part of the ICMP, we have developed flood hazard maps which help us understand the affects of extreme rainfall and how this can be managed through future infrastructure and design. The maps can be found within the ICMP document and shows where flooding or ponding is likely to occur. These maps will eventually be included in the District Plan.

We are currently in the consultation phase and are seeking feedback. The Ruakura ICMP and supporting documents are available online at www.hamilton.govt.nz/ICMP.

If you have trouble viewing these documents or would like further information, please don't hesitate to contact us:

- visit www.hamilton.govt.nz/ICMP
- phone 07 838 6903 to speak to a staff member
- or email city.development@hcc.govt.nz

We'd also like to encourage you to come along to our Information Day:

- Where: McMeekan Centre within Agresearch site
- When: Tuesday 25 February, 3pm-7pm

Feedback must be received by 4pm Monday 10 March 2014. You can give us your feedback online at www.hamilton.govt.nz/ICMP or by filling in the form provided with this letter.

Kind regards,

Martin Mould
City Development Manager

ATTACHMENT C

List of intended recipients

Owner Full Name Initial	Postal Address 1	Postal Address 2	Postal Address 3
A F Julian & B W Julian	53A Ryburn Road	RD 6	Hamilton 3286
A L Wan & S T Wan	PO Box 12386	Chartwell Square	Hamilton 3248
A N Clarke & S L Clarke	187A State Highway 26	RD 6	Hamilton 3286
AgResearch Ltd	Privart Bag	Waikato Mail Centre	Hamilton 3240
B S Irving & LM Irving	171 State Highway 26	RD 6	Hamilton 3286
Blink Trading Ltd	187 B Morrinsville Road	Hillcrest	Hamilton 3216
BP Phee & B J Phee	7 Vista Terrace	Hillcrest	Hamilton 3216
C Ferguson	169 Powells Road	RD 1	Hamilton 3281
C S Lee & S A Lee & Others	7 Vista Terrace	Hillcrest	Hamilton 3216
C S Lee & S A Lee & Others	7 Vista Terrace	Hillcrest	Hamilton 3216
Chedworth Park Ltd	PO Box 28003	Horsham Downs	Hamilton 3256
D Alexander	580 Main Wedonside Road	Gore 9777	
D C Ferguson & M W Crawford & Others	68 Webster Road	RD 4	Hamilton 3284
D C Ferguson & M W Crawford & Others	68 Webster Road	RD 4	Hamilton 3284
D E Chibnall & K Chibnall	124A Percival Road	RD 6	Hamilton 3286
D M Young & K L Young	4 Brighton Grove	RD 6	Hamilton 3286
D Qiao	177 State Highway 26	RD 6	Hamilton 3286
E N Nicholson & S H Nicholson & Others	194 Morrinsville Road	RD 6	Hamilton 3286
Eastside Apostolic Church	11 Bisley Road	Enderley	Hamilton 3214
ES Cunningham & P D Cunningham	2020 River Road	RD 1	Hamilton 3281
G A Leek & M L Leek	8 Gordonton Road	RD 1	Hamilton 3281
G E Goodwin & J K Goodwin	7 Hamilton Parade	Hamilton Central	Hamilton 3204
GJ McEwen & G J Knox & Others	12 B East Ridge Grove	RD 6	Hamilton 3286
Go Do It Ltd	134A Percival Road	RD 6	Hamilton 3286
H Wang & K T Shang	51A Ryburn Road	RD 6	Hamilton 3286
Hamilton City Council	Private Bag 3010	Waikato Mail Centre	Hamilton 3240
Hamilton City Council	Parks & Open Spaces	Private Bag 3010	Hamilton 3240
Hamilton City Council	Parks & Open Spaces	Private Bag 3010	Hamilton 3240
Hamilton City Council	City Waters	Private Bag 3010	Hamilton 3240
Hamilton City Council - City Transportation Unit	City Transportation Unit	Private Bag 3010	Hamilton 3240
Hamilton Ramayan Sanstha Incorporated	PO Box 164	Waikato Mail Centre	Hamilton 3240
I B Carmichael & N A Carmichael	6 Brighton Grove	RD 6	Hamilton 3286
Inovation Waikato Ltd	PO Box 9466	Hamiton 2015	
J E Cornwall	134 State Highway 26	RD 6	Hamilton 3286
J H Hely & H J Montgomerie	188B Morrinsville Road	RD 6	Hamilton 3284

J H Lovatt & M T Lovatt	12C East Ridge Grove	RD 6	Hamilton 3286
J H Lovatt & M T Lovatt	12C East Ridge Grove	RD 6	Hamilton 3286
J Huang & J S Wan	22A Fenwick Crescent	Hillcrest	Hamilton 3216
J M Evans	64 Ryburn Road	RD 6	Hamilton 3286
J P Ryan & B E Ryan	3 Brighton Grove	RD 6	Hamilton 3286
J Yuan & D Deng	177A State Highway 26	RD 6	Hamilton 3286
K F Wallace & A K Spence & Others	10 East Ridge Grove	RD 6	Hamilton 3286
K J Collier & E H Halsey	130 Percival Road	RD 6	Hamilton 3286
K J Willmott & D M Willmott & Others	PO Box 22396	Khandallah	Wellington 6441
L Gou & X Li	177B State Highway 26	RD 6	Hamilton 3286
L J Cooper & M J Cooper & Others	PO Box 19367	Hamilton 3244	
L L Van Der Beek	PO Box 82	Raglan 3265	
L Wang & S Yang	51C Ryburn Road	RD 6	Hamilton 3286
M J Griffin & J M Griffin & Others	170 State Highway 26	RD 6	Hamilton 3286
M Kang & Y Bai	187 B Morrinsville Road	Hillcrest	Hamilton 3216
M Tang & M Yang	51B Ryburn Road	RD 6	Hamilton 3286
M Van De Ven	221 State Highway 26	RD 6	Hamilton 3286
NM Bruce & KI Bruce	166 State Highway 26	RD 6	Hamilton 3286
NZ Transport Agency	C/O Colliers International	PO Box 19093	Hamilton 3244
P L May & C Nikkel & Others	96 Greenhill Road	RD 1	Hamilton 3281
Peter May Farms Ltd	96 Greenhill Road	RD 1	Hamilton 3281
R L Bush & N J Bush	12A East Ridge Grove	RD 6	Hamilton 3286
R Spirig & W J Spirig	116 Percival Road	RD 6	Hamilton 3286
R T Cursons & G A Verkerk	161 State Highway 26	RD 6	Hamilton 3286
R W Heap	16 Wye Street	Oamaru 9400	
Rusty Racing Limited	PO Box 14002	Five Cross Roads	Hamilton 3252
S L Chiu	124B Percival Road	RD 6	Hamilton 3286
S Lee	124B Percival Road	RD 6	Hamilton 3286
SJ Wells	32 Flynn Road	Hillcrest	Hamilton 3216
T A Fearnley & J E Fearnley	136 State Highway 26	RD 6	Hamilton 3286
Tainui Development Ltd	PO Box 19295	Hamilton 3244	
Tainui Development Ltd	PO Box 19295	Hamilton 3244	
Tainui Development Ltd	Private Bag 3115	Waikato Mail Centre	Hamilton 3240
Tainui Group Holdings Ltd	Private Bag 3230	Waikato Mail Centre	Hamilton 3240
Tainui Group Holdings Ltd	PO Box 9466	Hamilton 2015	
TJ Hancock & L G Hancock	PO Box 24188	Abel	Hamilton 3253
W C Engelander & K A Engelander	PO Box 24162	Abels	Hamilton 3253
W G Harris & J E Harris	152 State Highway 26	RD 6	Hamilton 3286
W R Cowie & R M Cowie	60 Percival Road	RD 6	Hamilton 3286
Waikato Krishna Limited	PO Box 920	Waikato Mail Centre	Hamilton 3240

Waikato Krishna Limited	PO Box 920	Waikato Mail Centre	Hamilton 3240
X Wang & B Han & Others	PO Box 942	Waikato Mail Centre	Hamilton 3240
Y Chang & A Wang	137 State Highway 26	RD 6	Hamilton 3286
Y Chen & LY Wu	16 Ayrshire Drive	Grandview Heights	Hamilton 3200
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Ann Hardy

Appendix K

Mangaheka Wastewater Servicing Report

Mangaheka ICMP
Hamilton City Council
16-Jun-2017

Mangaheka Wastewater

Servicing Concept

Mangaheka Wastewater

Servicing Concept

Client: Hamilton City Council

Co No.: N/A

Prepared by

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Date 16-Jun-2017

Prepared by Benjamin Smith

Reviewed by Chris Hardy

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
A	24-Mar-2017	Draft for Client	Chris Hardy Principal Civil Engineer	
B	16-Jun-2017	Final	Chris Hardy Principal Civil Engineer	

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1.0 Background

AECOM has been engaged by Hamilton City Council (HCC) to perform a desktop assessment to conceptually define the strategic wastewater network in the Mangaheka Catchment and northern extension areas 1C and 1E. Wastewater in the area will connect to the Far Western Interceptor (FWI).

The existing FWI is 1050 mm in diameter. The FWI extends southwest from the Wastewater Treatment Plant and under the North Island Main Trunk Railway to the Te Rapa Bypass where it tracks parallel to the road to within about 400 m of the Te Wetini Drive Interchange.

Several suitable connection points exist at manholes along the FWI alignment with invert levels ranging from 24.84 m to 27.14 m (about 6 m below existing ground level).

2.0 Assessment scope

The majority of the Mangaheka catchment already has gravity trunk network installed or planned; shown in the HCC GIS. These areas have been assessed for their compliance with the Infrastructure Technical Standard (ITS) and suitability for conveying flows from other sub-catchments. Preliminary pipe sizes and strategic network layouts have been identified for the areas where no existing network is installed or planned.

The study area has been divided into sub-catchments based on topography and areas able to be serviced by gravity to various connection points. The areas and the indicative pipeline layout can be seen in the plan in Appendix A. Design flows have been assessed based on the sub-catchment land area with the following inputs and assumptions:

- The overall catchment area has been assessed as industrial with the exception of the northern extension area 1C which is residential.
- Sub-catchment flows have been calculated as per the ITS with a population equivalent of 45 persons per hectare for all areas.
- Existing network inverts and pipe diameters have been taken from the HCC GIS.
- Minimum pipe gradient and velocity are taken from the ITS.
- Assumed ground levels are based on the HCC LiDAR ground model.
- A maximum pump station depth of 6m has been assumed.

This assessment is intended to be a conceptual network assessment. Pipe locations and sizing are indicative only. Final sizing and locations will be subject to detailed design and engineering approval.

3.0 Wastewater master plan (WWMP2) flows

The population equivalents used based on the ITS have been compared the WWMP2 modelling population equivalents as summarised in Table 1.

Table 1 WWMP2 population comparison

Area	Zoning	ITS population equivalent (people/ha)	WWMP2 population equivalent (people/ha)
Mangaheka catchment (Rotokauri stage 1A)	Light industrial	45	30
Mangaheka catchment (Rotokauri stage 2B)	Light industrial	45	30
Northern extension 1C	Large lot residential	45	30
Northern extension 1E	Deferred industrial	45	20

The population equivalents used for the WWMP2 modelling are lower than those required by the ITS. All peak flow estimates quoted in this report have been based on the ITS method using the WWMP2 population equivalent in order to remain consistent with the network modelling approach.

For all of the sub-catchments assessed, it is the minimum grade requirements that hold most bearing on the layout rather than the pipe capacity. The higher flows yielded using ITS population equivalents do not typically affect the layout and pipe sizing can be confirmed in later planning. Should HCC deem the higher flows to be more suitable, this should be taken into account during detailed design, particularly in relation to pump station design flows and emergency storage.

4.0 Undeveloped areas

Preliminary pipe sizes and network layouts have been identified for undeveloped areas based on the ITS. Refer to the plan in Appendix A for catchment locations and extents.

4.1 Mangaheka Undeveloped Area 1

This area is approximately 20.2 hectares which yields a design peak flow of 8.9 L/s. A new 150 mm pipeline flowing west to the FWI (Manhole WWL10001, GIS invert level 26.21 m) will be required to collect wastewater from this area.

4.2 Mangaheka Undeveloped Area 2

This area is approximately 46.8 hectares which yields a design peak flow of 19.9 L/s.

Wastewater planning for the Rotokauri ICMP includes consideration of this area due to proximity and location on the west side of the Te Rapa bypass, south of Te Kowhai Road. The Rotokauri ICMP indicates that a 600 mm diameter trunk main will pass through this area into manhole WWK09003. This areas wastewater has been allowed for in the Rotokauri ICMP by gravity connection to the proposed 600 mm trunk main.

4.3 Northern Extension 1C

This area was also included in the Rotokauri ICMP wastewater plan as an area potentially serviced by gravity. The sub-catchment is approximately 24.7 hectares which yields a design peak flow of 10.9 L/s.

The area slopes to the north which makes the northern extremity too low to be collected directly by gravity (without filling - based on existing topography). The area is also too low and to distant to be serviced by a proposed pump station in the Northern Extension 1E area. Approximately half of this area will be serviceable by gravity and the other half will require a lift pump station to raise flows up to the gravity network.

The exact split between gravity and pumped area will depend on final topography and detailed assessment. The proposed pump station may also be able to be eliminated if filling is undertaken, or if flatter gradients than allowed by the ITS is approved. An increase of approximately 1.5 m in ground level in the northern extent appears to be required to make gravity collection feasible.

The portion serviceable by gravity will require an approximate 225 mm diameter pipeline flowing south to the 600 mm trunk pipeline proposed in the Rotokauri ICMP. The downstream elevation of this is constrained by the existing connection point to the FWI (manhole WWK09003) which has an invert level of 25.64 m. The 225 mm pipeline will also collect pumped flows from the northern half of the area and possibly some gravity flow from the Rotokauri catchment along the alignment.

4.4 Northern Extension 1E

The Northern Extension 1E is located north of Ruffell Road and has a total area of approximately 82 hectares. This area is bisected by the North Island Main Trunk Railway (NIMT) so proposes a pump station on either side. The capacity of downstream network receiving the pumped flows has been assessed in Section 5.3.

An area of approximately 5.7 hectares from the western half should be serviceable by gravity to the existing network on Ruffell Road. This area has been accounted for in the existing network in Section 5.3.

Immediately south of Old Ruffell Road there is a 7ha wastewater catchment with an existing gravity sewer. The current proposal is to drain this sewer to an interim pump station located 50m east of the North Island Main Trunk Railway (NIMTR) in Ruffell Road. The pump station will discharge via 90mm diameter rising main is proposed to run for 400m along Ruffell Road to join into the existing existing manhole WWJ09001 in Arthur Porter Drive.

