Plan change 12– Enabling Housing: Part 2 Section 32 Evaluation

Appendix 2.6 On-Site Stormwater Management

Section 32(1)(b)(ii) and (iii), section 32(2), section 32(3) of the RMA

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1 Introduction

1.1 Purpose of this report

This report sets out and assesses proposed changes to on-site stormwater management provisions in the Hamilton City Operative District Plan, as part of Hamilton City Council (Council)'s reporting obligations under section 32 of the Resource Management Act 1991 (RMA).

The proposed on-site stormwater provisions form part of Council's Intensification Planning Instrument (IPI) (referred to as Plan Change 12) to give effect to the National Policy Statement on Urban Development 2020 (NPS-UD) and implement the Resource Management Act (Enabling Housing Supply and Other Matters) Amendment Act 2021 (the Enabling Act) including the Medium Density Residential Standards (MDRS). Plan Change 12 includes significant changes to increase permitted heights and densities of residential development across the city, and particularly in locations of higher accessibility.

Under section 80E(1)(b)(iii) of the RMA as amended by the Enabling Act, as well as implementing the MDRS, an IPI may introduce 'related provisions' that relate to stormwater management (including permeability and hydraulic neutrality). These proposed on-site stormwater provisions accordingly address the consequences of the intensification enabled by the IPI on stormwater management for the City. The proposed 'related provisions' relate to the residential zones of the City only, since these are the zones undergoing significant changes as part of Plan Change 12. For clarification, the proposed on-site stormwater management provisions are not 'density standards' under the MDRS nor a 'qualifying matter' that would amend the height or density of development.

1.2 Structure

Section 2 of this report sets out the current state of play for stormwater management in Hamilton and the need for changes to the on-site stormwater management provisions in the district plan to accompany Plan Change 12.

Section 3 evaluates the proposed objective for stormwater management and the different options available to achieve the objective.

This report relies upon technical reports by SCO Consulting and Morphum Environmental Ltd which are attached as Attachment One.

This report should be read in conjunction with the comprehensive Plan Change 12 s32 report, including Appendix 2.5 - Infrastructure Capacity provisions report, which addresses wider infrastructure constraints and water conservation measures, and outlines another package of changes being proposed.

2 Background and Issues

2.1 Hamilton's stormwater system

Stormwater generated within Hamilton is discharged directly or via the reticulated piped network to open drains, streams, lakes and ultimately the Waikato River. Approximately 5,000 hectares of the land area of Hamilton, including the majority of the existing urban areas, does not discharge via a public stormwater management device that controls the volume and treats the quality of stormwater entering the Waikato River and its tributaries (see grey areas in Figure 1 below). Additionally, more than 200 of Hamilton's watercourse reaches have been identified as having high susceptibility to erosion and are therefore particularly sensitive to any increases in stormwater volumes (non-peak volumes as well as peak flows).

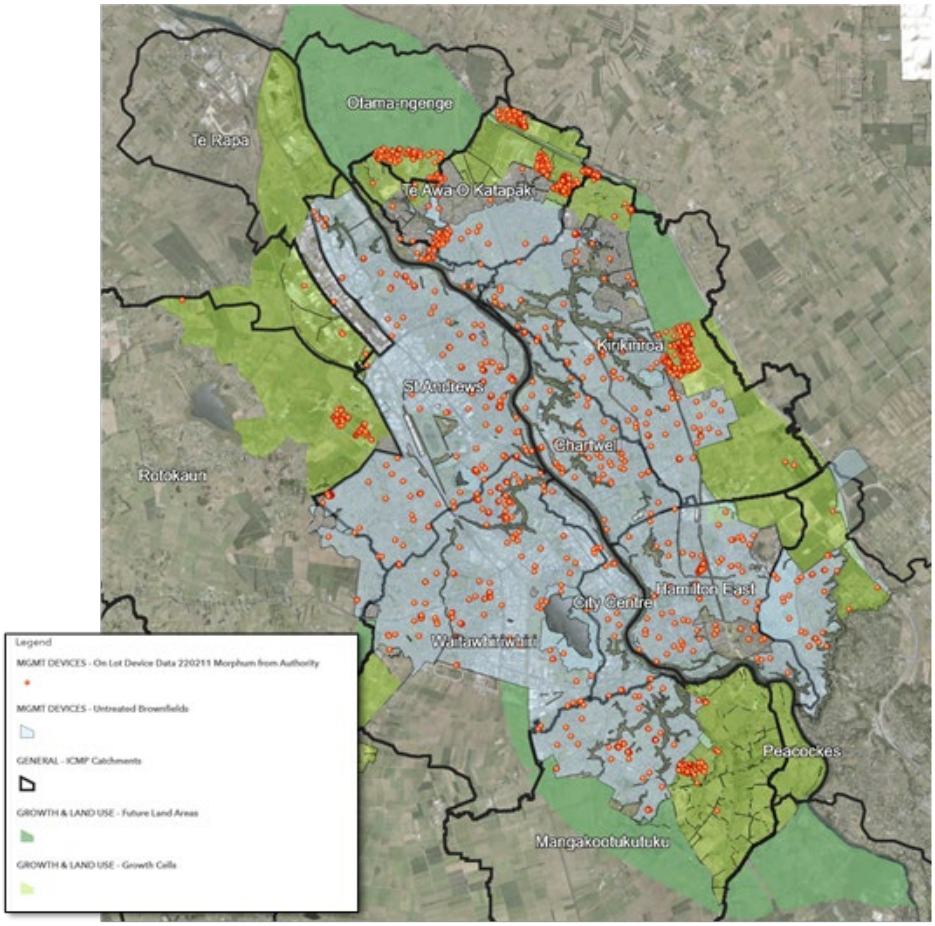

Figure 1: Hamilton stormwater catchments – those with no public treatment device shaded grey

The areas that have existing, fit-for-purpose stormwater management devices are generally the newer greenfields development areas on the fringes of the city (generally also the areas that have Integrated Catchment Management Plans (ICMPs) in place). In the existing urban area (brownfields), significant areas of land would need to be bought up in order to retrofit communal stormwater management devices. It has been estimated that retrofit of untreated areas could cost in excess of $2 billion.

Private on-site stormwater management devices are also present within new growth areas and some redeveloped sites in the existing urban area. Known devices are mapped with red dots on Figure 1, which are mostly small scale attenuation devices.

The lack of appropriate stormwater treatment devices across much of the city does not provide for the protection and restoration of receiving waters, and the Waikato River Authority 5 year report (2021) reported a dominance of 'deteriorating' or 'as likely improving as deteriorating' trends in water quality and ecological indicators for the Waikato River catchment.

2.2 Comprehensive stormwater discharge consent

Council has a 'city-wide' comprehensive stormwater discharge consent from Waikato Regional Council (consent 105279, granted in 2011) to divert and discharge stormwater to receiving environments from its existing urban network for a period of 25 years. The consent authorises the city's stormwater discharges at the time the consent was granted. For all new stormwater diversion and discharge activities, consent condition 3 states that these can also be authorised by the consent if the Waikato Regional Council is satisfied that:

> The new activities are consistent with the other conditions of the consent, which include
>
> - The Best Practicable Option for stormwater management being implemented;
> - Avoiding as far as practicable (otherwise minimising) scour, erosion, deposition, flooding, effects on aquatic ecosystems, other visual quality effects on receiving bodies;
> - Discharges will not cause specified technical parameters for quality of discharge to be exceeded (dissolved oxygen, pH, suspended sediments, undesirable biological growths, temperature, turbidity, ammoniacal nitrogen and other contaminants as per the US Environmental Protection Agency National Recommended Water Quality Criteria);
>
> Peak discharge rates and flow volumes are not increased, or any changes have no additional adverse effects on the environment or downstream properties;
> In developing (greenfields) catchments, the new activities are consistent with Catchment Management Plans prepared prior.

As the holder of this consent, it is Council's obligation to control new and altered discharges going into its reticulated stormwater network to a degree that ensures the conditions can be met.

Condition 28 of the consent also requires a Stormwater Quality Improvement Programme to be prepared and progressively implemented, which is designed to improve the quality of stormwater network discharges. This includes use of regulatory powers (e.g. consent and bylaw requirements) to avoid, remedy and mitigate the adverse effects of stormwater discharges.

2.3 Current district plan provisions

Currently the district plan employs a number of techniques to manage stormwater at source, including:

- Requirements for stormwater management (Rule 25.13.4.2)
- Requirements for incorporation of water efficiency measures (Rule 25.13.4.5)
- Rules requiring water impact assessments and ICMPs for larger developments
- Minimum permeable area requirements (Residential zones – primarily for amenity reasons).

Minimum permeable surface coverage is 30% in the General Residential zone, and 20% in the Residential Intensification zone and Medium Density zone.

City-wide Chapter 25.13 – Three Waters contains most of the stormwater management provisions (with flooding being separately dealt with under Chapter 22 Natural Hazards). Rule 25.13.4.2 contains a stormwater standard applying to all activities. It firstly requires the provision of a stormwater reticulation and disposal system that is "*adequate to safeguard people from injury or illness and protect property from damage caused by surface water*". The standard also requires stormwater management measures to be *"in place and operational upon the completion of subdivision and/or development to ensure that the rate of stormwater discharge offsite is at or below pre-development rates"*.[1] Stormwater management measures are to be implemented, as appropriate, in accordance with a stated 'drainage hierarchy': retention for reuse; soakage techniques; detention and gradual release to a watercourse; and detention and gradual release to stormwater reticulation.

The existing stormwater rule does not provide control over overall stormwater volumes or stormwater quality, and provides limited guidance on expected levels of performance or how to determine 'adequacy'. It refers in a note to the Hamilton City Infrastructure Technical Specifications (now Regional Infrastructure Technical Specifications - RITS) for acceptable means of compliance. In practice, it is difficult to determine compliance just from the district plan rule alone.

In addition to the stormwater standard, Rule 25.13.4.5 sets out a number of 'Water Efficiency Measures' that must be incorporated into new residential development. The water efficiency standard requires that in addition to low flow fixtures, at least one water sensitive technique for stormwater shall be incorporated, connected to, achieved or maintained as part of any new development as identified. The methods mix water conservation measures (i.e. rain tank for non potable use) with stormwater management (e.g. permeable paving). Some of the techniques able to be selected have no stormwater quality benefit. The rule is as follows:

> *In addition to Low Flow Fixtures, at least one water sensitive technique for stormwater shall be incorporated, connected to, achieved or maintained as part of any new development as identified below.*

[1] Pre-development being defined as relating to the physical characteristics of the site at the point of lodgement of a new resource consent application. While the wording of the rule is somewhat ambiguous, in practice the achievement of "pre-development rates" is being applied to storm event peak flows, rather than overall volumes.

Detention of stormwater to 80% of pre-development runoff by an appropriate means

Permeable surfaces protected to achieve at least 20% above the minimum standard of the zone. For the purposes of this rule the permeable surfaces may include:

Permeable paving for parking, access and manoeuvring areas associated with residential units (excluding where used for shared vehicle access)

Uncovered decks which allow water to drain through to a surface which can absorb water.

Rainwater tank for non-potable reuse system

Other equivalent feature.

The selection of water efficiency measures is also intended to be informed by more appropriate site / development / catchment specific measures coming out of a Water Impact Assessment or an ICMP.

Rule 25.13.4.6 requires a water impact assessment for larger scale developments, including all development of four or more units, or creating a new building for industrial activities with a gross floor area greater than 1,000m². These are a restricted discretionary activity, and Appendix 1.2.2.5 sets out information requirements for a water impact assessment, which include details of what water-sensitive techniques are proposed.

Rule 25.13.4.1 requires an ICMP for larger scale developments including more than 40 residential units or allotments or being over 3ha in size. These are a restricted discretionary activity, and Appendix 1.2.2.6 sets out the information requirements for ICMPs. The rule also requires that Three Waters infrastructure be developed in accordance with any existing full ICMP applying to that area. Compliance with an ICMP is considered a means to comply with the other three waters standards, including Rule 25.13.4.2.

The relevant existing objectives and policies for stormwater management are as follows:

Objective	Policies
25.13.2.1 Water resources are protected from the adverse effects of subdivision and development.	**25.13.2.1a** Subdivision and development is located and designed to minimise adverse effects on ground and surface water resources, particularly the life-supporting capacity of water bodies and their riparian margins.
	25.13.2.1b Subdivision and development on the margins of natural watercourses and wetlands should be located and designed to maintain, and where possible enhance:

<table>
<tr><td></td><td>i. Riparian margins.
ii. Water quality.
iii. Water resources.
iv. Aquatic habitats.</td></tr>
<tr><td>25.13.2.2
Measures to facilitate the efficient use of water resources are incorporated into new subdivision and development.</td><td>25.13.2.2a
Water-sensitive techniques are incorporated into new subdivision and development to reduce demand on water supplies, wastewater disposal and to manage stormwater.</td></tr>
<tr><td rowspan="3">25.13.2.3
Three Waters infrastructure is provided as part of subdivision and development, and in a way that is:
• Integrated
• Effective
• Efficient
• Functional
• Safe
• Sustainable</td><td>25.13.2.3a
All subdivision and development provides integrated Three Waters infrastructure and services to a level that is appropriate to their location and intended use.</td></tr>
<tr><td>25.13.2.3b
Subdivision and development shall not occur unless the required infrastructure is available to service it.</td></tr>
<tr><td>25.13.2.3c
Three Waters infrastructure is to be designed and constructed in accordance with any existing Structure Plan and relevant Integrated Catchment Management Plan.</td></tr>
<tr><td></td><td>25.13.2.3d
Large scale subdivision and development proposals are to prepare an Integrated Catchment Management Plan (where one does not already exist) or a Water Impact Assessment.</td></tr>
<tr><td colspan="2">In areas where a full Integrated Catchment Management Plan does not exist the following policies also apply:</td></tr>
<tr><td colspan="2">Design
25.13.2.3e
Three Waters infrastructure is designed and constructed to:</td></tr>
</table>

i.	Minimise the effects of urban development on downstream receiving waters and groundwater.
ii.	Ensure that the capacity, efficiency and sustainability of upstream and downstream infrastructure will not be compromised.
iii.	Facilitate access, maintenance and operational requirements.
iv.	Cater for the potential effects of climate change.
v.	Ensure appropriate standards of public health, safety and amenity.
vi.	Ensure that surface water runoff is appropriately managed in accordance with the following drainage hierarchy. 1. Retention for reuse. 2. Soakage techniques. 3. Detention and gradual release to a watercourse. 4. Detention and gradual release to stormwater reticulation.
Stormwater **25.13.2.3f** Stormwater management techniques are designed and constructed to:	
i.	Maintain or improve the quality of stormwater entering the receiving environment.
ii.	Avoid or mitigate off-site effects from surface water runoff.
iii.	Sustainably manage the volume and rate of discharge of stormwater to the receiving environment.