In its current format the design flowrate of the pump station is 6 L/s at 18 m head. The proposed pump station is termed ‘interim’ as it may be reconfigured as part of its incorporation into the future network Catchment 1E.

4.4.1 West of NIMT

Approximately 38.4 hectares of the northern extension 1E sub catchment, west of the NIMT is not serviceable by gravity. This area yields a design peak flow of 16.3 L/s. The area is generally flat with an elevation of approximately RL 30 m.

The long and narrow sub catchment is suitable for a single central pump station. A central pump station will reduce pipe depths and allow the area to be serviced with one pump station. It may be feasible to locate the pump station at the ends of the area but pipe depths will need to be assessed.

It may be possible to eliminate the western pump station with a gravity network which collects all of the western flows in a central location then flows to the pump station located on the eastern side of the railway. Such a design would have the following implications:

- Eliminate the west pump station
- Increase the design flow for the east pump station. This may also impact the possible discharge connection points for the east pump station.
- A larger rising main and carrier pipe required to cross the NIMT.
- An additional gravity crossing under the railway with trunk main depths potentially in excess of 6m.

The feasibility of the alternative solution could be investigated further by HCC or developers once the future network, topography and road layout is finalised.

4.4.2 East of NIMT

Approximately 43.6 hectares of the northern extension 1E sub-catchment is located east of the NIMTs (including the 7 hectare area that will be temporarily pumped). This area yields a peak design flow of 18.6 L/s. The area has a central gully with a high bank level approximately 29 m and a base level of approximately RL 23 m.

Based on existing topography the sub-catchment will require a pump station constructed in the low point of the gully with a rising main pumping back up to manhole WWJ09001. The topography is such that a local 150 mm diameter gravity collection network should be sufficient to convey flows to the pump station (subject to detailed design).

Rising main carrier pipe

Construction of a rising main under the railway will require trenchless installation and an encasement pipe to meet the Kiwirail specifications for pressure pipelines. The design for the temporary railway crossing should consider the fully developed situation. Refer to Section 6.0 for more detail.

5.0 Areas with existing network

Existing serviced areas have been assessed for their compliance with the ITS and suitability for conveying flows from other sub catchments. Pipe sections have been grouped together based on their network location and diameter. The average grade across several pipes has been used in the assessment as opposed to assessing every pipe length by itself.

All of the pipe lengths assessed have sufficient capacity to meet the design peak flows. Some instances of pipes with an average grade flatter than the ITS standard have been identified and are highlighted in Sections 5.1 to 5.3.

Pipelines can operate at less than the nominal design gradient often without issue but there is an increased risk that cleaning will be required. Based on the average grade none of these pipes are considered flat enough to warrant early replacement.

5.1 Mangaheka Existing Area 1 (Arthur Porter Drive & Chalmers Road)

This area has three branches of 150 mm diameter gravity pipeline along Arthur Porter Drive to manhole WWM11006. From manhole WWM11006 a 225 mm diameter branch flows southwest to manhole WWM11009 where the diameter increases to 300 mm in the fifth section. Discharge is to the FWI (manhole WWM11001, invert level 27.14 m).

The five sections were assessed separately as shown in Table 2. At the time of writing the GIS for this area was found to be incorrect so the assessment has been based on the as-built drawing for the subdivision.

Table 2 Existing Area 1 assessment

Pipe section	WWL11011 to WWM11006	WWL12060 to WWM11006	WWM12011 to WWM11006	WWM11006 to WWM11009	WWM11009 to WWM11001
Estimated max. catchment (ha)	14.0	12.0	21.0	55.0	59.4
Design flow (L/s)	6.4	5.7	9.2	23.0	24.9
Average grade (%)	0.53	0.53	0.53	0.31	0.28
Diameter (mm)	150	150	150	225	300
Pipe capacity (L/s)	11.3	11.1	11.3	25.4	51.6
Comments	Pipes have sufficient capacity Average grade is slightly lower than the ITS standard (0.55% for 150 mm diameter, 0.33% for 225 mm diameter)				Has sufficient capacity and grade

5.2 Mangaheka Existing Area 2 (south of the FWI)

This area has a central gravity pipeline which flows north Te Kowhai Road East to the FWI at manhole WWK10008 (invert level RL 25.13 m). At manhole WWK10013 the central gravity increases in diameter from 150 mm to 225 mm. The two sections with different diameters have been assessed separately based on the average grade. The results of this assessment are shown in Table 3.

Table 3 Existing Area 2 assessment

Pipe section	WWL10005 to WWK10013	WWK10013 to WWK10008
Estimated maximum catchment (ha)	21	52.2
Design flow (L/s)	9.2	21.9
Average grade (%)	0.38	0.77
Diameter (mm)	150	225
Pipe capacity (L/s)	9.5	40.2
Comments	Pipes have sufficient capacity. Average grade is lower than the ITS standard (0.55% for 150 mm diameter)	Pipe has sufficient capacity and grade.

5.3 Mangaheka Existing Area 3 (north of FWI)

This area has a central gravity pipeline which flows south from Ruffell Road to the FWI at manhole WWK10008 (invert level RL 25.13 m). At manhole WWJ09003 the pipeline increases in diameter from 300 mm to 375 mm.

Assumptions regarding the connection of pumped flows relative to the two sections are as follows:

a. WWJ09001 to WWJ09003 – 300 mm diameter

Manhole WWJ09001 is assumed to be the intended future connection point for pumped flows from the northern extension 1E sub-catchment east of the railway. The west area could not also connect to this location without risking overflow or surcharge.

b. WWK09003 to WWK10008 – 375 mm diameter

Manhole WWJ09003 is assumed to be the intended future connection point for pumped flows from the northern extension 1E sub-catchment west of the railway. At this point

An area of 5.7 hectares at the southern end of the Northern Extension 1E zone (north of Ruffell Road) may be able to be serviced by gravity network to manhole WWK09003 based on existing topography so is shown within the existing area on the plan in Appendix A.

The estimated catchment areas used for the assessment total 79.5 hectares made up of the following:

- 43.6 hectares pumped from the Northern Extension 1E east of the NIMT.
- 38.4 hectares pumped from the Northern Extension 1E west of the NIMT.
- 5.7 hectares of gravity network from the Northern Extension 1E west of the NIMT.
- 35.1 hectares of local gravity flows from Existing Area 3.

The two sections have been assessed separately based on their average grade. The results of the assessment are shown in Table 4.

Table 4 Existing Area 3 assessment

Pipe section	WWJ09001 to WWJ09003	WWK09003 to WWK10008
Estimated maximum catchment (ha)	43.6 (Pumped)	122.8 (pumped + gravity)
Design flow (L/s)	18.6	48.8
Average grade (%)	0.22	0.17
Diameter (mm)	300	375

Pipe section	WWJ09001 to WWJ09003	WWK09003 to WWK10008
Pipe capacity (L/s)	46.1	73.1
Comments	Pipes have sufficient capacity and grade to receive pumped flows from Northern Extension 1E and the local gravity network	

6.0 Pump stations

Indicative pump station design parameters are shown in Table 5. The design pump rate is based on the calculated design peak wet weather flow.

An estimate of the rising main diameter has been calculated based on a nominal velocity of about 1.2 m/s. The stated diameters are indicative only and require detailed design to confirm.

Emergency storage is equal to the volume from 9 hours of the calculated average dry weather flow.

Table 5 Pump station concept design parameters

Pump Station	Northern extension 1C	Northern extension 1E west	Northern extension 1E east	Total northern extension 1E
Sub-catchment area (ha)	13.1	38.4	43.6	82.0
Average dry weather flow (L/s)	1.3	3.7	4.2	7.8
Pump rate (L/s)	6.2	16.3	18.6	33.7
Rising main diameter (mm)	90	150	150	200
Emergency storage flow (m^3)	41	119	135	254

<u>Northern Extension 1E east pump station</u>

As discussed in Section 4.4.2, the requirement to provide a carrier pipe for pressure pipes crossing the NIMT means the fully developed rising main sizes should be considered. The three scenarios considered are as follows:

- Temporary pump station – HCC have advised this will be a 90 mm diameter rising main.
- Northern extension 1E east pump station – Sizing has been based on the expected flows from the catchment east of the NIMT and a 150 mm diameter rising main is estimated.
- Total northern extension 1E pump station(east and west) – Sizing has been based on the expected flows from the catchment east of the NIMT plus the additional flows west of the NIMT as outlined as an alternative possibility in Section 4.4.1. A 200 mm diameter rising main is estimated.

Although the interim rising main will only need a carrier pipe of about 150mm dimeter, the maximum case would require a duct of about 300 mm diameter. Design of the carrier pipe should account for this.

7.0 Downstream network

All catchment and connections discussed in this report ultimately discharge to the FWI. For this assessment the downstream network has been assumed to have no capacity issues, surcharging potential, or overflow issues.

The following information based on the WWMP2 results were used to reach this assumption:

- No flooding occurs is predicted in the FWI downstream of the Mangaheka catchments for any of the future horizons (to 2061).
- In the 2061 horizon, several pipes in the FWI downstream of the Mangaheka catchments reach their full pipe capacity. This is not considered an issue for Mangaheka as no corresponding flooding is noted.
- Flooding and capacity issues are indicated between manhole WWM11006 and WWM11001 on Arthur Porter Drive. This was found to be caused by the incorrect GIS data discussed in Section 5.1 also being used for the WWMP2. The assessment made in Section 5.1 indicates that this is unlikely to be a real network issue.

8.0 Summary

The majority of the Mangaheka catchment already has gravity trunk network installed or planned. Existing serviced areas have been assessed for their compliance with the ITS and suitability for conveying future flows from other sub catchments. Preliminary pipe sizes and strategic network layouts have been identified for the areas where no existing network is installed or planned.

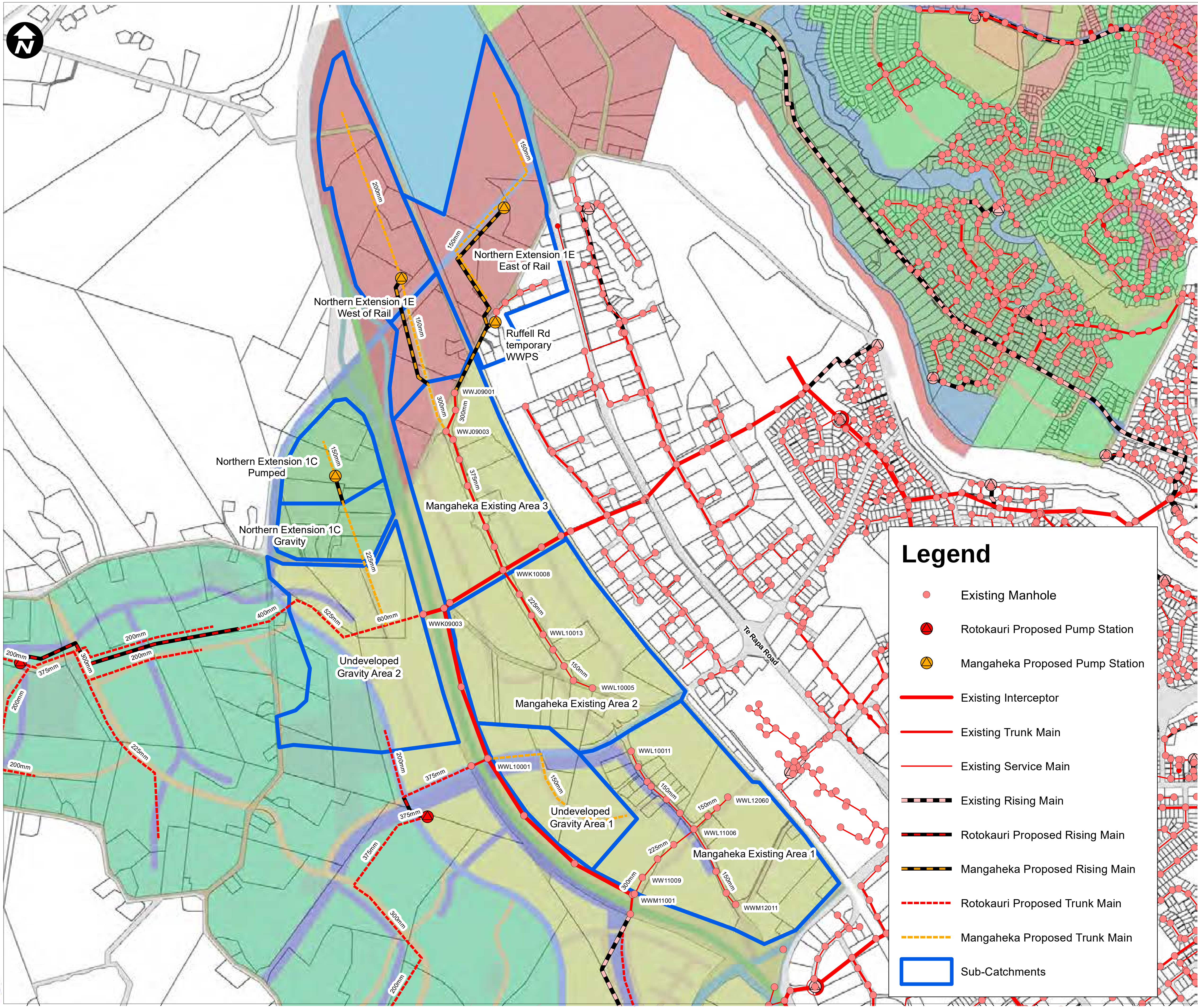
The key findings of the assessment are as follows:

- The existing network has sufficient capacity for future flows based on a population equivalent 30 persons per hectare. There are instances where there the ITS minimum gradients are not achieved resulting in an increased risk that these pipes may require operational cleaning. The average grades are not considered significantly flat enough to warrant early replacement.
- A pump station will be required for the low lying areas of the northern extension 1C sub-catchment. The remainder of the area can be served by gravity connection to the 600 mm trunk identified in the Rotokauri ICMP.
- Two pump stations will be required for the northern extension 1E sub-catchment. It may be possible to remove the western of these two pump stations if a gravity connection can be achieved to the east with a new pipeline under the NIMT.
- A temporary pump station is proposed to for an existing 7 hectare area of development south of Old Ruffell Road. The rising main will need to be constructed under the railway with a carrier pipe to meet the Kiwirail standards. Design of the carrier pipe should consider the rising main sizing for a fully developed situation.

Appendix A

Catchment Plan

ISO A3 297mm x 420mm



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Filename: \\nzham1fp001\projects\603X\60343024\4. Tech work Area\Task XX Mangaheka Wastewater\GIS\Plan21_3.mxd

AECOM

PROJECT

Mangaheka Catchment
Strategic Wastewater Network

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SPATIAL REFERENCE

Scale: 1:15,000 (A3 size)

200 100 0 200 400 Meters

Map features depicted in terms of NZTM 2000 projection.

Data Sources:
Cadastral Boundaries – LINZ NZ Cadastral Dataset 2016

PROJECT MANAGEMENT

Approved		Date	
Checked		Date	
Designed		Date	
Drawn	BS	Date	15/06/2017

PROJECT NUMBER

60343024

SHEET TITLE

Mangaheka Wastewater Catchment

MAP NUMBER

Appendix B

Calculations

Generic wastewater pipe sizing

Project Name: Mangaheka ICMP Wastewater
HYDRAULIC DESIGN OF SEWERAGE NETWORK
Generic pipe sizing for maximum sevice area

Branch No	Branch Sewer	Service Area (Ha)		HCC Peak Factor	Design Avg Flow	Design Peak Flow	Suggested Pipe Dia	Selected Pipe Dia, D	Pipe Material	Suggested Pipe Slope	Selected Pipe Slope	Part flow Coefficient	Q	V	q/Q	v/V	d/D	Flow Depth	Actual Velocity	Check Velocity	9 hr Storage	RM diameter
	Branch Area (Ha)	On Line	Accumulated		L/s	L/s	mm	mm		mm/m	mm/m		l/s	m/s				mm	m/sec		(m3)	mm @ 1.2m/s
New Sub Catchments																						
Northern extension 1C Total		24.7	24.7	3.2	2.36	10.85	150	225	uPVC	3.73	3.33	67	26.242	0.66	0.41	0.953	0.45	101.25	0.629	Check Slope		
Northern extension 1C Pump Station		13.1	13.1	3.7	1.25	6.21	150														41	90
Northern extension 1E West_1		11.6	11.6	3.8	1.11	5.58	150	150	uPVC	6.4	6.40	50	12.37	0.7	0.45	1	0.5	75	0.700	OK		
Northern extension 1E West_2		26.8	26.8	3.1	2.56	11.59	150	200	uPVC	4.36	4.36	62	21.991	0.7	0.53	1.04	0.55	110	0.728	OK		
Northern extension 1E West Pump Station (excluding 5.7 ha gravity area)		38.4	38.4	3.0	3.67	16.33	200														119	140
Northern extension 1E_East Half		17.7	17.7	3.3	1.69	7.90	150	150	uPVC	6.4	6.40	50	12.37	0.7	0.64	1.075	0.6	90	0.753	OK		
Northern extension 1E_East Pump Station (including 7 ha temporary pumped area)		43.6	43.6	3.0	4.16	18.55	200														135	150
Northern extension 1E_Full Area Pump Station (East and West)		82.0	82.0	2.8	7.83	33.74	250														254	190
Mangaheka Undeveloped 1		20.2	20.2	3.2	1.93	8.87	150	150	uPVC	6.4	6.40	50	12.37	0.7	0.72	1.103	0.65	97.5	0.772	OK		
Mangaheka Undeveloped 2		46.8	46.8	3.0	4.47	19.91	200	200	uPVC	4.36	4.36	62	21.991	0.7	0.91	1.136	0.75	150	0.795	OK		
Existing Pipes																						
WWL11011 to WWM11006		14.0	14.0	3.5	1.34	6.44	150	150	uPVC	6.4	5.32	49	11.31	0.64	0.57	1.041	0.55	82.5	0.666	Check Slope		
WWL12060 to WWM11006		12.0	12.0	3.7	1.15	5.69	150	150	uPVC	6.4	5.27	48	11.133	0.63	0.51	1.041	0.55	82.5	0.656	Check Slope		
WWM12011 to WWM11006		21.0	21.0	3.2	2.01	9.22	150	150	uPVC	6.4	5.29	48	11.31	0.64	0.82	1.124	0.7	105	0.719	OK		
WWM11006 to WWM11009		55.0	55.0	2.9	5.25	23.01	225	225	uPVC	3.73	3.09	66	25.447	0.64	0.9	1.136	0.75	168.75	0.727	OK		
WWM11009 to WWM11001		59.4	59.4	2.9	5.67	24.85	225	300	uPVC	2.56	2.76	86	51.601	0.73	0.48	1	0.5	150	0.730	OK		
WWL10005 to WWK10013		21.0	21.0	3.2	2.01	9.22	150	150	uPVC	6.4	3.79	46	9.543	0.54	0.97	1.145	0.8	120	0.618	Check Slope		
WWK10013 to WWK10008		52.2	52.2	2.9	4.98	21.84	200	225	uPVC	3.73	7.72	77	40.158	1.01	0.54	1.04	0.55	123.75	1.050	OK		
WWJ09001 to WWJ09003		43.6	43.6	3.0	4.16	18.55	200	300	uPVC	2.56	2.22	83	45.946	0.65	0.4	0.954	0.45	135	0.620	Check Slope		
WWK09003 to WWK10008		122.8	122.8	2.6	11.73	48.82	300	375	uPVC	1.92	1.71	98	72.895	0.66	0.67	1.073	0.6	225	0.708	OK		

Appendix L

Porter Properties Rotokauri Restoration Vision

Draft

Mangaheka Stream & Drain Network

RESTORATION VISION

July 2012

Document Quality Assurance

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Status: [DRAFT]	Revision / version: 0	Issue date: August 2012

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Contents

DRAFT

1. INTRODUCTION

In 2007 Hamilton City Council approved the Rotokauri Structure Plan to guide the long term development of the Rotokauri area, and this was incorporated into the Hamilton City Council District Plan through Variation 18. The Structure Plan included land zoned for industrial use to the north-west of Te Rapa.

The two main owners in the Rotokauri Industrial Area are Porter Properties Ltd (Porters) and Hamilton JV Ltd (HJV). Porters and HJV are required to obtain resource consents to develop the land, including a stormwater discharge consent.

The land currently drains to the Mangaheka Stream via a network of open drains. To determine the effects of stormwater discharge from the industrial development, Porters and HJV commissioned investigations into the Mangaheka Stream and drain catchment.

The ecological and water quality assessments of the watercourse and margins indicate that the catchment is highly modified and degraded. The main reasons are likely to be historic modification (e.g. straightening), removal of vegetation, the impact of surrounding rural land uses on water quality, and drain management practices.

As part of the resource consent process, consultation was undertaken with councils, landowners and Tangata Whenua to under the issues, and to communicate the findings of the assessments. The consultation process raised community awareness of the Mangaheka Stream and drains, and in particular raised awareness of the degraded state of the water course and catchment. Tangata whenua in particular wish to see the developer undertaking actions that improve water quality and other initiatives.

Although industrial development will not create adverse effects on the habitat and ecological values of the drains, Porters and HJV support restoration work on the watercourse and margins. There is an opportunity to create a beneficial outcome in the long term using the resources provided through development and urbanisation.

2. DOCUMENT CONTENT AND STRUCTURE

This document is a Restoration Vision for the Mangaheka Stream and drain network, based on the ecological, geotechnical and hydrological investigations undertaken as part of the Rotokauri Industrial Development consent process. Its purpose is to facilitate and guide community efforts to restore the Mangaheka Stream and drains. Small watercourses like the Mangaheka Stream tend to respond quickly to restoration efforts and there are a wide range of simple restoration measures that can be implemented to improve stream environments. This document presents a vision for the restoration of the Mangaheka Stream catchment based on the issues identified, with specific strategies and actions appropriate for each part of the catchment.

The document is divided into ten parts:

1. Introduction
2. Document content and structure
3. A summary of the stream and the restoration vision
4. Implementation
5. Restoration in the upper catchment (drains)
6. Restoration in the middle catchment (stream)
7. Restoration in the lower catchment (swamps)
8. Planting methods
9. Monitoring and maintenance
10. Other considerations.

2.1 How to Use this document

Step 1:

Read Section 3 to get an overview of the stream, identify where your property or restoration site is located in the catchment, and understand the restoration vision for the Mangaheka Stream catchment.

Step 2:

Refer to the section relevant to the part of the catchment where your site is located. Read the description of the existing environment to gain an understanding of why the aquatic environment exists in its present form. Then read the rationale and vision to understand what restoration activities are designed to achieve. Finally read the specific restoration actions you can take.

Step 3:

When you are ready to begin your restoration project, read the Implementation Methods section to get specific guidance on how to go about different activities.

Step 4:

Refer to the section on Other Considerations to get an understanding of various other tasks that can assist your restoration project.

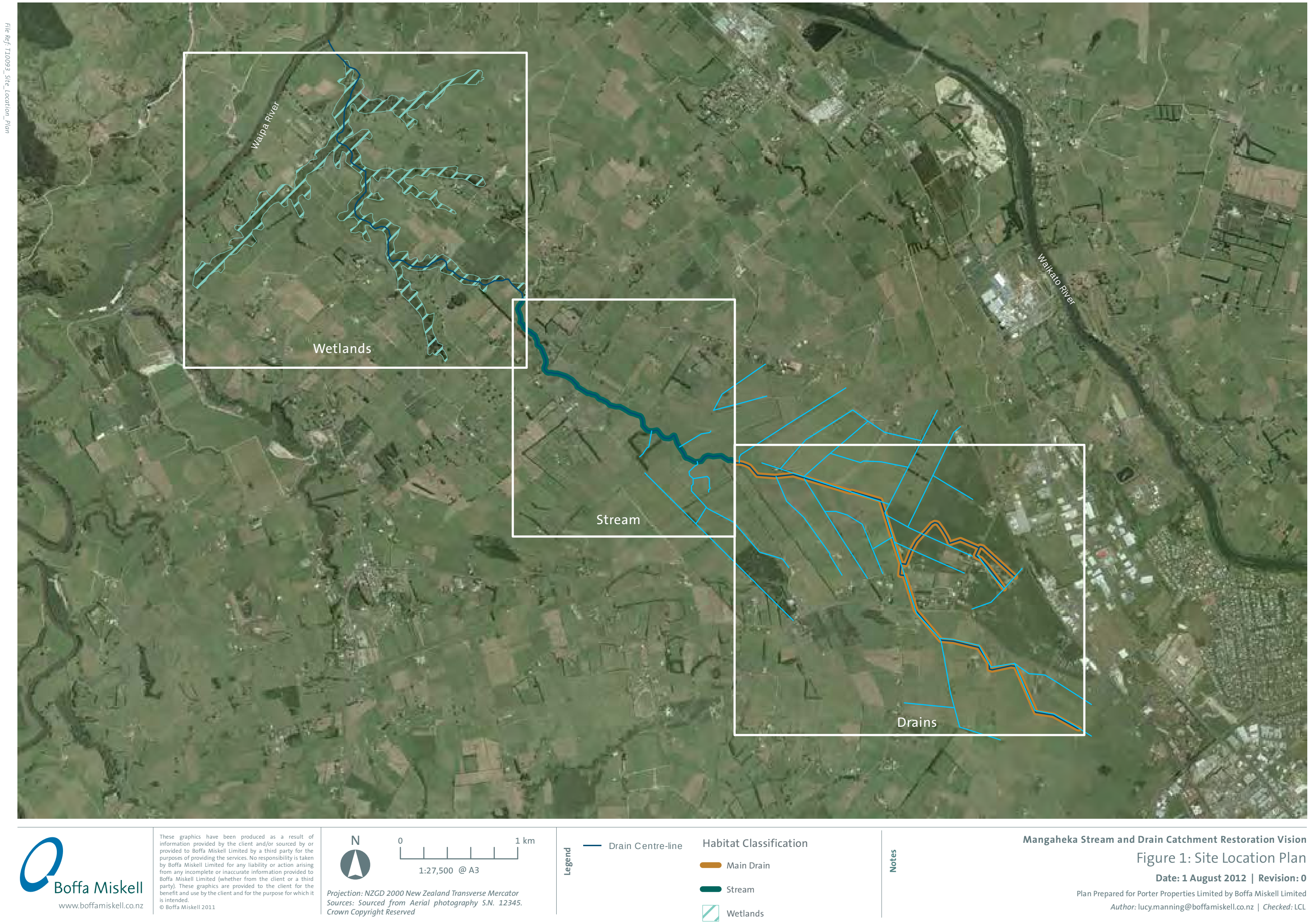

Figure 1: Site Location Plan

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3. RESTORATION VISION

The Mangaheka Stream catchment is a continuum of lowland aquatic habitats from small drains through to extensive swamps, linking lowland tributaries with the Waipa River. Figure 1 shows the location of the Mangaheka Stream and the different habitat types that make up the catchment.

Currently the catchment is degraded with poor water quality and poor habitat values. With coordinated effort from stakeholders and landowners, restoration of the catchment has the potential to restore these degraded watercourses to high quality habitats. However, it is important that the restoration efforts throughout the catchment are focused, consistent, and appropriate. This Restoration Vision provides guidance on the activities required in each part of the catchment.

The vision, objective and principles below are broadly similar to those in strategy and restoration documents for the Waikato River and Hamilton's gullies

3.1 Vision Statement

"To restore the lowland stream values of the Mangaheka Stream to a high quality aquatic environment, thereby providing for the long term availability of the stream for existing and potential uses consistent with the concept of sustainable management."

The objective of the Restoration Vision is to maintain the drainage function of the Mangaheka Stream while:

- improving water quality,
- restoring aquatic habitats,
- restoring indigenous vegetation cover, and
- improving bank stability.

3.2 Restoration Principles

The principles on which the Restoration Vision is based are:

- Natural stream processes should be allowed to occur except where assets require protection.
- Existing essential built assets and infrastructure should be protected from bank instability.
- Non-structural approaches to bank protection and habitat enhancement such as planting are preferable.
- Where oversteep banks are unstable, re-shaping and planting is preferable to armouring or other structural approaches.
- Vegetation on the stream banks should be managed in a way that promotes longterm bank stability.
- Remnant areas of indigenous stream riparian vegetation should be retained.
- Planting should involve eco-sourced indigenous species unless effective protection requires exotic species to be used.

3.3 Restoration Outcomes

The intended outcomes of the Restoration Vision are:

- Widespread community focus on restoration of the Mangaheka Stream catchment at a range of levels from individual landowners through to large funded projects.
- Extensive revegetation of the Mangaheka Stream and drains having multiple benefits to water quality and habitat quality, thereby improving the diversity and abundance of aquatic insects and native fish.
- Drain management processes based on adaptive management using targeted vegetation control and bioengineering, resulting in a significant reduction in channel spraying and cessation of bank spraying and ad hoc bank armouring.