In summary, the operative district plan contains a number of overlapping methods to address stormwater management issues, but has some gaps at an individual site level. The ICMP and Water Impact Assessment requirements only apply to larger scale developments. For smaller scale developments, an adequate stormwater system discharging at pre-development rates (for peak flows) and using at least one water sensitive technique is required. While some of the water sensitive techniques that may be selected for application on a site do also have water quality benefits, stormwater quality treatment is not a requirement and the rules for smaller scale developments fall short of meeting the stormwater quality objective.

2.4 Other relevant stormwater documents

2.4.1 Hamilton Stormwater Bylaw 2021

The Hamilton Stormwater Bylaw 2021 is a means of complying with Council's Comprehensive City-Wide Stormwater Discharge Resource Consent and Stormwater Management Plan. The Bylaw ultimately aims to assist in achieving the Vision and Strategy for the Waikato River by elping to protect aquatic habitats, minimising scour, erosion, and flooding and improving bathing water quality.

The Bylaw bans unauthorised discharges from entering the stormwater system such as chemicals, wastewater, sediment, concrete and rubbish. The Bylaw also states that Council Approval is required in order to connect to the public stormwater system; and Council does not have to approve connection, and may impose conditions. For a new connection Council may require demonstration that the discharge complies with any ICMP or Water Impact Assessment and will not cause a breach of the Comprehensive Citywide Stormwater Resource Consent.

The Bylaw includes a Schedule of High Risk facilities that are required to have a Pollution Control Plan in place and a private interception system installed (generally industrial activities and activities using environmentally polluting substances). It also includes requirements relating to the maintenance of private stormwater management devices.

The Bylaw is not generally equipped to control lower level, cumulative effects on water quality and quantity from residential development and intensification (e.g. additional impervious surfaces and vehicle contaminants).

2.4.2 Regional Infrastructure Technical Specifications

The Regional Infrastructure Technical Specifications (RITS) sets standards for design and construction of public infrastructure, including three waters. The RITS were adopted by the Hamilton City Council in June 2018 and are also adopted by a number of other councils.

It is not compulsory to design infrastructure in accordance with the RITS, and alternative solutions can also be presented for consideration. However compliance with the RITS is an accepted and efficient means of complying with resource consent conditions and the district plan's Three Waters general standards in Chapter 25.13.

The RITS are not rules in themselves. However the current approach in Chapter 25.13 of the district plan includes non-specific rules in relation to water, wastewater and stormwater (e.g. an 'adequate' system shall be provided) and then notes that acceptable means of compliance is contained within the RITS. The RITS contains a much greater level of technical detail and design requirements than the district plan (which provides very little in the way of technical requirements).

The RITS contains stormwater treatment train design requirements (being more stringent for high contaminant load profiles being roads > 10,000 vehicles per day, zinc or copper roofs, all industrial zones, and uncovered carparks > 750m^2). However no rule in the district plan specifically requires the implementation of these requirements, or any other quality / treatment requirements. Further, it is noted that the RITS does not specifically address the issue of hydrology and other urban contaminants such as temperature which are known to adversely impact freshwater receiving environments without appropriate management.

2.4.3 Three Waters Management Practice Notes

The Three Waters Management Practice Notes published on the Council website provide implementation guidance for the Three Waters requirements in the district plan and RITS. They expand on how to comply with the district plan rules in combination with applying the technical requirements of RITS in an easy-to-follow manner, providing accepted solutions. Separate practice notes are provided for rainwater reuse systems, soakage, bio-retention systems, rainwater reuse and detention systems, detention tanks, permeable surfaces and paving, automated greywater reuse systems, water impact assessments and ICMPs.

2.5 Plan Change 12 stormwater implications

Plan Change 12 increases the development capacity of a large number of sites across the city. These changes are set out in detail in the Plan Change 12 documents and section 32 report.

Relevant to stormwater management, the intensification enabled by Plan Change 12 is likely to see impervious area coverage increasing markedly in areas of redevelopment. Suburban residential sections typically have impervious coverage of about 50-60% (comprising roof area, driveways, paths, patios and the like). District Plan controls already allow impervious coverage to increase to 70% or 80%,[2] but while theoretically increased coverage is possible with a suburban pattern of development, in reality the redevelopment of sites from stand alone house to a terrace type product (such as enabled by the MDRS) is the prime driver of increased impermeable coverage. Therefore Plan Change 12 could lead to a significant increase in stormwater runoff from the increased impervious coverage.

Intensification also has the potential to concentrate vehicle use into a smaller area, compared to if the same level of development was spread over a larger area. At an on-site level, intensification will likely lead to more concentrated use of right of ways by vehicles. Currently a stand alone house on a 600m^2 site may have (on average) 1.79 cars.[3] If the single house is replaced by 3 units, then vehicle ownership may increase to 5.37, each potentially making 10 trips (in and out) per day. Accordingly, the contaminants generated associated with vehicle use (total suspended solids, heavy metals, oils and grease) and entering stormwater would also be more concentrated.

As set out in section 2.3 above, the current district plan only specifically targets peak flows for stormwater run-off management, and other water sensitive measures are applied varyingly. Stormwater volumes at other (non-peak) times, as well as stormwater quality, will not be adequately managed through the current suite of district plan rules, the Stormwater Bylaw, or off-site communal stormwater management devices. Plan Change 12 enables three dwellings to be constructed as of right on a residential zoned site, which is not significant enough in scale to trigger the existing Water Impact Assessment or ICMP rules. The cumulative effects on stormwater quality and quantity of these developments all across the city are likely to be significant, especially when considered in the context of the current water quality and erosion susceptibility of the Waikato River and its tributaries.

[2] Plan Change 12 retains 70% and 80% impermeable coverage controls for residential zones.

[3] Average based on 2018 census data for Hamilton Urban Area.

In summary, with increased intensification options to be enabled across the city, there is a need for more comprehensive and better targeted controls relating to stormwater management.

2.6 Need for on-lot stormwater management measures

Attachment One contains technical reporting prepared by SCO Consulting Ltd and Morphum Environmental confirming a preference for requiring on on-lot stormwater devices as a cost-effective means of mitigating stormwater effects (both quality and quantity) and enabling waterway outcomes (including giving effect to Te Mana o te Wai and Te Ture Whaimana o te Awa o Waikato) to be achieved over time. It notes that on-lot devices enable management of stormwater runoff at source, before it enters the public drainage system and natural waterways. These devices serve to mitigate the effects of changes to natural stormwater processes of absorption, evaporation and runoff – mainly caused by development activities including the addition of impervious surfaces. Evidence clearly shows that on-lot measures can be highly cost effective if designed, implemented and maintained properly. In some cases (e.g. brownfields), they are the only viable option for mitigating stormwater contaminants, if public stormwater treatment systems are not viable due to such issues as available land space. Additionally, land values are increasingly prohibitive for Council to strategically purchase private land to develop stormwater management assets for brownfields sub-catchments.

2.7 Council's role and jurisdiction in stormwater management

Under section 30 of the RMA, Waikato Regional Council has the function of controlling the use of land for the maintenance of the quantity and quality of water in waterbodies. In this respect the Waikato Regional Plan contains rules controlling higher risk and larger scale stormwater discharges. Rule 3.5.11.4 generally permits stormwater discharges to water from residential developments of one hectare or less in the urban area, while Rule 3.5.11.5 generally permits stormwater discharges to land if they do not cause flooding.