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4. IMPLEMENTATION

4.1 Responsibility

The intention is that the Restoration Vision will be adopted by the Waikato Regional Council and incorporated within the Waipa Zone Management Plan. The Waipa Zone Management Plan is the primary tool for the implementation of river and catchment management activities within the Waipa Zone. The plan fulfils asset management planning requirements for river and catchment management assets in the Waipa Zone.

At present, parts of the watercourse fall outside the defined drainage district. Achievement of a comprehensive management approach would be supported by a change in the drainage district boundaries to provide full coverage. This will require a change to the Drainage District Boundaries under the Local Government Act.

4.2 Kaitiakitanga

Tangata Whenua have indicated a desire to have a role in the planning, design, implementation and monitoring of the Restoration Vision. This can be formalised through a memorandum of understanding.

4.3 Land Owners

A number of landowners have expressed support for the Restoration Vision. This support will provide a foundation for implementation.

Powers of entry are provided under legislation for essential works for property protection. It is likely that the Restoration Vision proposals go beyond that which is considered “essential”. Therefore, entry to property to undertake the works will need to be by agreement.

4.4 Timeframe

It is anticipated that the restoration work on the drains and streams would be completed within a 10 year period, while the restoration of the swamps would take up to 20 years. This aligns with the development timeframe for the Rotokauri Industrial Area and the availability of funding via a targeted rate.

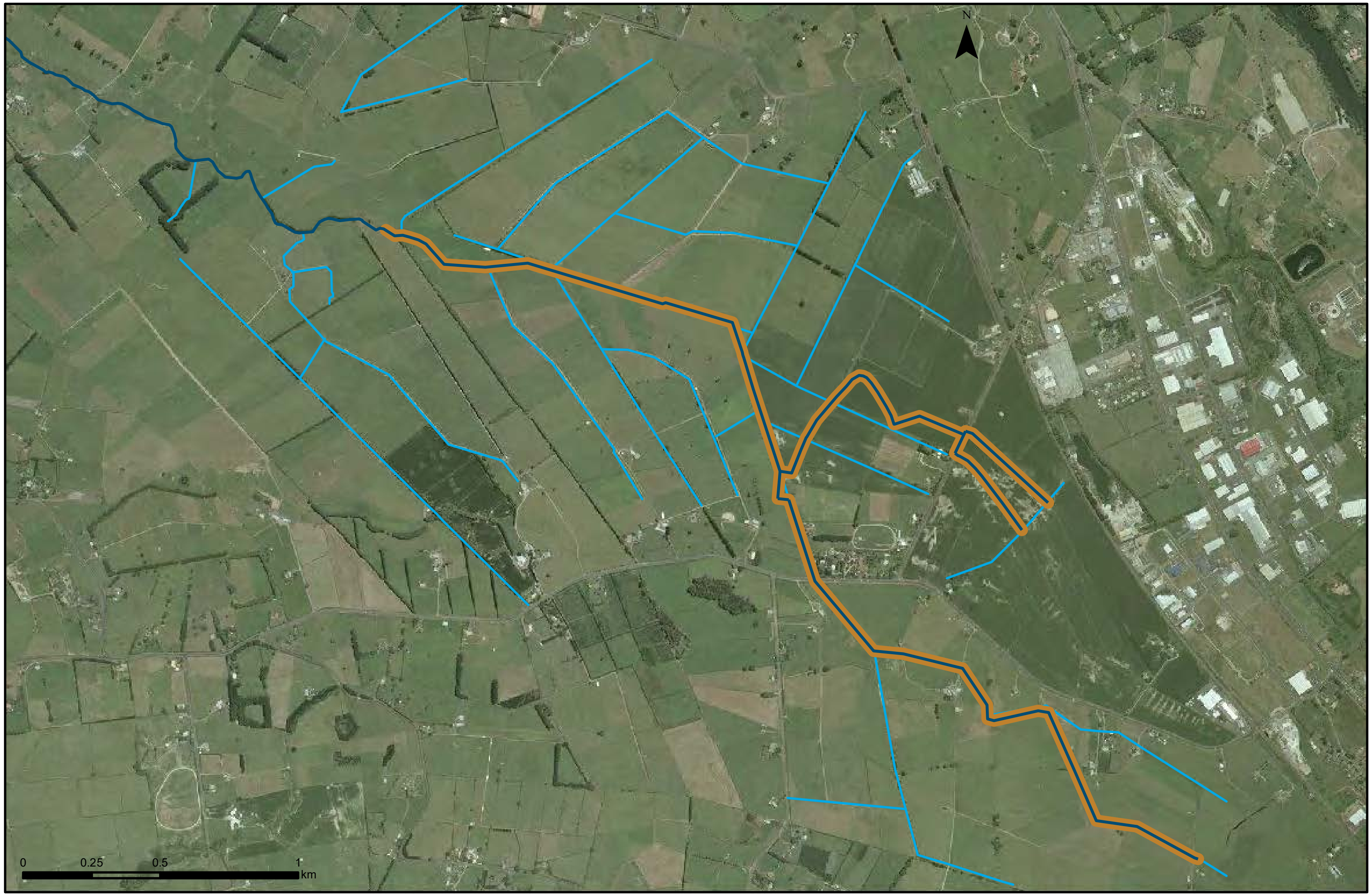
Timeframe will primarily be influenced by the willingness of landowners to allow access for the works to be undertaken.

4.5 Funding

Implementation of the Restoration Vision will require funding to be sourced . Provisional estimates are that the capital costs of restoration works are likely to be in excess of $250,000, spread over several years . Actual costs will require refinement once the scope of works is finally established.

100% of the revenue used to fund activities in the Waipa Zone is currently sourced via targeted rate. It is proposed that the targeted rate be extended to include land within the Rotokauri Industrial Area.

Even without the restoration vision proposal, it is fair that the Industrial Area landowners contribute to the cost of down stream management.



Aerial Image 1

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5. UPPER CATCHMENT

5.1 Location

From northwest of Avalon Drive to approximately midway between Ruffell Road and Horotiu Road, the watercourse is classified as a drain.

The image (left) shows only the main drain channels, but the description and restoration activities provided below can be applied to any of the tributary drains that are part of the network but not shown.

5.2 Description of the Existing Environment

The drains were originally dug through swamps to drain groundwater. In their current form, the drains are characterised by:

- steep banks,
- straight channels,
- uniform channels with little habitat diversity for aquatic animals, and
- little or no flow during dry periods.

Testing of water in the drains shows that water quality is very poor with:

- very high concentrations of nutrients that are likely to be causing algal blooms
- high concentrations of metals that are likely to be toxic to many stream animals, and
- high concentrations of faecal bacteria, potentially making the water unsafe for human contact and livestock drinking.

It is also likely that the drains have spikes of very high suspended sediment after rainfall, particularly near cropping land.

Habitat for fish and aquatic insects is very limited except where aquatic plants create habitat. It is likely that the only fish present in the drains are short finned eel and the noxious pest, mosquitofish, both of which are tolerant of poor water and habitat quality. The stream insect communities are dominated by species that are tolerant of disturbance and pollution.

Riparian (streamside) vegetation is mainly grass with some shelterbelt trees, but in many places riparian vegetation has been sprayed. Because the underlying pumice subsoils are weak and the drain banks are usually steep, spraying is resulting in bank erosion and slumping. Where spraying has not occurred, erosion and slumping is not occurring or is noticeably less.

5.3 Rationale for the Restoration of Drains

Even though the Mangaheka Stream drains are artificial watercourses and the existing environment within them is poor, the restoration potential of drains can be very good. Drains can have a disproportionately large impact on water quality because the water flowing into them can have very high concentrations of contaminants that are not diluted. Drains are less likely to be fenced or have adequate riparian buffer strips to filter out contaminants from surrounding land.

The restoration of drains can be undertaken with simple methods that can have a large positive impact. Even a 1.0 metre strip of grass alongside a small drain, fenced off from stock and left unsprayed, can result in a large improvement in drain water quality and create habitat for stream insects and some fish.

5.4 Restoration Vision for Drains

The restoration vision for the Mangaheka Stream drains is as follows:

- All drains fenced at a distance of at least 1.0m from the top of the bank. This will allow for livestock to graze beneath the fence, while leaving strip of vegetation on relatively flat land that is out of reach of stock. This grass filter strip has been shown to be highly effective at filtering out sediment, nutrients and faecal bacteria as long as the grass sward is dense.

  Placing fences at a distance of 1.0m from the crest of the drain bank will reduce the impact of livestock treading and machinery on the stability of the banks.
- All drain banks fully vegetated and unsprayed.

  The pumice subsoils along the drains are weak and unstable without the root structure of vegetation to hold them together. By keeping drain banks vegetated, the banks are less likely to slump and erode when water levels are high in the drains.

  The vegetation can either be rough grass and weeds, or the drains can be planted with native species that are found in the area naturally. Plant species lists are provided in the following section.
- Drain channels sprayed only if the channel is becoming choked with vegetation over more than 50% of a defined reach.

  Many of the aquatic plants present in drains will not impede high flows in drains. However, some plants such as willow weed are detrimental to the efficient flow of water because they produce dense vegetation growth above the water. Spraying of vegetation should be undertaken when aquatic vegetation reaches a level that is likely to impede flows, and spraying should only be in the drain channel.

  Care should be taken to avoid over-spray onto drain banks to retain bank vegetation.
- Drain bank instability controlled through appropriate fence location, bank re-shaping and planting.

  Where drain banks are unstable (i.e. slumping, undercutting, slipping or eroding), it is important to first identify the reason for the instability. If the drain is unfenced or fence posts are located too close to the edge of the bank, pressure from livestock treading can contribute to bank slumping and collapse. If this occurs, fencing the drain or moving fence posts further away from the bank edge can eliminate this problem. Some landowners may be reluctant to do this because of the loss of pasture, but the trade-off is the ongoing loss of land into the drain as unstable banks collapse. If the banks are unstable because they are too steep, then armouring and planting will generally be ineffective, and armouring is likely to exacerbate bank instability. Oversteep banks require reshaping which can be achieved quickly and effectively with an excavator. As with moving fences, this will result in the loss of some pasture, but minimises the future loss of land into the drain. If fences are located appropriately and banks are not oversteep, then bank instability can be effectively controlled with planting.

Plant species lists are provided in the following section.

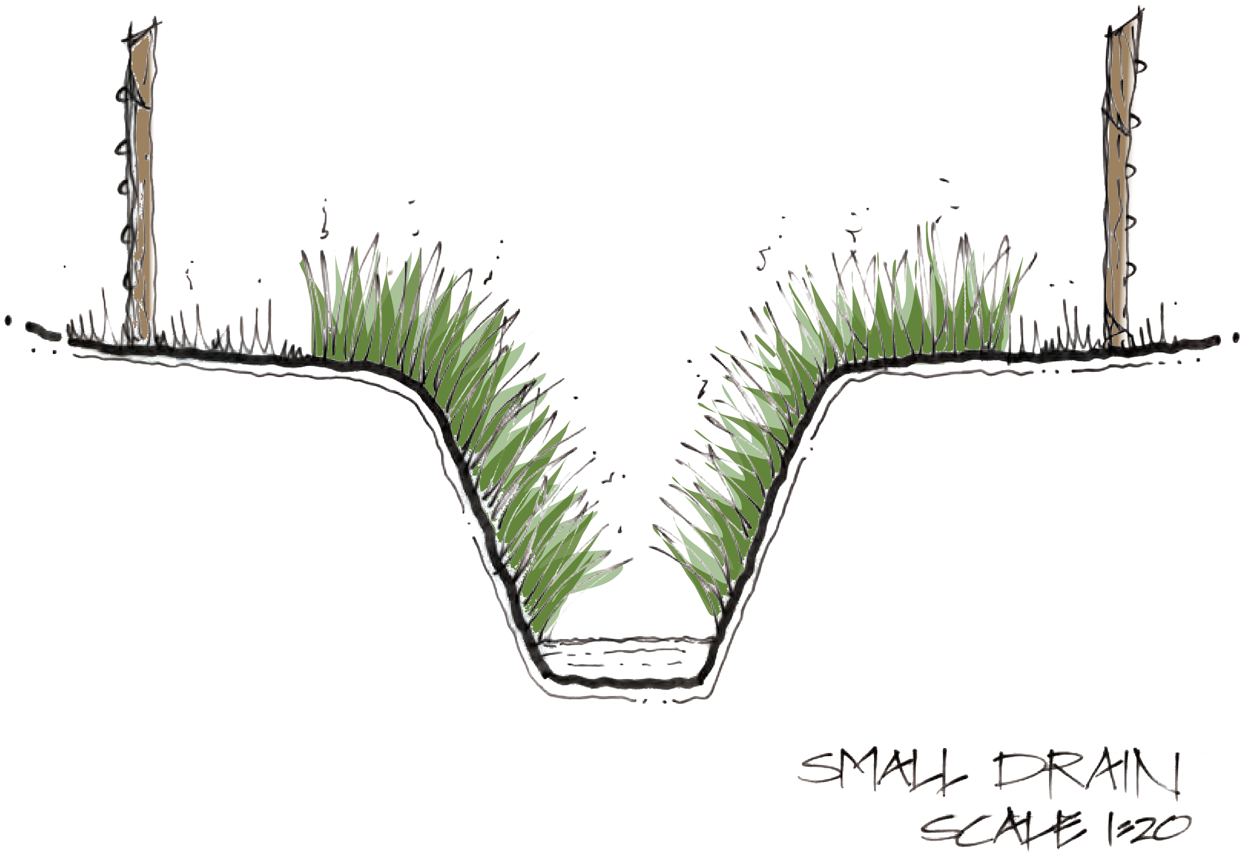

Diagram 1

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5.5 Species to Plant on Drain Banks

If you want to have vegetation other than grass on drain banks, the following plant species are considered to be the most appropriate species for this area. There are a number of things to consider in selecting plants including:

How big is the drain?

If the drain is small (e.g. less than 1.0m deep), simply letting grass grow on the drain banks without grazing or spraying will be sufficient to improve water quality and habitat in the drains. When growing densely, the grass will filter contaminants (especially when combined with the grass filter strip outside the drain banks), and provide shade and habitat. Diagram 1 shows how a small grass-vegetated drain is intended to look when the grass cover has re-established.

Does the drain flood regularly?

If the drain floods regularly, plants that flatten under the water flow will reduce any impact on the efficiency of the drains at removing water after rainfall. Plants that are dense and woody are, therefore, not appropriate as they will impede flows and can worsen erosion and scour.

What is the orientation of the drain: north-south or east-west?

An important aspect of aquatic environments is how much sunlight reaches the water. Generally, the ideal scenario is that watercourses are completely shaded by vegetation or banks. If the orientation of the drain is north-south, then the watercourse will get a lot of sunlight during the hottest part of the day, compared to drains that are oriented in an east-west direction which are partly shaded by their banks. As a result, drains that run in a north-south direction generally need taller vegetation to provide more shade.

It is particularly important to remember that if a drain is well shaded by bank vegetation, aquatic plants will have difficulty growing in the channel. This therefore improves the efficiency of the drain at removing water after rainfall and means that spraying the drain will be unnecessary.

Planting methods are outlined in Section 8.

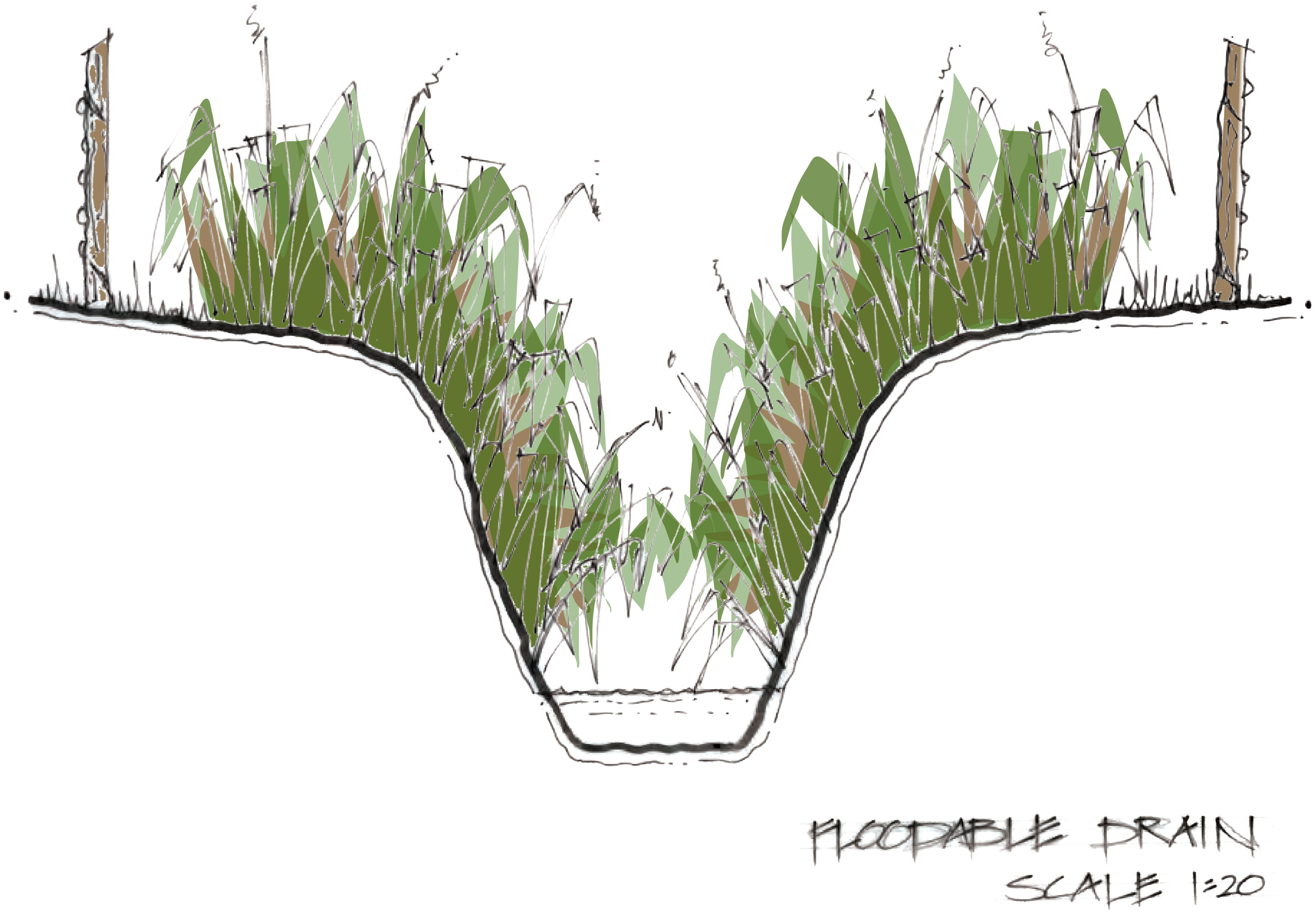

Diagram 2

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Latin name	Common name	Comments
Blechnum novae-zelandiae	kiokio	Not on peat
Carex geminata	cutty grass; rautahi	Tall vegetation for north-south drains
Carex lessoniana	cutty grass; rautahi	Tall vegetation for north-south drains
Carex maorica	sedge, purei	
Carex secta	pukio	Not on peat
Carex virgata	pukio	Not on peat
Chionochloa conspicua	bush tussock	Good on dry soils
Cordyline australis	cabbage tree, ti kouka	Excellent for unstable banks
Cortaderia fulvida	toetoe; kakaho	Tall vegetation for north-south drains.
Cortaderia toetoe	toetoe	Tall vegetation for north-south drains.
Cyperus ustulatus	giant umbrella sedge	Tall vegetation for north-south drains.
Gahnia setifolia	mapere	Tall vegetation for north-south drains.

5.5.1 Plants for Drains that Flood Regularly

All these plants can be planted at a spacing of 0.5m to 0.75m. All are frost resistant and are found naturally in the Waikato. Most have rhizomatous root structures that reduce the potential for erosion and scour of drain banks.

Although it is generally better to plant a variety of these species rather than one or two species, any planting along the drains is better than no planting at all.

Although flaxes are normally the plant of choice in this environment, flaxes are not appropriate for drains that flood regularly. Flax root structure is small relative to the size of the mature plant, and the vegetation density is large. As a result, flaxes can impede flood flow and entire plants can be torn out of banks (especially when soils are weak) exacerbating erosion and scour.

Diagram 2 (left) shows how the planted drain is intended to look when the planting is mature.

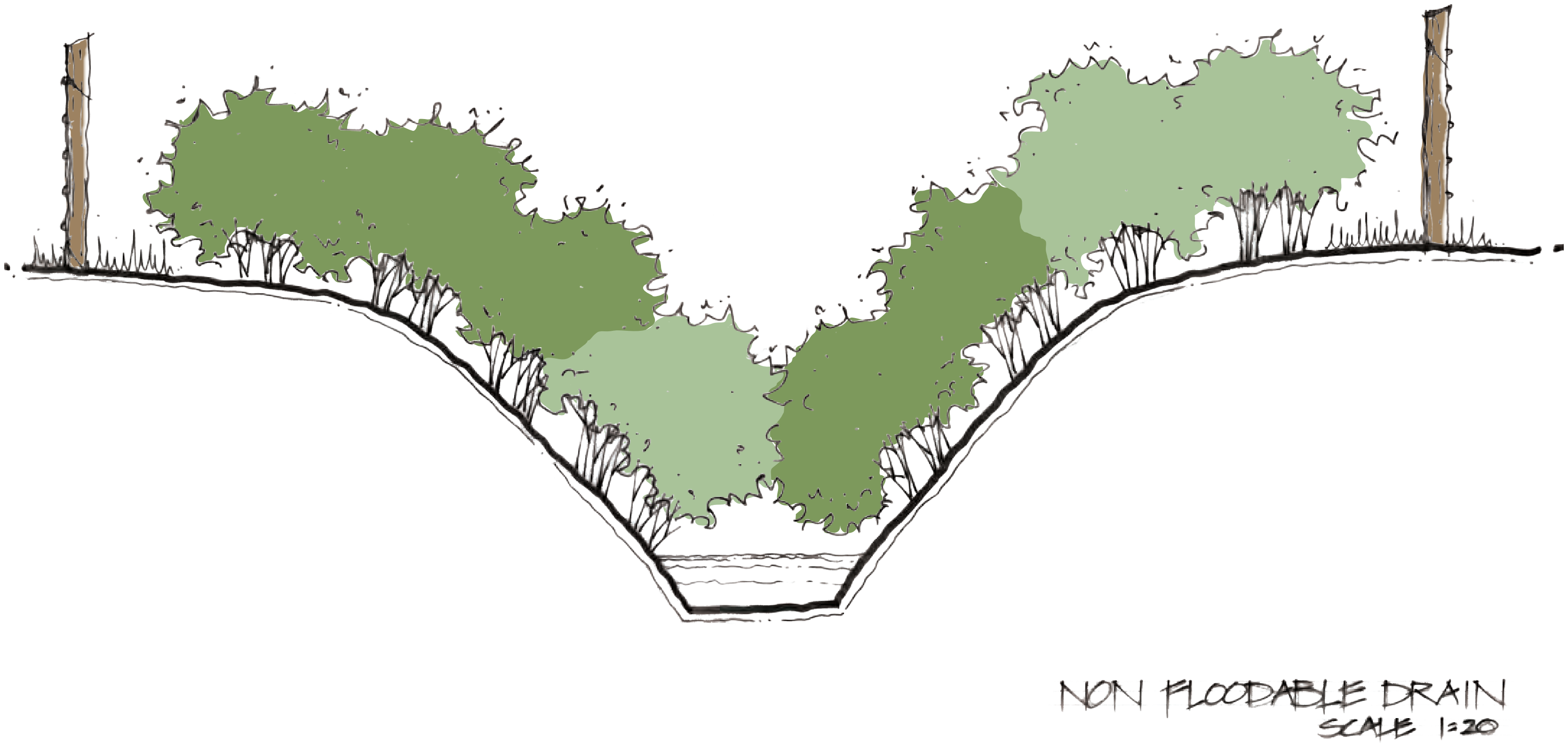

Diagram 3

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Latin name	Common name	Comments
Carex geminata	cutty grass; rautahi	Tall vegetation for north-south drains
Carex lessoniana	cutty grass; rautahi	Tall vegetation for north-south drains
Coprosma lucida	shining karamu; kakaramu	Provides food for birds
Coprosma robusta	karamu	Provides food for birds
Cordyline australis	cabbage tree, ti kouka	Excellent for unstable banks
Cortaderia fulvida	toetoe; kakaho	Tall vegetation for north-south drains
Cortaderia toetoe	toetoe	Tall vegetation for north-south drains
Dodonea viscosa	akeake	Good in dry soils
Gahnia setifolia	mapere	Tall vegetation for north-south drains
Hebe parviflora	koromiko	Not on peat
Hebe stricta	koromiko	Not on peat
Kunzea ericoides	kanuka	Needs to be ecosourced. Not on wet soils
Leptospermum scoparium	manuka	A good robust colonising plant
Myrsine australis	mapou	A good robust colonising plant
Phormium tenax	flax	
Pittosporum eugenioides	lemonwood, tarata	Needs to be ecosourced. Not on steep banks
Pittosporum tenuifolium	kohuhu	Needs to be ecosourced. Not on steep banks
Pseudopanax arboreus	five-finger; whauwhaupaku	A good robust colonising plant. Not on steep banks

5.5.2 Taller Plants for North-South Drains

These species should not be planted where drains flood regularly, although they can be planted outside the crest of the drain banks without unduly impeding drain flows.

All these plants can be planted at a spacing of 1.5m to 2.0m. All are frost resistant and are found naturally in the Waikato.

Most have strong fibrous root structures that will assist in stabilising banks. Some also provide food (mainly berries) for native birds.

Although it is generally better to plant a variety of these species rather than one or two species, any planting along the drains is better than no planting at all.

Aerial Image 2

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6. MIDDLE CATCHMENT

6.1 Location

From midway between Ruffell Road and Horotiu Road, the watercourse is classified as a stream.

The image (left) shows only the main stream channel, but the description and restoration activities provided below can be applied to any of the small tributaries that are part of the catchment but are not shown.

6.2 Description of the Existing Environment

The stream is characterised by:

- A defined stream channel that has a relatively natural meander,
- Short but steep banks within a wide floodplain,
- Moderate habitat diversity for aquatic animals with variation in channel width and depth, and
- Permanently flowing water.

The stream flows through rolling land within a well-defined gully system that has a wide floodplain and rolling to steep gully walls. The stream has a relatively natural channel with some reaches where historic straightening is apparent from aerial photographs. From around 1,200m southeast of Horotiu Road, the gully intersects with the groundwater table. Large springs and seeps discharge from the gully toe and floodplain. These springs contribute to a rapid increase in the base flow of the stream with distance downstream, but also limit the use of the floodplain to summer grazing only.

The stream floods regularly with floods escaping the banks onto the floodplain 5 to 10 times per year, with the depth and frequency of flooding increasing with distance downstream.

Riparian (streamside) vegetation is predominantly of grass with some areas of indigenous cutty grasses (sedges) and ferns. North of Horotiu Road, most of the stream's riparian vegetation has been sprayed. Because of the low cohesion of the underlying pumice soils and subsoils, the removal of the vegetation is resulting in wide-scale slumping of the banks. Where spraying has not occurred, erosion and slumping is not occurring or is noticeably less.

6.3 Rationale for Restoration of the Stream

The Mangaheka Stream is a natural watercourse that has experienced historic modification in places from straightening and the installation of culverts and road embankments. A visual assessment of the streams indicates that:

- Water quality is likely to be better than in the drains because groundwater entering the stream (either directly or via springs along the floodplain) dilutes the contaminants. However, concentrations of nutrients, sediment and faecal bacteria are likely to frequently exceed national guidelines to the extent that fish and stream insect communities are affected, and use of the water (e.g. for contact recreation, livestock drinking water, and food collection) may be limited.
- Habitat quality is better than in the drains because the stream has a more natural and varied channel providing habitat diversity for fish and stream insect communities. However, the suitability of the stream as a habitat for fish and stream insects is limited by the lack of riparian vegetation which would provide:
  - filtering of contaminants,
  - improved bank stability,
  - reduced sun exposure, and
  - increased inputs of organic matter (leaves, twigs, branches) that forms the basis of the food chain and contributes to habitat diversity.

The restoration potential of small streams can be very good because their small size makes it relatively simple to address habitat and bank stability issues without unduly impacting on surrounding land uses or flooding issues. In the case of the Mangaheka Stream, improvements to water quality are likely to come predominantly from restoration of the drains upstream.