Although the management of water discharge matters is generally the responsibility of regional councils, the RMA specifically excludes water which is in a pipe, tank or cistern from the definition of water. Therefore, stormwater discharges from developments that occur directly into an existing piped stormwater system are not captured by section 15 of the RMA, and as such are not the responsibility of the regional council. Accordingly the Waikato Regional Plan does not control individual discharges to Council's piped network. The explanation and reasons to the Regional Plan stormwater discharge provisions note the need for integrated management of stormwater with territorial authorities, given that they own and manage the large majority of stormwater systems in the region.

As previously outlined, the Council holds consent from the Waikato Regional Council for the discharge of stormwater from its piped network. It is necessary for the Council to manage the quantity and quality of stormwater discharged into its piped network to manage the stormwater being ultimately discharged, and to ensure compliance with network discharge consent conditions.

The key role of the Council under the RMA is the control of the actual or potential effects of land use and development. The implementation of source control measures through the District Plan is provided for under section 9 of the Act – *Restrictions on use of land* – whereby the use of land

will have an effect on stormwater discharges, relating to the extent and use of impervious surfaces such as buildings and paved areas.

As a territorial authority, under section 31 of the RMA Council has the function of establishing plan provisions to achieve integrated management of the effects of land use and associated natural and physical resources. It has the control of the effects of land use including on amenity values, natural hazards and indigenous biological diversity. District plan controls to maintain and improve river/stream health are considered to be within the scope of Council's functions under section 31 RMA.

Section 74 of the RMA states that a territorial authority must prepare and change its district plan in accordance with its functions under section 31 and the provisions of Part 2. Section 75 states that a district plan must give effect to any national policy statement and regional policy statement. Under section 13(4) of the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010, Hamilton City Council must also give effect to Te Ture Whaimana (Vision & Strategy for the Waikato River) through its district plan, which has pre-eminence over a policy statement in the event of any inconsistency. The relevant provisions from those documents are set out in section 3, and include stream health matters.

Council also has responsibilities under the Local Government Act 2002 (LGA) to provide for good quality local stormwater infrastructure in a cost-effective way, taking a sustainable development approach.

The inclusion of stormwater provisions within the District Plan aligns the Council's responsibility over the stormwater network with the control of land use activities to manage stormwater discharges into its network.

The statutory framework discussed above establishes the jurisdictional basis for the Council to manage stormwater quality and quantity under the District Plan.

2.8 Summary

Given the above it is assessed that the intensification enabled by Plan Change 12 to implement the NPS-UD, Enabling Act and MDRS will result in the current District Plan stormwater provisions, Stormwater Bylaw and the city's stormwater management system being insufficient to manage the effects of stormwater on the health and wellbeing of the Waikato River. Council needs to enhance its stormwater controls regime in order to give effect to Te Ture Whaimana, and protect and restore the health and wellbeing of the Waikato River.

3 Evaluation of the Proposed Changes

While a comprehensive section 32 evaluation has been undertaken for Plan Change 12 as a whole, a section 32 evaluation specifically relevant to on-site stormwater management is set out here.

3.1 Proposed objective

The following new objective 25.13.2.1a is proposed:

<u>The health and well-being of the Waikato River is protected from the adverse effects of stormwater runoff from subdivision and development and enhanced when development or redevelopment occurs.</u>

It is considered that this new objective is the most appropriate way to achieve the purpose of the RMA for the following reasons:

- It seeks to ensure that future development/intensification within Hamilton does not negatively impact on the health and wellbeing of the Waikato River by managing the potential for increased effects on stormwater quality and quantity.
- It directs enhancement of the health and wellbeing of the Waikato River. The Waikato River requires improvement to its current state in order to sustain its potential to meet the needs of future generations and provide for social and cultural wellbeing. This restoration is a key aspect of the Vision & Strategy (required to be given effect to), prepared by the kaitiaki of the Waikato River and stemming from a Treaty Settlement.
- The Waikato River is an important ecological, landscape, amenity and recreational resource within the city, and deserves protection under section 6 and 7 of the RMA.

3.2 Assessment of options

Several higher level methods were considered in terms of their ability to achieve the objective and protect and enhance the health and wellbeing of the Waikato River from the adverse effects of stormwater runoff, including:

- **Option 1:** Status quo district plan provisions, with accelerated investment into public stormwater infrastructure
- **Option 2:** Enhanced district plan provisions for stormwater quantity and quality management onsite
- **Option 3:** Applying a qualifying matter to restrict or prevent intensification
- **Option 4:** Controlling discharges through the Stormwater Bylaw and connections approvals

- **Option 5:** Provision of incentives for retrofitting on-lot stormwater management measures.

These options include methods both inside and outside of the District Plan and are not mutually exclusive. They have been assessed under section 32(1)(b) of the RMA in the table below.

Option 1: Status Quo district plan provisions with accelerated investment into public stormwater infrastructure	
Costs	Economic costs to Council, via developers and ratepayers. Retrospective installation of communal stormwater treatment in the older areas of the city is very difficult and costly due to existing property and land use, with high purchase costs for land. Financial contributions taken on a piecemeal basis for infill development would be very slow to raise the scale of investment required for retrofitting communal devices as a sole solution. Ongoing maintenance costs for public communal devices would fall to Council.
Benefits	Public communal stormwater devices would be suitably designed and maintained by Council to achieve a range of ongoing environmental benefits. Ongoing maintenance and operation costs per property served would generally be cheaper. In some cases, communal devices may be the most practical option for dealing with small scale cumulative stormwater effects. Some onsite stormwater management and associated environmental benefits is also already achieved by the status quo plan provisions, including peak flow management.
Efficiency	Space constraints to stormwater devices are likely to apply in brownfields areas, limiting the feasibility of larger scale public intervention. Not all areas could be appropriately treated/managed. Even with a downstream communal device in place, the upstream portions of watercourses can still be negatively impacted by stormwater runoff.
Effectiveness	Due to funding limitations, even if development contributions taken or rates increased, Council is unlikely to afford all the upgrades that would be required within the next ten years. Additionally, development contributions for a stormwater retrofit programme could not be introduced until the 2024 Long Term Plan. In the meantime, stream/river health could continue to decline.
Risk of acting or not acting	The risk of this option is that not all public stormwater upgrades required will be able to be implemented, and the existing suite of plan provisions does not go far enough to protect and enhance the

	health and wellbeing of the Waikato River (given the intensification now being enabled), so the Vision and Strategy will not be given effect to.
Recommendation	While public stormwater improvements will be able to contribute towards achieving the objective, where feasible and funding is available, cannot rely on this option to achieve the objective on a city wide basis.
Option 2: Enhanced district plan provisions for stormwater quantity and quality management onsite	
Costs	Economic cost to landowner/developer to design, install and maintain onsite stormwater devices. Space requirements for devices are unlikely to constrain site development potential, given that 30% permeable surface coverage is required and rain tanks are excluded from coverage calculations and yard setbacks.
Benefits	Onsite stormwater devices can manage stormwater generated from a site so as to closely align with a natural water balance, protecting downstream waterways and ecosystems. They can be installed at the time of development, immediately mitigating adverse effects and reducing stormwater management requirements in the downstream catchment. Co-benefits of rainwater reuse tanks include reduced municipal water demand, increased resilience in dry conditions/emergencies and increased community awareness of rainfall/runoff processes.
Efficiency	New development and redevelopment can be captured by district plan provisions, but not existing development subject to existing use rights. Onsite stormwater measures (and associated plumbing) are most efficient to consider at the initial design stage and install upon development / redevelopment of a site.
Effectiveness	Onsite measures can provide an effective method of managing stormwater runoff for that property if operated and maintained correctly. In some circumstances where sites cannot achieve best practice standards, there may be residual cumulative effects that will still require mitigation at a downstream public device. Would be effective at protecting stream health, and in some cases at enhancing stream health when the existing situation is able to be improved upon redevelopment.