Therefore the rationale for restoration of the middle catchment of the Mangaheka Stream is to improve bank stability and enhance aquatic habitats. The restored stream will be a more attractive feature as it flows through the landscape, enhancing indigenous biodiversity, creating a corridor for birds and lizards, and reducing the risk of livestock losses.

6.4 Restoration Vision for the Stream

The restoration vision for the Mangaheka Stream middle catchment is as follows:

- All reaches of the stream fenced at a distance of at least 2.0m from the top of the bank, and smaller tributaries fenced at a distance of at least 1.0m from the top of the bank.

  This will allow for livestock to graze beneath the fence, while leaving riparian margin of vegetation that is out of reach of stock. This riparian margin has been shown to be effective at filtering out sediment, nutrients and faecal bacteria as long as the vegetation is dense. A distance of 2.0m allows for taller vegetation to be planted forming a canopy over the stream.

  Placing fences at a distance of 1.0 – 2.0m from the crest of the drain bank will reduce the impact of livestock treading and machinery on the stability of the banks.
- All stream banks fully vegetated and unsprayed.

  The pumice subsoils along the stream and its tributaries are weak and unstable without the root structure of vegetation to hold them together. By keeping banks vegetated, the banks are less likely to slump and erode when water levels are high.

  The vegetation can either be rough grass, or the stream can be planted with native species that are found in the area naturally. Plant species lists are provided in the following section.
- Stream channels sprayed only if the channel is becoming choked with vegetation over more than 50% of a defined reach.

  Many of the aquatic plants present in drains will not impede high flows in drains. However, some plants such as willow weed are detrimental to the efficient flow of water because they produce dense vegetation growth above the water. Spraying of vegetation should be undertaken when aquatic vegetation reaches a level that is likely to impede flows, and spraying should only be in the drain channel.

  Care should be taken to avoid over-spray onto drain banks to retain bank vegetation.
- Stream bank instability controlled through appropriate fence location and planting.

  Where stream banks are unstable (i.e. slumping, undercutting, slipping or eroding), it is important to first identify the reason for the instability. If the stream is unfenced or fence posts are located too close to the edge of the bank, pressure from livestock treading can contribute to bank slumping and collapse. If this is occurring, fencing the stream or moving fence posts further away from the bank edge can eliminate this problem. Some landowners may be reluctant to do this because of the loss of pasture, but the trade-off is the ongoing loss of land into the stream as unstable banks collapse.

  If the banks are unstable because they are too steep, then armouring and planting will generally be ineffective, and armouring is likely to exacerbate bank instability or shift the problem downstream. There are two solutions to this. Oversteep banks can be reshaped quickly and effectively with an excavator. However, in a meandering stream channel this requires specialist knowledge of stream dynamics to avoid causing erosion problems elsewhere. A simpler solution is to accept that some bank instability is a result of natural stream meandering, and plant a wider margin of riparian vegetation to manage the instability over a longer term. As with moving fences, this will result in the loss of some pasture, but minimises the future loss of land into the stream. Plant species lists are provided in the following section.

6.5 Species to Plant on Stream Banks

In many places along the Mangaheka Stream, the value of pasture within the gully is relatively limited particularly given that in most places are limited to summer grazing because of springs and pasture value is affected by frequent flooding. On this basis, landowners can make decisions about how much of the gully to plant. Where the land within the stream floodplain provides high quality pasture, landowners could choose to fence and plant only the minimum riparian margin. Where the pasture is of poor quality, available only for limited periods in summer, or used only for lifestyle farming, landowners could choose to fence the gully and plant the entire floodplain and gully slopes. Therefore, the sections below provide species list for the various ground conditions found in the Mangaheka Stream gully.

Planting methods are outlined in Section 8. Diagram 4 shows how the floodplain of the Mangaheka Stream is intended to look when the planting is mature.

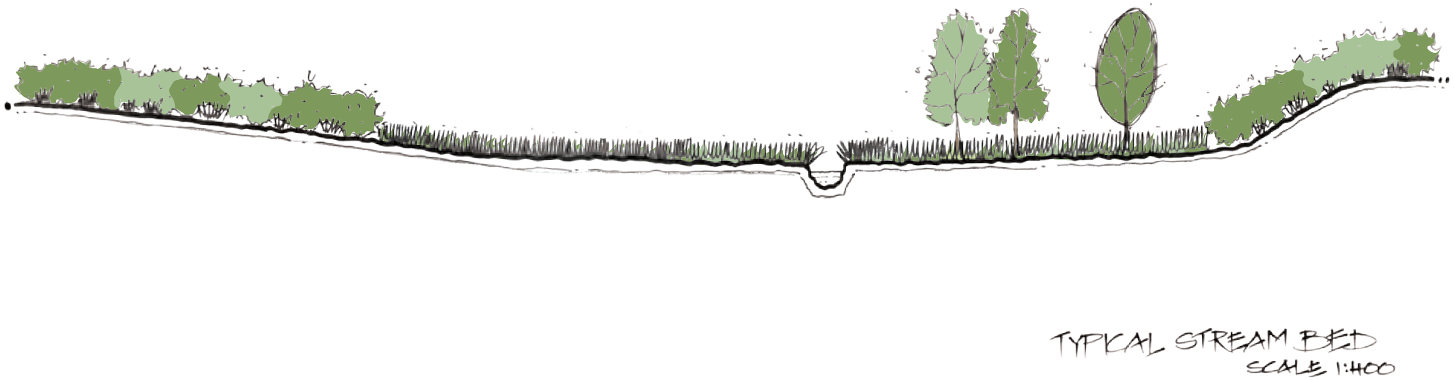

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Diagram 4

6.5.1 Plants for Dry Gully Slopes

The plants should be mixed or in small species groups (3 – 5) planted at a spacing of 1.5 - 2.0 metres. Except for wineberry, all are frost resistant and are found naturally in the Waikato. Most have strong fibrous root structures that will assist in stabilising banks. Some also provide food (mainly berries) for native birds and many provide food for honey bees.

Latin name	Common name	Comments
Aristotelia serrata	Wineberry	Fast growing but frost tender when young
Coprosma lucida	Karamu	Also provides food for birds
Coprosma robusta	Karamu	Also provides food for birds
Coryline australis	Cabbage tree	Excellent for unstable banks
Dodonea viscosa	Akeake	Fast growing but not in wet soils
Hebe parviflora	Koromiko	Fibrous shallow root system
Hebe stricta	Koromiko	Fibrous shallow root system
Kunzea ericoides	Kanuka	Needs to be ecosourced. Not on wet soils
Leptospermum scoparium	Manuka	A good robust colonising plant
Melicytus ramiflorus	Mahoe	Also provides food for birds
Myrsine australis	Mapou	A good robust colonising plant
Pittosporum eugenioides	Lemonwood, tarata	Needs to be ecosourced. Not on steep banks
Pittosporum tenuifolium	Kohuhu	Needs to be ecosourced. Not on steep banks
Pseudopanax arboreus	Five finger	Also provides food for birds
Pseudopanax crassifolius	Lancewood, horeka	Also provides food for birds

It is not necessary to plant all of the species listed, but using a greater variety of species will add to the diversity and long-term structure of the planting, and assist the natural regeneration process.

6.5.2 Plants for Springs/Seeps/Swamps

Latin name	Common name	Comments
Baumea rubiginosa		Good for filtering contaminants
Carex geminata	cutty grass; rautahi	Good for filtering contaminants
Carex lessoniana	cutty grass; rautahi	Good for filtering contaminants
Carex maorica	sedge, purei	
Carex secta	pukio	Not on peat
Carex virgata	pukio	Not on peat
Cordyline australis	cabbage tree, ti kouka	Good for standing water
Cortaderia fulvida	toetoe; kakaho	Good for filtering contaminants
Cortaderia toetoe	toetoe	Good for filtering contaminants
Eleocharis acuta	spike sedge	Good for filtering contaminants
Eleocharis sphacelata	bamboo spike sedge	Good for standing water
Gahnia setifolia	mapere	
Juncus edgariae	leafless rush	Good for standing water
Juncus pallidus	giant rush	Good for standing water
Leptospermum scoparium	manuka	On drier mounds
Phormium tenax	flax	Good for standing water

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Most of these plants can be planted at a spacing of 0.5m to 0.75m. The toetoe, mapere, flax and manuka should be planted at a spacing of 1.5m. All are frost resistant and are found naturally in the Waikato. All are adapted to wet soils and will assist in filtering contaminants to prevent them from entering the stream.

Although it is generally better to plant a variety of these species rather than one or two species, any planting in these boggy areas is better than no planting at all.

6.5.3 Plants for the Stream Riparian Margin and Floodplain

Based on visual assessment of the stream, the species lists provided assume that the stream floods regularly, stream banks have some form of instability, the stream does not need regular excavation, and the stream channel has a predominantly east-west direction. Although riparian margins would normally include shrub species, this list excludes woody species (except cabbage tree) to maintain efficient drainage of flood waters.

Latin name	Common name	Comments
Carex geminata	cutty grass; rautahi	Tall vegetation for stream shade
Carex lessoniana	cutty grass; rautahi	Tall vegetation for stream shade
Carex maorica	sedge, purei	
Carex secta	pukio	Not on peat
Carex virgata	pukio	Not on peat
Cordyline australis	cabbage tree, ti kouka	Excellent for unstable banks
Cortaderia fulvida	toetoe; kakaho	Tall vegetation for stream shade
Cortaderia toetoe	toetoe	Tall vegetation for stream shade
Cyperus ustulatus	giant umbrella sedge	Tall vegetation for stream shade
Gahnia setifolia	mapere	Tall vegetation for stream shade
Phormium tenax	flax	Tall vegetation for stream shade

Most of these plants can be planted at a spacing of 0.5m to 0.75m. The toetoe, mapere, and flax should be planted at a spacing of 1.5m. All are frost resistant and are found naturally in the Waikato. All are adapted to riparian soils and will assist in filtering contaminants to prevent them from entering the stream. Most have rhizomatous root structures that will assist in stabilising the stream banks.

Although it is generally better to plant a variety of these species rather than one or two species, any planting of the stream riparian margins is better than no planting at all.

If desired, there are a number of canopy species that can also be planted in clusters along the stream banks and on the floodplain without unduly affecting the efficient drainage of floodwaters. These species can be planted in clusters of 5, 7 or 9 at a spacing of 3 – 5m apart.

Latin name	Common name	Comments
Alectryon excelsus	titoki	Good for bank stability. Provides food for birds
Alectryon excelsus	tawa	Not on peat. Food for kereru
Dacrycarpus dacrydioides	kahikatea	Good on peat. Provides food for birds
Dacrydium cupressinum	rimu	Good for bank stability.
Knightia excelsa	rewarewa	Not in wet soil. Provides food for birds.
Prumnopitys taxifolia	matai	Provides food for birds
Sophora microphylla	kowhai	Provides food for birds. Good for bank stability. Keep away from livestock
Syzygium maire	Swamp maire	Provides food for birds

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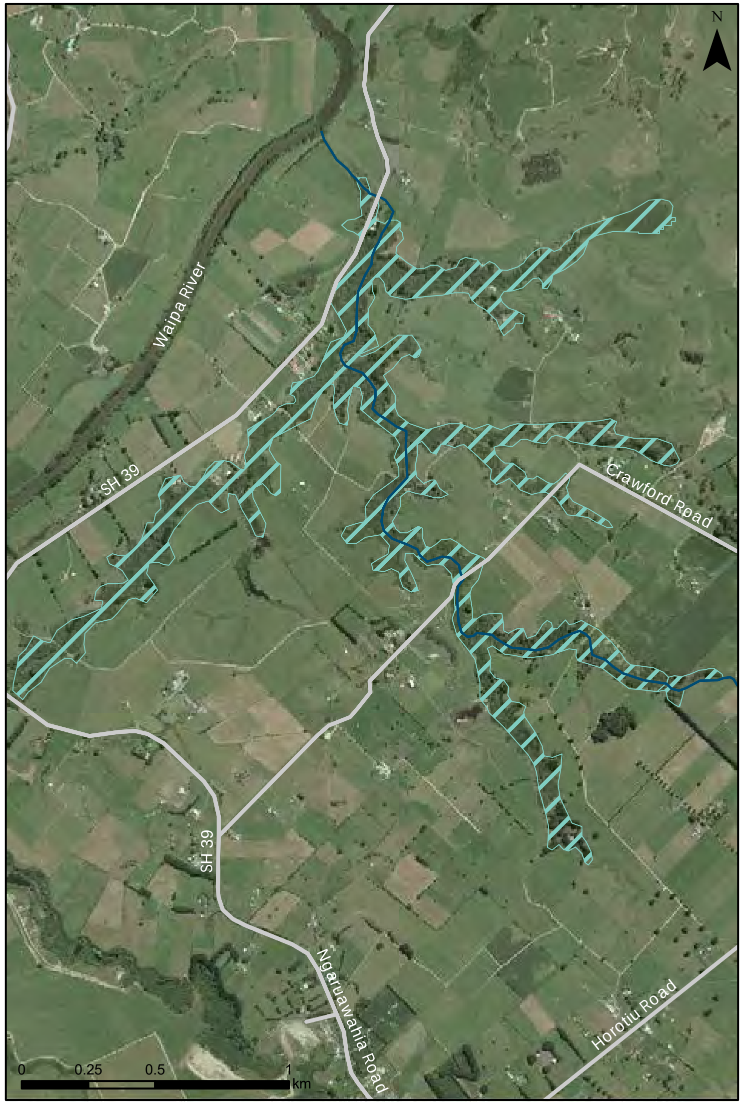

Aerial Image 3

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7. LOWER CATCHMENT

7.1 Location

From approximately 820m northwest of Horotiu Road to SH39, the watercourse can be classified as a lowland shrub – sedge swamp.

The image (left) shows the main areas of swamp, but the description and restoration activities provided below can be applied to any of the other swamp areas that are part of the catchment but are not shown.

7.2 Description of the Existing Environment

The swamps are located within a rolling to very steep gully between Horotiu Road and SH39 Ngaruawahia-Te Kowhai Road. The watercourse varies considerably depending on the characteristics of the swamp at any given location. The swamp has standing water, multiple flowing channels (leads), and numerous large seeps and springs flowing into the swamp around the flood plain and gully walls. The channels appear to be almost entirely natural with little historic modification. Although a survey of the swamp vegetation was not undertaken, the vegetation generally consists of a canopy dominated by grey willows (Salix cinerea) with an understorey of indigenous sedges (Carex virgata, Carex geminata) and a small component of indigenous trees and shrubs (Coprosma species, mahoe (Melicytus ramiflorus), mamaku (Cyathea medullaris), cabbage trees (Cordyline australis) and kahikatea (Dacrycarpus dacrydioides)). The gully is very densely vegetated and the vegetation is likely to provide almost 100% shade over most of the wetland leads.

Anecdotal evidence from landowners indicates that fish species in the swamp include short finned eel (Anguilla australis), long finned eel (Anguilla dieffenbachii), giant kokopu (Galaxias argentus), possibly banded kokopu (Galaxias fasciatus), and koura (Paranephrops planifrons). The NIWA Freshwater Fish Database records short finned eel and black mudfish (Neochanna diversus) from a site near Crawford Road. It is likely that the swamps flood frequently but because the swamps are largely inaccessible, it is unlikely that floods affect the use of the area.

7.3 Rationale for Restoration of the Wetland

The Mangaheka Stream swamps are likely to be natural features but enlarged from the swamp area that would have been present historically as a result of the SH39 road embankment that partially impounds the catchment. The swamps have experienced historic modification in places from the installation of culverts and farm tracks. An assessment of the swamps was not undertaken but it can be assumed that:

- Water quality is likely to be better than in the stream and drains because groundwater entering the swamps (either directly or via springs along the floodplain) dilutes the contaminants and many contaminants are filtered out by swamp vegetation. Concentrations of nutrients, sediment and faecal bacteria may periodically exceed national guidelines particularly during floods. Fish and stream insect communities are unlikely to affected by this because they are adapted to swamp conditions, but use of the water (e.g. for contact recreation and food collection) may be occasionally limited.
- Habitat quality is likely to be better than in the drains and the stream because the swamps have:
  - natural stable channels providing high habitat diversity for fish and aquatic insect communities,
  - almost total shade of water during summer, and
  - high inputs of organic matter (leaves, twigs, branches) that forms the basis of the food chain and contributes to habitat diversity.

The restoration potential of swamps is generally excellent where natural hydrological conditions exist, because the issues are generally limited to enhancing indigenous biodiversity. In the case of the Mangaheka Stream swamps, enhancing indigenous biodiversity is simplified by the existing indigenous vegetation already present beneath the willow canopy.

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Therefore the rationale for restoration of the middle catchment of the Mangaheka Stream is to enhance wetland indigenous plant biodiversity. The restored swamps will provide an important habitat native birds, fish, and lizards, provide potential for cultural harvest of indigenous plants and fish, and a reduced plant pest reservoir. This will be in addition to the existing swamp functions of flood flow attenuation, contaminant filtration, and fish habitat.

7.4 Restoration Vision for the Wetland

The restoration vision for the Mangaheka Stream lower catchment is as follows:

- Progressive control of plant pest species throughout the swamps to restore a wetland environment that is dominated by native vegetation.

  It is assumed that the wetland has a relatively high density of indigenous wetland plants throughout the core of the wetland that will increase in diversity and density over time as the canopy of willows and other exotic species are controlled. Eventually the swamps will develop into lowland swamp forest dominated by species such as kahikatea, swamp maire, and pukatea with a dense tier of cabbage trees, manuka, ferns, flax, sedges and rushes. Because the swamps are large, covering at least 85ha, they will provide an important habitat for wetland bird, lizard, fish and crustacean species. This can become an important resource for food collection (pataka kai) and medicinal plants (rongoa).

- Planting required within the swamp is limited.

  The key priority for the swamp is plant pest control. However, some areas may have exotic vegetation that is so dense it suppresses the growth of native vegetation. In these places, supplementary planting may be required after control of plant pests to re-establish native plants. In some areas, it may be desirable to increase the diversity of plant species, particularly to re-establish plant species that are normally found in lowland Waikato swamps but are absent from the Mangaheka Stream swamps.

- Margins of the swamp fenced at a distance of at least 2.0m from the highest winter water level, and smaller branches of the swamp, including small springs and seeps, fenced at a distance of at least 1.0m from the highest winter water level.

  This will allow for livestock to graze beneath the fence, while leaving riparian margin of vegetation that is out of reach of stock. This riparian margin has been shown to be effective at filtering out sediment, nutrients and faecal bacteria as long as the vegetation is dense. A distance of 2.0m allows for taller riparian vegetation to be planted forming a buffer for the more sensitive wetland core.

  Placing fences at a distance of 1.0 – 2.0m from the highest winter water level will reduce the impact of livestock treading on saturated soils.

- Where appropriate, swamp margins fully vegetated and unsprayed.

  Riparian margins have been shown to be effective at filtering out sediment, nutrients and faecal bacteria as long as the vegetation is dense. The vegetation can either be rough grass, or the can be planted with native species that are found in the area naturally. Plant species lists are provided in the following section.

7.4.1 Plant Pest Control Principles

Specific methods for plant pest control are outlined in Section 6.0 Implementation.

The goal of plant pest control in the swamps is to progressively reduce the dominance of exotic plants to allow indigenous plants to flourish. Plant pest control needs to be undertaken using appropriate methods that keep ongoing maintenance to a minimum and allow natural processes to assist the restoration process. Therefore, the emphasis is on keeping existing vegetation cover in place and minimising soil disturbance to prevent the growth of exotic plant seedlings. To achieve this, mechanical removal should be avoided in favour of spraying herbaceous and shrub species, and drilling and poisoning or frilling tree and woody species.

7.4.2 Plants for Swamp Margins

Planting methods are outlined in Section 8.

Most of these plants can be planted at a spacing of 0.5m to 0.75m. The toetoe, mapere, flax and manuka should be planted at a spacing of 1.5m. All are frost resistant and are found naturally in the Waikato. All are adapted to wet soils and will assist in filtering contaminants to prevent them from entering the swamps.

Although it is generally better to plant a variety of these species rather than one or two species, any planting in these boggy areas is better than no planting at all.

Latin name	Common name	Comments
Baumea rubiginosa		Good for filtering contaminants
Carex geminata	cutty grass; rautahi	Good for filtering contaminants
Carex lessoniana	cutty grass; rautahi	Good for filtering contaminants
Carex maorica	sedge, purei	
Carex secta	pukio	Not on peat
Carex virgata	pukio	Not on peat
Cordyline australis	cabbage tree, ti kouka	Good for standing water and instability
Cortaderia fulvida	toetoe; kakaho	Good for filtering contaminants
Cortaderia toetoe	toetoe	Good for filtering contaminants
Gahnia setifolia	mapere	
Juncus edgariae	leafless rush	Good for standing water
Juncus pallidus	giant rush	Good for standing water
Leptospermum scoparium	manuka	On drier mounds
Phormium tenax	flax	Good for standing water

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8. PLANTING METHODS

This is a general outline of planting methods.

8.4.1 Site preparation

Undertake spot spraying of long grass and herbaceous weeds for at least 1m diameter around each planting site 4 to 6 weeks prior to planting. Inspect the spraying to ensure that spray has been effective and respray where necessary.

8.4.2 Planting time

In the Waikato, planting is typically undertaken in early spring (September, October, up to mid-November) and autumn (April, May, June), but is locally weather dependent. The target is the period of increased rain, while moderate temperatures persist. Since irrigation is not a practical option, and since frosts may be severe through winter and early spring, a planting time of October/November or April/May is appropriate. Planting beneath an existing canopy of shelterbelt trees or within the swamp willow canopy can be undertaken at any time.

8.4.3 Fertiliser

There are substantial growth benefits in the use of a slow release fertiliser applied at the time when the trees and shrubs are actually planted. However fertiliser is only required along the drains and on dry gully slopes, as the soils at all other locations will have adequate nutrients to supply plant needs. The best means of fertilising is to use slow release pellets (preferably of a balanced N:P:K product) dropped into the planting hole immediately prior to the plants going in. Ask your nursery for the best product (or slow release fertiliser may already be included with the potting mix). Where cost is an issue, blood and bone is acceptable.

8.4.4 Mulch

While plants do not require mulch, mulching has the benefit of suppressing weed competition around the plant (thereby reducing maintenance), retaining water in the soil over summer periods and adding to soil nutrient levels as it breaks down. In this case it should only be used in relation to the shrub and tree species along the drains and on the gully slopes. Hay or straw bales can be used effectively, although they may contain weed and grass seeds. Bark mulch (untreated) is also appropriate. Other mat products are also beneficial.

The mulch does not have to cover the entire area that has been spot sprayed, but should at least cover a radius of 300mm around the stem centre to an uncompacted depth of 75mm (for bark, hay or straw).

8.4.5 Marking

If the areas to be planted are relatively large, or the planting will occur in and around areas of scrub, we recommend marking the location of each plant with a stake at the time of planting. This will ensure that plants can be easily located for monitoring and maintenance. For greater visibility, dip the ends of the stakes in bright paint.

9. MONITORING AND MAINTENANCE

The planted areas need to be inspected at least twice a year, preferably in late spring (October/November) and autumn (April/May). The inspections should include the following:

- Monitoring of the health of the planted specimens. Nutrient-related stress (which is usually characterised by a yellowing of the leaves) will need to be rectified by hand-application of blood-and-bone (or similar). Dead or unhealthy specimens should be marked and replaced by the same species as those that have died, unless a group of this species die in the same place. If this occurs, a different species from the supplied list should be planted instead.
- Releasing (control or removal of competing plants from around the seedlings) may be required for up to 3 years for slower growing species. Releasing can be undertaken by hand using a grubber, slasher or weedeater but it is important to ensure that the roots and bark of the seedlings are not damaged, particularly with weedeating. Alternatively, use an appropriate herbicide taking care to avoid any spray contact with the seedling. Spraying should not be undertaken on days that are windy.
- Monitoring and control of plant pests will be required throughout the planted area to identify and remove all pest plants. This will be required on an ongoing basis as the revegetation matures to ensure that new plant pests do not become established within the developing shrubland.
- Monitoring and ongoing control of animal pests may be required for up to 3 years until plants are sufficiently established to resist possum, rabbit and hare browse.

9.1 Plant Pest Control

The goal of plant pest control, particularly in the swamp areas, is to progressively reduce the density of exotic vegetation so that eventually native vegetation naturally suppresses the growth of weeds. The first step is to establish which plant pests are present in the restoration area and the appropriate control methods for each species. Should you require advice on weed control, Waikato Regional Council's Plant Pest Control Officers may be a good source of information and assistance.

Removal of weed species should use methods that do not dramatically disturb the tree canopy in the swamps such as pulling seedlings, ring-barking or drilling and poisoning older/larger specimens, or spraying vine/bramble/herbaceous species. Disturbance of the canopy within the swamps provides an opportunity for weeds to out-compete native species, so it is desirable to leave the exotic canopy in place and allow it to gradually disintegrate over time after poisoning/ringbarking.

It is recommended that initial weed control of a defined area be undertaken in spring to achieve substantial control, followed up by weed control activity the following autumn and spring to target any regrowth from vine species and willows. The last major weed control activity should target fresh growth of any weed missed in the previous two seasons and should be followed by planting where this is required.

On dry gully slopes and drain/stream banks, it is desirable to retain existing vegetation cover as this will assist in retaining topsoil and soil moisture while the native shrubland is becoming established, and will also provide some wind protection for native seedlings.

The planting site for each plant should be sprayed within the existing vegetation rather than spraying all the vegetation.

9.2 Animal Pest Control

Pukekos can cause significant damage to new plantings. If populations of pukekos are present, hunting can reduce populations but must be undertaken regularly to discourage influx of new populations (refer to Fish & Game for local bag limits). If hunting is not considered appropriate, netting around the plants or stakes/pins at the base of plants will be required to prevent seedling removal.

If monitoring determines that possums, rabbits and hares are causing damage, appropriate control methods (hunting or poisoning) should be undertaken to reduce and control populations.

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10. OTHER CONSIDERATIONS

10.1 Training

One of the elements in the success of restoration projects is education to ensure that everyone working on the restoration project can identify both native and pest plants. This will ensure that pest plants are identified and removed using appropriate methods, and native plants are identified and not inadvertently removed during weed control activities. We suggest the purchase of plant identification reference materials that will also guide the restoration activities in later years as the plantings achieve canopy cover and begin to mature.

10.2 Resources

Another element to the success of the Mangaheka Stream restoration vision will be ensuring that the restoration project groups and landowners can allocate sufficient resources over time to maintain the plantings. Revegetation requires ongoing inputs of time to ensure that dead and failing specimens are replaced, that plants are regularly released until they have become established, and that animal pest and plant pest control is continued. If resources cannot be assured for a large restoration project, it is prudent to select one part of the restoration programme for completion through to maintenance, before commencing the restoration of another area. Generally, each parts of the restoration can be completed independently of the other parts if necessary without compromising the overall integrity of the project, provided that plant pest control between areas is maintained to prevent re-infestation of previously controlled areas.

10.3 Monitoring

Monitoring the environment is a way of providing an objective measure of the improvement in water quality and habitat in the Mangaheka Stream catchment over time. The three suggested monitoring tasks are as follows:

10.3.1 Aquatic Insects

Monitoring of populations of aquatic insect communities on a regular basis (e.g. once a year, say late spring, after a fortnight of relatively calm weather) at fixed survey locations is a way of measuring improvements in water quality and habitat over time. Suggested fixed survey locations are at each of the road crossings (Horotiu Road, Crawford Road, and SH39). It is essential to use an appropriate methodology for collecting aquatic insects such as Ministry for the Environment (2001) Protocols for sampling macroinvertebrates in wadeable streams.

The interpretation of the results depends on ensuring that the samples are collected, preserved, and handled correctly, and that analysis of the samples is carried out by appropriately trained people. It is prudent to seek advice from Waikato Regional Council staff or a freshwater ecologist on the specific location and timing of sample collection.

10.3.2 Fish

Monitoring of fish populations on a regular basis at fixed survey locations is another way of measuring improvements in water quality and habitat. However, accurate monitoring depends on the characteristics of the survey location, the types of fish present, the types of sampling methods used, and the climatic conditions leading up to the sampling event. It can be easy to misinterpret the results of a fish survey if the timing and method of survey is not carefully managed.

The Department of Conservation may also require permits to be obtained for handling native species prior to fish sampling.

Because of this, we recommend seeking advice from qualified staff at Waikato Regional Council or a freshwater ecologist.

10.3.3 Water Quality

Monitoring of simple water quality parameters on a regular basis can provide an ongoing direct measure of water quality improvements. The following table provides a list of the most appropriate water quality parameters. To collect these will require both a portable water quality probe and analysis at a laboratory. It is

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essential that the samples are collected, preserved, and handled correctly, and that analysis of the samples is carried out by appropriately trained people. We recommend seeking advice from qualified staff at Waikato Regional Council staff or a freshwater ecologist. Carried out correctly, such samples will provide a year-on-year comparison of water quality conditions.