Risk of acting or not acting	The risk of not enhancing the district plan provisions is that the existing suite of provisions does not go far enough to protect and enhance the health and wellbeing of the Waikato River, and the Vision and Strategy will not be given effect to.
Recommendation	Implement this option, potentially in combination with Option 5.
Option 3: Applying a qualifying matter to restrict or prevent intensification for stormwater quality reasons	
Costs	Reporting costs incurred by Council to justify the qualifying matter being applied, involving a detailed evaluation. This would likely be applied city-wide, as incremental stormwater quality and quantity effects are common to all development. Economic/social costs associated with reduced development potential from what has otherwise been directed by the NPS-UD and MDRS. Opportunity/environmental cost for potential to improve the existing stormwater situation when a site is redeveloped and intensified.
Benefits	Reduced intensification pressures would mean less new impervious coverage, so less effects on stormwater quality.
Efficiency	Use of a qualifying matter is not valid if the stormwater quality effects can be managed through other means without compromising the level of intensification, which is thought to be the case. Therefore the qualifying matter may not be accepted through the hearings process, making the whole process inefficient.
Effectiveness	Would be somewhat effective at protecting stream/river health, but not at enhancing stream/river health.
Risk of acting or not acting	Risk that this option does not meet the requirements of the NPS-UD and MDRS and would be considered invalid.
Recommendation	Only justified if no other option can achieve the objective.
Option 4: Controlling discharges through the Stormwater Bylaw and connections approvals	
Costs	Costs of making a change to the Stormwater Bylaw which places more specific requirements upon individual residential and non-

	residential sites in order to obtain connection approval. Increased complexity of connections approval process. Economic cost to landowner/developer to design, install and maintain onsite stormwater devices. Space requirements for devices may constrain site development potential. Costs likely to be higher if design changes are needed in the middle of the development process.
Benefits	Onsite stormwater devices can manage stormwater generated from a site so as to closely align with a natural water balance, protecting downstream waterways and ecosystems. Maintenance to ensure the ongoing effectiveness of private stormwater devices can be enforced through the Bylaw.
Efficiency	Connections approval stage is not the most efficient time to require people to install onsite stormwater devices. If people are unaware of the Bylaw requirements and developments have proceeded as permitted activities, the development may have already been designed by the time the stormwater requirements are confirmed. Onsite devices could be put in as an afterthought (with potentially compromised quality of outcomes) rather than being considered in an integrated manner upfront.
Effectiveness	Under the Local Government Act, territorial authority bylaws are generally to be made for the purposes of asset protection, protection from public nuisance, public health and safety. While stormwater quality and quantity matters can be linked to nuisance effects, a Bylaw is not an effective manner of directly addressing the cumulative environmental effects on the Waikato River and tributaries (and achieving the objective).
Risk of acting or not acting	Risk of poor outcomes from managing stormwater through a Bylaw alone, as outlined above.
Recommendation	That the Bylaw continue to form part of the stormwater toolbox, but the district plan is a more appropriate method than a Bylaw for managing environmental effects at individual site level.
Option 5: Provision of education and/or incentives for retrofitting on-lot stormwater management measures	
Costs	Economic cost to Council in funding the incentives (e.g. discounted or free consent fees, subsidising the cost of the device, or even

	installing for free). The remainder of costs for design, installation and maintenance of devices fall to the landowner.
Benefits	Every device installed has a small cumulative environmental and cultural benefit in improving stormwater quantity/quality entering the Waikato River and tributaries. Devices installed by the owner's choice are likely to have better maintenance and upkeep.
Efficiency	As an opt-in measure, incentives cannot be relied upon to achieve any large scale improvements to stormwater quantity/quality.
Effectiveness	Due to existing use rights, this is the most effective option to encourage retrofitting of existing properties. The devices that are installed are likely to be effective for that property, but overall expected take up of the incentives would not be high enough to achieve the objective.
Risk of acting or not acting	No particular risks identified from acting. Without attempting to address stormwater quality and quantity from existing development, it could be difficult to achieve a significant degree of restoration of the Waikato River.
Recommendation	Suitable as part of a wider package of measures, and an important part of encouraging improvements to the existing situation, but will not on its own achieve the objective.

It is concluded that Option 2 is the most efficient and effective way of achieving the objective within the scope of Plan Change 12, while investment into public stormwater infrastructure, provision of incentives and the application of the Stormwater Bylaw are also important tools to achieve the objective outside of the District Plan.

3.3 Analysis of proposed provisions

Having assessed above that enhanced plan provisions are required to achieve the objective, the detail of those plan provisions is now analysed.

Policies

To better achieve the new proposed objective as well as the RPS objectives which focus on both protection and enhancement of stream/river health, a new policy is proposed. The proposed policy is:

25.13.2.1c
Subdivision and development incorporate on-site stormwater management measures that:

- *retain increased stormwater volumes from new development, prior to discharge;*
- *protect and improve water quality of receiving environments; and*
- *enhance the health and wellbeing of the Waikato River by reducing the effects of existing development at the time of site redevelopment.*

This would replace Policy 25.13.2.3f Stormwater (below) which applies to areas without ICMPs. The new policy would apply to all areas.

Stormwater **25.13.2.3f** Stormwater management techniques are designed and constructed to:	
i.	Maintain or improve the quality of stormwater entering the receiving environment.
ii.	Avoid or mitigate off-site effects from surface water runoff.
iii.	Sustainably manage the volume and rate of discharge of stormwater to the receiving environment.

Another new policy is proposed to signal that financial contributions may be required to address the adverse effects of development on stormwater at a sub-catchment scale:

25.13.2.1d
In accordance with Chapter 24, require a financial contribution when off-site stormwater works are needed in a sub-catchment to avoid, remedy or mitigate the adverse effects of development or to restore and protect the health and wellbeing of the Waikato River.

Rules

A number of features to the rules were considered, as summarised in the table below. The SCO Consulting and Morphum Environmental Ltd paper in Attachment One contains full technical details and justification for the proposed rule.

Rule Feature	**Explanation**
Application of rule	The amended rule applies to residential zones, as this is where the intensification of Plan Change 12 is concentrated. While the identified gaps in the existing stormwater rule also

	apply to non-residential zones, the status quo provisions for non-residential zones are carried through.
Nature of stormwater rule	A performance standard was considered to be most effective as a rule, with different configurations of stormwater management devices being available to achieve the performance standard. A performance standard (as opposed to blanket requirements on device design) corresponds most closely to mitigating the actual effects of the development proposal. Retention (via rainwater reuse tanks and soakage) is required as the primary method of stormwater mitigation. This is considered to provide a suitable means of matching undeveloped hydrological characteristics and mitigating both quality and quantity effects, so as to assist in meeting the conditions of the comprehensive discharge consent, protect and enable progressive enhancement of downstream waterways and ecosystems. Catchpits will be required to remove contaminants off hardstands prior to soakage, and roof contaminants will be captured in rainwater tanks, so a retention approach provides robust stormwater quality benefits. Another option available for stormwater mitigation, if infiltration is not feasible, is for a high proportion of rainfall to undergo quality treatment before discharge, should a developer wish to choose this route. This will also achieve acceptable stormwater quality outcomes. At least 20% of remaining existing impermeable surfaces are to be mitigated upon substantial redevelopment of a site, as a substantial redevelopment should create betterment opportunities for existing areas to be mitigated, in line with the Vision and Strategy. As the rule is considered to represent the latest best practice, it will override any on-lot stormwater requirements in older ICMPs.
Technical requirements of rule	As set out in Attachment One, modelling has been undertaken to establish what rainfall depths can practicably be attenuated on-site to match undeveloped hydrological characteristics and mitigate both stormwater quality and quantity effects. It was determined that retaining 10mm of runoff depth onsite and would mimic natural catchment conditions and meet required technical parameters. It was also determined that a combination of rainwater capture/reuse and infiltration is

	optimal to achieve this, and can support retention of 60-70% of the mean annual rainfall volume, with the reuse of 20-30% of mean annual volume mimicking natural levels of water loss through evapotranspiration. At least 70% of all site generated contaminants would also be removed through retaining 10mm of rainfall. Modelling has established the stormwater solutions that would be needed for a range of lot sizes with up to 50% building coverage and 70% impermeable coverage. The modelling results indicated that smaller houses (e.g. attached terraced houses) on 100m² lots would each require a 2,000L tank for roof water and either one 700L soak hole or permeable paving for the hardstand, while larger houses on 500m² lots would require a 5,000L tank for the roof and 3,500L of soakage capacity, with a range of outcomes in between. Extended attenuation of peak flows (e.g. 2 year, 10 year ARI rainfall events) was not considered particularly beneficial at a small lot scale, as the benefits and desirability of this requirement would vary according to location within the catchment, extent of network capacity limitations and flooding problems. It has not been included in the technical requirements of the rule, but will be considered as part of the assessment for larger scale developments. 20m² has been selected as the area of additional impermeable surfaces that triggers a requirement for stormwater mitigation. This allows for smaller patios, single garages or carports to be constructed without an onsite stormwater management device (if within site impermeable coverage limits). It is considered appropriate for all larger scale developments to manage stormwater quality and quantity, in line with Te Ture Whaimana. A 25m² extension to impermeable surfaces would require one 250L soak hole, or permeable paving to be used.
Activity status	A permitted standard is provided to enable smaller scale development to occur without the need for resource consent, while still requiring appropriate levels of stormwater mitigation to achieve the objective. Alternative mitigation measures would require consent. A restricted discretionary status applies to development not meeting the standard, which enables the consideration of site constraints / characteristics which may limit space for on-site

	measures and any alternative on or offsite mitigation measures. A restricted discretionary status with a site-specific stormwater management plan requirement also applies to larger scale developments (with impermeable surfaces over 1,000m² in area) to enable full consideration of the site-specific stormwater solutions proposed, similar to the Water Impact Assessment process that is used in the existing district plan. This is because bigger sites/developments have the opportunity for site-specific solutions to be used rather than standard, 'deemed to comply' solutions; additionally it may be appropriate and practical for such sites to achieve additional stormwater parameters, for example, mitigating peak flows.
Compliance	Permitted activities are required to install stormwater management in accordance with the design standards provided by the Three Waters Management Practice Notes, or an alternative method of meeting the performance standard. Compliance will be determined at the stage of building consent, or resource consent if this is required for another matter.
Maintenance	To increase visibility of the requirement for ongoing maintenance to be undertaken for stormwater management devices to continue to operate effectively, a maintenance clause has been included in the rule. The requirements of the Stormwater Bylaw will also continue to apply. An operations and maintenance plan will need to be provided and implemented for communal devices for apartments, where a body corporate or similar structure may be needed. If installed in accordance with the Three Waters Practice Notes, rain tanks and soak holes are relatively easy to carry out regular maintenance checks on. Council is currently implementing a monitoring programme to check whether existing private stormwater devices are complying with requirements.
Design standards	To facilitate ease of consent processing, a set of design standards is provided illustrating how to achieve the district plan requirements. These are contained within the Three Waters Management Practice Notes and will be updated to reflect rule changes.

Consistency with bulk & location provisions	To avoid creating a barrier to implementation of rain tanks, rain tanks are currently excluded from site coverage, permeable surfacing, and side and rear boundary setback requirements, provided they have a capacity under 10,500L. This situation is proposed to continue. This recognises that the effects of a rain tank of this scale would be minor and ensures that any potential conflict between protection of amenity and protection of stream health can be assessed (through consents for tanks greater than these dimensions). It also limits any effects on the development potential of a site resulting from the incorporation of rain tanks.

3.3.1 The benefits and costs of the proposed rules

The main benefits of the rules are anticipated to be:

- Environmental, cultural, landscape, ecological and amenity benefits associated with protection and potential enhancement of the health and wellbeing of the Waikato River and its tributaries as a result of:
    - Existing erosion issues not being exacerbated
    - Reduced vehicle, building material and other contaminants entering water bodies
    - Potential for improvements through mitigation of existing impervious surfaces being included upon site redevelopment.
- A permitted standard will enable accepted solutions to be implemented without the need for resource consenting processes. Continuing to allow for smaller rainwater tanks to be excluded from potential consent requirements will also reduce the need for resource consenting processes.
- The performance standard provides greater clarity to district plan users on the technical requirements for any stormwater management device than the status quo.

Designers and developers will be aware of the need to incorporate on-site systems at the start of the development process, rather than at the middle or end.

Co-benefits of rainwater reuse tanks including reduced municipal water usage, increased resilience in dry conditions and emergencies, and increased community awareness of rainfall/runoff processes.

The main costs of the rules are anticipated to be:

- Installation and maintenance costs – higher specification/more expensive stormwater management device(s) will be required than the status quo situation. Typical costs have been quantified as follows:
    - Rainwater reuse tank including plumbing and installation: approximately $10,000

- Soakage pit: approximately $3,000-$4,000
- Permeable paving: approximately $240/m² (or around $90/m² more expensive than standard concrete)
- Compliance with the proposed rules for a new residential unit will generally require a rainwater reuse tank and either a soakage pit or permeable paving. This is costlier than the cheapest option out of the status quo requirements, being a detention tank at a cost of approximately $5,000.

- Stormwater design costs (already payable in the status quo situation). Costs will be reduced as much as possible by providing Three Waters Management Practice notes on acceptable design solutions.
- Retrofitting costs from the 20% additional stormwater mitigation requirement – potential costs have been reduced by only applying this requirement to a substantial redevelopment where it is likely to be practical to redirect existing impervious surfaces as part of the redevelopment.
- Some residual cumulative effects on stormwater quantity will likely still need to be addressed through retrofitting new or improving the performance of existing communal public stormwater devices in existing urban areas.
- Reduced development potential – the requirement for onsite stormwater devices is unlikely to have much effect on the amount of land available for development, as soakage can occur under driveways, and tanks are permitted in yards and not included in site coverage and impermeable surface calculations.
- Reduced choice of building material.
- Some additional compliance and maintenance monitoring. Monitoring will be an important part of ensuring the stormwater quality and quantity outcomes continue to be achieved following completion of developments.

3.3.2 Effectiveness and efficiency of achieving objectives

The rules are appropriate for achieving the new proposed objective in combination with the existing district plan objectives, by protecting the health and wellbeing of the Waikato River to the extent that is possible for district plan stormwater provisions, and promoting enhancement outcomes where there is opportunity to do so. With the proposed residential rules in place, the natural hydrological characteristics of those areas should be effectively maintained and water quality should be protected from a range of urban contaminants.

Additional non-district plan methods that would increase overall effectiveness at achieving the objectives include:

- Brownfields retrofit programme for addressing small scale but cumulative stormwater quantity effects that are inefficient to deal with at an individual lot scale.
- Maintenance programme to ensure the measures continue to operate effectively.

- An incentives scheme could be established in future to promote improvements on existing sites that are not being changed.