Water quality probe measured on site:

- Temperature
- Dissolved oxygen

Analysed at a laboratory:

- pH
- Suspended sediment
- Faecal bacteria
- Nutrient suite (includes different types of nitrogen and phosphorus).

10.3.4 Interpreting Monitoring Results

Monitoring results cannot be viewed in isolation. They must be interpreted against the area and type of restoration being undertaken, and they must be interpreted in aggregate rather than individually.

Fish and aquatic insects respond to local conditions at the site where they are being surveyed. They will respond to improvements in both water quality and habitat. If habitat is improved but water quality remains poor, the monitoring results may show no improvement in the population abundance or diversity of fish or aquatic insects. Water quality results show the cumulative quality of water received from all over the catchment and is therefore a fundamental monitoring tool, but cannot measure improvements in habitat. Ideally, a monitoring suite of water quality, fish populations and aquatic insects undertaken at the same time each year in fixed survey locations will provide the best assessment of how restoration is improving the Mangaheka Stream catchment.

Therefore establishing a central database of all the restoration projects being undertaken in the Mangaheka Stream catchment is essential. Records should include:

- who is carrying out the restoration,
- the area of swamp or length of watercourse being restored, and
- the stage of the restoration (e.g. fencing, planting <1yr, planting 1-2 yrs, planting 2-3years, planting >3yrs).

The length of watercourse under restoration as a proportion of the total catchment length, or as a proportion of different parts of the catchment (drains, stream, swamp) can then be used as a basis for comparison with monitoring results.

10.4 Other Factors

Restoration is a holistic undertaking that encompasses more than simple weed control and revegetation, although these are important foundational tasks. When undertaking a restoration programme, consideration needs to be given to the ongoing development of the site into the future. Consideration can also be given to the following factors:

- Construction of fish pass structures at perched culverts to enable non-climbing fish species to access the upstream catchment.
- Partnership with neighbours, Department of Conservation, Waikato River Authority, Waikato Regional Council and Waikato District Council to establish vegetation connections (corridors) with nearby remnant indigenous vegetation, particularly the Waipa and Waikato Rivers, peat lakes and other lowland streams.
- Animal pest control that includes mustelids, cats, and rodents to improve the breeding success of native fauna, particularly birds, herpetofauna (lizards) and frogs. However, mustelid, cat and rodent control is not required for the success of a revegetation programme.
- Retain ongoing photographic records, vegetation surveys, and animal pest control records to document the ongoing progress of the restoration.

Appendix M

Industrial Activities – Top 15 Risks

HCC "Top 15" High Risk Activities		Notes	Title on WSWMG/AC ITA List
1	Car Wreckers	Not on HRFR list	"Automotive Dismantling"
2	Hazardous Waste treatment sites	Not on HRFR list	"Hazardous materials storage or treatment"
3	Waste management sites (transfer stations, compost sites, landfills etc)		" Waste transfer stations", " Non-metal recycling (composting, glass paper or paper board." and "Landfills" on WSWMG and AC ITA
4	Manufacture or processing of chemicals, and of petroleum, coal, rubber and plastic products.		Various Activities "Petroleum or coal product manufacturing" and Various " Rubber Industry" and Various :"Other Chemical Products"
5	Bitumen Plants	Medium risk on Waikato SW Mgmt Guide list.	"Bitumen/asphalt premix or hot mix"
6	Electroplaters, foundries,galvanisers and metal surfacing.		" Processing of metals (smelting, casting)", "Metal plating, anodising or polishing"
7	Timber preservation, treatment and storage sites where chemically treated timber is stored		"Treated Timber Storage" and "Timber Treatment"
8	Stockpiled tyres		"Tyre manufacturing or retreading", "Recycling, recovery, reuse or disposal
9	Manufacture of fabricated metal products, machinery and equipment		Various: " Machinery or equipment manufacturing"
10	Concrete batching plants and asphalt manufacturing plants.		"Concrete batching plants (ready mixed concrete)"," Bitumen/asphalt premix or hot mix"
11	Crushing, grinding or separation works (other than sand, gravel, rock or mineral - e.g slag, road base, demolition material)		"Metals (crushing, grinding, sorting or storage)"
12	Road freight transport depot (non-chemical) with mechanical servicing		Same
13	Log storage yards (outside of forested areas)		Same
14	Truck wash facilities		Not on other lists
15	Car wash and valet services.		Not on other lists

Appendix N

Review of Existing Stormwater Devices

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Hamilton City Council
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3 September 2018

Attention: Melissa Slatter/Andrea Phillips

Dear Melissa / Andrea

Mangaheka ICMP – Review of Existing Stormwater Management Devices

Scope

Hamilton City Council (HCC) engaged Beca Ltd to carry out the following services:

1. To carry out a high level desktop review of the as builts for the two existing devices (building on the work already reported on in the Beca Water Quality Assessment Report, dated 15 February 2018)
2. Quick review of HCC Infrastructure Technical Specifications (ITS) for wetland design to understand expected outcomes
3. Quick review of Waikato Regional Council (WRC) draft Stormwater management guidelines for wetland function expectations
4. Identify any fatal flaws/design issues that may be impacting the existing functioning of the wetlands
5. Discuss findings with the author of the water quality report referred to above
6. Prepare a brief email to HCC ahead of May 17th workshop with Porters/HJV on key findings and proposed approach for the workshop
7. Attend workshop to discuss wetland operating issues with Porters technical team

- The purpose of this document is to provide the further information as detailed above in points 1 – 4.
- Points 5-7 have been completed and this output reflects those discussions.

High level desktop review

The designs for the HJV and Porters wetlands have been reviewed. A number of items have been identified and are discussed below.

1. In the design, there is no fall engineered into the low flow channel. This channel is designed to be 200 mm deep. Over the length of this channel (approx. 365 m for HJV) it is unlikely that it will operate as a flowing channel during the drier months. It is recommended that a slight fall is introduced into this channel to ensure at least a minimum of flow at all times. This also agrees with the draw down

considerations of HCC ITS section 4 pg 4-43. It is my understanding that Porters have done this. This flow should be able to be manipulated through the use of a manually height changeable outflow weir.

2. As the low flow channel is designed to be constantly wet, the planting scheme does not follow accepted guidelines for planting in certain areas of the wetland. Some of the varieties planted in the base of the low flow channel, are not suited to a continual submerged root zone. Others that are planted in the wetting and drying zone would benefit from being changed.

3. The wetland is not offline. Therefore, during high flow, there is no diversion or ability to “protect” the wetland from adverse events. The high flow occurs through the wetland, and over the designed spillway. This is contrary to HCC ITS section 4-43. It is noted, however, that the ITS came into effect after the wetlands were designed and constructed, thus this is not a requirement.

4. The wetlands are not lined. 3 waters management HCC09 Water Impact Assessments states that design information for devices suitable for managing stormwater from a whole development (rather than individual sites) is available in AC TP10. In this document, constructed treatment wetlands are not required to be lined. Treatment of the water occurs as the water moves through the wetland, not just horizontally through the plants, but also vertically through the soil that is used to cover the wetland and plant into. It is natural for some wetlands to dry out over summer and planting varieties must take this into account.

   HCC03 states On-site stormwater soakage provides the following benefits:

   a. Improved water quality by filtering out contaminants

   b. Improved hydrological response of stormwater peak flow by holding and releasing stormwater in a controlled and more natural manner

   c. Supports groundwater recharge

   d. The design of surface soakage devices can add to the amenity of the site and surrounding area

This wetland is in an area where the water table is relatively close to the surface. HCC ITS states that if this is the case lining may not need to be undertaken. This is a means to ensure the plants in the low flow channel of the wetland remain wet at all times. Altering the planted species in the base of the low flow channel will ensure that even if there is no water in the base, often caused by evapotranspiration over the summer dry period, the plants survive. Therefore I consider the design to be appropriate.

Site visit

A site visit to the Porter wetland on 9th May 2018 showed that extensive rework of the wet pond was underway. Discussion with John De Luca (Porters) on site confirmed that during the construction period there had been a lot of sediment from earthworks enter the wetland. This had now been removed, the original design was followed, with some minor changes to low flow channel gradient and planting scheme, and the wetland reinstated. It is not known if organic topsoil was layered into the base of the re-contoured wetland to ensure plants re-established well.

A site visit on 14th May 2018 demonstrated this wetland working as a stormwater detention pond, as the significant rainfall the evening before was retained, and was being slowly released – likely slower than designed as the outlet structure was currently offline due to the reworking of the site, outflow being managed by a pump.

Figure 1 – Photograph showing Porters wetland being planted, 9th May 2018

Figure 2 – Photograph showing the newly replanted Porters wetland on 14th May following heavy rainfall

Comments from review of relevant documents

HCC ITS, Section 4, table 4.2 Landuse Categories, defines all industrial zones over 750 m^2 as High Contaminant Load profile.

Table 4.4 determines that High Contaminant Load profile requires primary treatment at source via a Gross Pollutant Trap (GPT) or other private stormwater treatment device. This would therefore be expected in this industrial area.

Auckland Regional Council TR2010/004 “Development of the Contaminant Load Model” document, gives guidance on the load reduction factors irrespective of device position in the treatment train. These are discussed at length, and values given, in the Beca water quality report. It is pertinent to note that these load reduction factors are long term averages, and not instantaneous.

Catchpits would be necessary on all sites as an entry to the stormwater system. Therefore, a treatment train consisting of catch pits, swales and constructed wetlands will potentially reduce contaminants by load factors as shown below.

Table 1 – Load removal factors and total efficiency of a prescribed treatment train of devices

	Total SS	Total Zn	Total Cu
Catchpit	0.2	0.11	0.15
Swale	0.65	0.6	0.50
Constructed wetland	0.70	0.65	0.65
TOTAL EFFICIENCY	92%	88%	85%

The HCC ITS states in Table 4.1 that the devices should be designed to achieve maximum practical removal rates. There are no specific numbers. The calculations below are therefore an exercise in understanding the dynamics of the treatment train options.

In addition to this requirement, as per the HCC ITS section 4 as detailed above, each lot would need on site treatment.

The Beca report formulated an average annual loading value based on a number of different literature sources.

Thus the Beca derived average annual loading values, in $g/m^2/yr$ are:

- Total Suspended Solids - 32
- Total Phosphorus – 0.14
- Total Nitrogen – 0.47
- Total Zinc – 0.49
- Total Copper – 0.032

Within the Beca report there was reference to ANZECC guidelines. It is important to note that these came from the Boffa Miskell report and relate to the 90% level for species protection for a modified waterway. I am comfortable that this species protection level has been correctly identified.

There is no mention in any of the documents of the Hardness modification factor. Further investigations suggest that Hardness has not been recorded in any of the previous sampling. Hardness levels in the water ($CaCO_3$) allow the contaminant trigger guideline values to be modified as per Table 3.4.3 in ANZECC guidelines 4, vol 1, to produce a Hardness Modified Trigger Value (HMTV).

I therefore took two samples of the water in the receiving stream to gain a basic understanding of this chemistry. Hill labs reported pH and hardness levels for these samples of 6.5 and 43 g/m^3 as $CaCO_3$ respectively. These will need repeating to ensure validity, however, using the formula as described in ANZECC, and the values as per ARC CLM industrial zoning (pgs 48 and 50), the HMTV's are:

- For Zn the guideline trigger value becomes 0.02 g/m^3
- For Cu the guideline trigger value becomes 0.0024 g/m^3

Thus using the HMTV, the output becomes:

Table 2 – Contaminant removal

Contaminant	Load	Removal efficiency	Load	Average concentration	Guideline
	g/m²/yr	%	Post treatment (g/m²/year)	g/m³	g/m³
Total suspended solids	32	92	2.6880	**2.560**	None
Total phosphorus	0.14	72	0.0397	**0.038**	0.015-0.3
Total Nitrogen	0.474	59	0.1941	**0.18**	0.04-0.1
Total Zinc	0.49	88	0.0611	**0.06**	0.02
Total Copper	0.032	85	0.0048	**0.005**	0.0024

This assumes that an on lot swale is installed after the catchpit / GPT in the treatment train and a constructed wetland is the last in the system prior to discharge.

Research relating to pervious concrete from the US suggests that when it is used on-lot, it has a removal rate >80% for both copper and zinc. Further investigation into this as a future mitigation option is recommended.

It is prudent to note that ANZECC guidelines relate to base flow conditions. USEPA guidelines are often used for stormwater flows. However it must be noted that there is no account for the attenuation, treatment and potential dilution that occurs within the wetland, when the available buffer storage capacity is utilised.

Mangaheka Stream levels

To determine any issue with regard the stream levels, as suspected and reported by Porters due to the water in the wetland not flowing away, an investigation was undertaken into the relative levels of the system. Historical levels were checked, and new levels were taken for a distance approximately 32 m past the Koura Drive culvert and specific others to check and ensure tie in with the historic surveys.

Figure 3 – Photographs showing the clogged stream between SH1 and Koura Drive. Taken 14th May 2018

The outcomes are detailed below.

1) The historic survey levels are in agreement with the new survey levels.

2) The relative levels taken for both Porters and HJV wetlands appear to be consistent with the plans.

3) The new survey extended 32 m past the outlet of Koura Drive culvert and identified that there is a stream bed high point 10 m after the outlet of Koura Drive culvert. This culvert currently needs to have a minimum of 0.2 m depth of water before it will start to flow over this high point.

4) 32 m after the Koura Drive culvert, the stream bed level reverts to the same RL as the base of that culvert.

5) Currently, Porters outlet pipe RL is at 28.3. Koura drive high point is at 28.1. This is 20 cm of fall over 950 m (fall of approx. 1 : 4750).

6) The drain between Waikato expressway and Koura Drive has sections that are choked with weeds as shown below. This will likely be impacting the flow and causing backwater effect.

To improve the flow and go some way towards mitigating potential backwatering effects, there are 2 actions that I recommend should be carried out.

- Remove the high point after Koura Drive culvert. Approx. 35 m of drain downstream of the Koura drive culvert would benefit from being re profiled.
- The drains should be clear of weeds and other vegetative obstructions to allow unrestricted flow through the drains.

These apply to both the HJV and Porters wetland.

These basic maintenance tasks should improve the flow of water out of the wetland. However, due to the extremely limited fall present in the system, the effects of these tasks should be regularly monitored.

Yours sincerely

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