3.3.3 The risk of acting or not acting

There is sufficient and certain information to determine that managing stormwater on-site and achieving a reduction in volumes and peak flow rates will help to mitigate the adverse effects of urban growth and development on stream health in a more effective way than reliance upon public infrastructure.

The risk of not acting now is that with the residential intensification introduced by Plan Change 12 which will increase the drivers for sites to maximise their impervious areas up to the permitted 70%, river/stream health will be adversely affected. The impact of this will be particularly evident in existing urban areas that are subject to significant change. Putting enhanced measures in place now to ensure that appropriate mitigation is implemented for the increasing amount of development provides greater certainty that the current health and wellbeing of the Waikato River and its tributaries can be maintained.

3.3.4 Summary of reasons for decision on the provisions

The intensification enabled by Plan Change 12 to implement the NPS-UD and MDRS will result in the current District Plan stormwater provisions and Stormwater Bylaw being insufficient to manage the effects of stormwater on the health and wellbeing of the Waikato River. Council needs to enhance its stormwater controls regime in order to give effect to the Vision and Strategy, and protect and restore the health and wellbeing of the Waikato River. The most appropriate and effective method of doing this is to amend the District Plan provisions so that enhanced stormwater management is required in conjunction with intensification. Having these provisions in place will enable intensification to proceed without compromising the Vision and Strategy (in terms of stormwater quality).

The specific nature of the provisions has been carefully considered, with the aim of minimising changes to the hydrological characteristics of the city, meeting the conditions of the comprehensive discharge consent, and avoiding the discharge of additional urban contaminants to waterbodies. The implementation costs of the provisions are not significantly higher than the status quo and not out of proportion to the overall cost of a development. They have been reduced to the extent practicable by making the stormwater requirements a permitted standard (no resource consent); allowing rainwater tanks to be exempt from some building coverage and location controls; and making Practice Notes available which provide design guidance and deemed to comply solutions. While the requirement for enhanced private stormwater infrastructure comes at a cost to the landowner/developer, it is directly related to the effects of development. Landowners installing rainwater reuse tanks will obtain benefits from water efficiency and increased resilience.

4 Conclusion

Plan Change 12 increases the development capacity of a large number of sites across the city. It is likely to see impervious area coverage increasing markedly in areas of redevelopment and could lead to a significant increase in stormwater runoff. Intensification is also likely to increase the concentration of contaminants associated with vehicle use entering stormwater. The cumulative effects on stormwater quality and quantity are likely to be significant, and the current District Plan stormwater provisions are insufficient to manage these effects on the health and wellbeing of the Waikato River.

The most appropriate and effective method of giving effect to the Vision and Strategy, and protecting and restoring the health and wellbeing of the Waikato River in respect of stormwater effects, is to amend the District Plan provisions so that enhanced stormwater management is required in conjunction with intensification. Enhanced stormwater provisions have therefore been proposed as part of Plan Change 12, as 'related provisions' under section 80E(1)(b)(iii) of the RMA. These have been informed by a detailed technical analysis, with the aim of minimising changes to the hydrological characteristics of the city, meeting the conditions of the comprehensive discharge consent, and avoiding the discharge of additional urban contaminants to waterbodies, which is included in Attachment One. Careful consideration has also been given to making the implementation of these provisions as efficient as practicable.

Attachment One: SCO Consulting and Morphum Environmental Ltd technical reporting

MORPHUM environmental

Co-creating a thriving ecosystem

On Lot Best Practice SW

Technical Summary Report

Final

Prepared for Hamilton City Council

Document Control

Client Name: Hamilton City Council

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Executive Summary

Hydrological analysis has been undertaken to quantify and validate provisions for the management of site generated stormwater within private lots to address potential for adverse environmental outcomes close to source and reduce the requirements for large, consolidated stormwater treatment systems to manage impacts from private developments. Modelling has been based on typical development scenarios which reflect likely intensification and infill housing outcomes in existing developed areas of Hamilton and small-scale developments in new growth areas where ICMP's or WIA's are not required or operative.

Based on modelling it is determined that site generated stormwater can be feasibly managed on site from impervious surfaces to align with a natural water balance as closely as practicable to protect downstream waterways and the ecosystems they support. This is required to align with the legislated requirements in the vision and strategy of Te Ture Whaimana in addition to other national and regional regulatory drivers around management. Achieving a reliable and maintainable level of on lot water management requires a consideration of balancing:

1. Rainfall that would naturally be intercepted and evaporated back to the atmosphere.

2. Rainfall that naturally soaks into the ground to recharge shallow and deep groundwater and support baseflow in waterways between rainfall events.

3. Rainfall that runs off as stormwater during larger rainfall and discharges to waterways as overland flow (or in pipes in smaller rainfall events depending on levels of service).

The first two of these are generally referred to as 'retention' or 'initial abstraction', being the proportion of rainfall that is managed on site to prevent surface runoff from small frequent rainfall events. If unmanaged, the changes (increases) in stormwater flowrates and flow volumes in frequent small to moderate rainfall events has the potential to adversely impact on freshwater systems and the biodiversity values they support through instream scour, flashy flow characteristics, bed disturbance, increased turbidity and increased velocities impacting fish passage. Where unmanaged, these frequent runoff events are also shown to convey contaminants from impervious surfaces, cause fluctuating temperatures in summer rainfall and cause rapid changes in water characteristics including dissolved oxygen and pH.

Management of on lot stormwater is therefore required to ensure alignment with statutory and non-statutory policies and rules to protect freshwater and Te Mana o Te Awa. Modelling undertaken and resulting recommendations for rules to be included within the Hamilton City Council District Plan are intended to provide a means of matching undeveloped hydrological characteristics and by default will also support water quality benefits, which are commensurate.

The following key assumptions have informed analysis to estimate achievable performance and quantify outcomes:

- Modelling based on 5 years of continuous gauged rainfall from 2008-2012 (inclusive).
- Modelling undertaken at 5-minute timestep with outputs exported at daily timestep.
- Modelling undertaken for lot sizes from 100m^2 (representing multistorey attached housing) to 500m^2 (representing standalone dwelling) at 100 m^2 increments.
- Site coverage based on 50% building coverage and 70% total imperviousness.
- Rainwater tanks analysed from 1,000 L to 5,000 L.
- Reuse demand for rainwater tanks based on internal and external non potable water demands (toilet flushing, cold water laundry washing and outdoor water use). Internal non potable water use modelled at 40% of total demands applied constantly across all days and external non potable

use modelled at 15% of total demands applied with seasonal variability based on Evapotranspiration rates and rainfall.
- Total water use estimated at 230 L/pp/day based on HCC estimates for future water demands.
- Population density estimated at 2.7 persons/dwelling based on HCC estimates. It is noted that this is an average with actual densities to vary around this average.

Based on modelling it is shown that the retention and partial reuse of 10mm of daily rainfall depth on impervious surfaces at a lot scale will retain 60 – 70% of mean annual rainfall volume onsite, and achieve a minimum of 20% reduction in mean annual runoff volume for the total lot. This closely aligns with the estimated rainfall interception and loss (evaporation) in a natural catchment condition. This can be readily achieved through the sizing, installation and use of rainwater tanks and soakage as per below:

Equivalent lot size (m^2)	Required tank volume (L)	Required soakage volume (L)
100	2,000	370
200	3,000	735
300	3,000	1,100
400	5,000	1.45
500	5,000	1,850

The proposed stormwater rule will support intensification and development of smaller lots (not captured by ICMP's and/or WIA's) in a manner which provides an appropriate level of protection to downstream waterways and alignment with the Vision and Strategy of Te Ture Whaimana. The management of rainfall within the private lots will reduce the scale of stormwater management devices which would otherwise be required to be retrofitted within existing urban areas to achieve comparable levels of environmental protection. Existing urban areas are particularly space constrained with limited unencumbered public open space requiring acquisition of private land to accommodate stormwater management which cannot be achieved on lot.

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1. Introduction

Morphum Environmental Ltd (Morphum) were engaged alongside SCO Consulting Ltd (SCO) by Hamilton City Council (HCC) to support the revision of the HCC District Plan, in particular the inclusion of provisions to support improved management of stormwater generated from private lots prior to discharge to the public network or the environment.

These provisions are intended to apply primarily to small scale developments that are not within developments that are subject to integrated catchment management plans (ICMP) or water impact assessments (WIA) but the assumptions, analysis and provisions can equally be applied at these larger scales to consider the potential to manage site generated stormwater on lot and reduce the spatial requirements for subsequent downstream stormwater devices (such as wetlands and raingardens) in the public realm and vested to HCC.

Specifically, the modelling to support District Plan provisions was based on the quantification of flow metrics to demonstrate an ability to manage frequent flows and as a proxy for the effective removal of contaminants from residential development and redevelopment sites. On lot treatment devices have been selected for analysis based on consideration of life cycle maintainability and compatibility with realistic maintenance oversite by homeowners. This has supported the preference for rainwater tanks (with non-potable re-use) and small-scale soakage. The justification, ancillary benefits and challenges with these is discussed separately in the Stage 1 report.

This report summarises the technical assumptions, modelling approach and outcomes only and should be read in conjunction with the Stage 1 report and other published guidance material referenced in these reports.

1.1. Intent of on lot runoff management

Management of site generated stormwater within private lots provides the opportunity to support the objectives of the Regional Infrastructure Technical Standards (RITS) and Waikato Regional Council (WRC) Guidelines in a manner which can mimic the natural hydrological regime for the local climate and reduce discharge of contaminants. This is intended to provide a high level of protection for downstream receiving waterways. This combined consideration of hydrology and contaminants is required to meet the vision of Te Ture Whaimana and align with other regulatory requirements including the National Policy Statement – Freshwater. It is noted that both the RITS and WRC Guidelines have historically focussed more on water quality rather than hydrology with standards and design criteria set by defining a proportion of flows to be detained and treated via devices such as constructed wetlands and raingardens. These devices remove urban contaminants via a complex mix of biological, chemical and physical processes with the sizing based on the ability of devices to treat the initial first flush of stormwater runoff.

The first flush is typically defined by the water quality volume (WQV) on the basis that if this is captured, detained and passed through treatment, approximately 80-90% of the mean annual volume of stormwater from urban surfaces will have been effectively treated. To treat a greater proportion is regarded as inefficient due to contaminant wash off and diminishing returns in terms of contaminant load removal. Industry agreement is that treating the volume associated with 1/3 of the 50% AEP rainfall event is optimal.

The detention of the WQV is supported through the design of treatment devices which include capacity for temporary ponding which enables devices to detain inflow rates which exceed optimal treatment flow and slowly release this over a prescribed time to optimise water quality treatment functions. This is

referred to as the extended detention volume (EDV) which is used to size devices in accordance with the RITS and WRC guidelines. Technical guidelines in New Zealand have typically defined drawdown of extended detention as being over a period of 24 hours, but in reality, for raingardens the drawdown is closer to 6 hours (dependent on saturated hydraulic conductivity of filter media). The assumed 24-hour drawdown of EDV has more recently been inferred to provide appropriate protection of freshwater streams through mitigation of changes in hydrology from frequent small rainfall events. This is based on the attenuation of small, frequent rainfall events and slow release over an extended timeframe. Whilst this results in a reduced flowrate it extends the time over which this flowrate occurs and could worsen instability in certain stream types and prolong the period with elevated flows.

In a natural catchment (without urban development) these smaller frequent events will often not generate any surface runoff due to the combined influence of interception and evapotranspiration by vegetation and infiltration to surface soils (and potentially to groundwater). The rate by which this occurs varies substantially depending on factors including vegetation type, soils, slopes and seasons. This important component of the water balance is often referred to as 'initial abstraction' in hydrological modelling and in the Waikato is the justification for rules related to retention (through infiltration) of initial rainfall depth (generally varying between 5 and 10 mm). These rules are therefore intended to support a more natural hydrological regime and sustain baseflow fed streams but do not reflect the portion of rainfall which is evapotranspired in a natural catchment.

A water balance approach was therefore developed to test modelled outcomes and estimate performance to align with existing rules for water quality and quantity. This considered the natural water cycle and hydrology including the following:

1. Interception of rainfall by vegetation and shallow soils which is subject to evapotranspiration and does not connect with surface or groundwater. In modelling this is replicated through rainwater reuse which effectively diverts this water away from site discharge via diversion to the wastewater network or evaporation.
2. Interception of rainfall in surface soils which support infiltration to groundwater and sustenance of baseflow in streams and groundwater dependant ecosystems.
3. Surface runoff in events which exceed the capacity of vegetation and soils and contribute to variable streamflow during moderate to large rainfall events.

The first two of these are generally referred to as 'retention' or 'initial abstraction' (as detailed above) being the proportion of rainfall that is managed on site to prevent surface runoff from small frequent rainfall events. If unmanaged the changes (increases) in stormwater flowrates and flow volumes in frequent small to moderate rainfall events has the potential to adversely impact on freshwater systems and the biodiversity values they support through instream scour, flashy flow characteristics, bed disturbance, increased turbidity and increased velocities impacting fish passage. Where unmanaged, these frequent runoff events are also shown to convey contaminants (such as heavy metals, hydrocarbons, nutrients and sediments) from impervious surfaces, cause fluctuating temperatures in summer rainfall and cause rapid changes in water characteristics including dissolved oxygen and pH. The discharge of contaminants are known to contribute to acute and chronic impacts on freshwater ecosystems which combine with modified flow and seasonal variability to adversely impact stream health and the associated cultural, ecological and social benefits it supports.

The intention for the provision of on lot stormwater management is therefore to adopt a water balance based hydrologic regime which protects receiving streams from adverse flow characteristics whilst meeting or supporting existing rules defined by the RITS and WRC guidelines to achieve water quality and retention objectives.

1.2. Predeveloped hydrology

Prior to clearance of forests across the Waikato, rainfall was assimilated into the natural water balance which limited the frequency, volume and flowrate of surface runoff and enabled streams, the river and wetlands to be stable and support resilient freshwater biodiversity. Key components of this 'natural' condition are evapotranspiration and infiltration. The natural hydrologic regime supports baseflow within streams, recharges groundwater (and dependent ecosystems) and enables more stable flows within streams without rapid changes in flowrates which can cause ecological disturbance and scour.

Quantification of natural evapotranspiration rates are difficult to define as they vary significantly between soil types, vegetation types and seasons. In New Zealand research has been done but this typically looks at specific landcovers such as pasture, plantation pine or regenerating bush with limited data available for mature indigenous forest which were present in the area now occupied by Hamilton.

For the purposes of modelling, the following overall water balance objectives were targeted based on limited published data:

- Intercept and retain through combination of infiltration and reuse 60 – 70% of mean annual rainfall volume from full site. This mimics the natural interception of rainfall which does not discharge off site as overland flow.
- Intercept and retain (through non-potable reuse) 20 – 30% of mean annual volume from full site. This mimics the proportion of rainfall which does not naturally contribute to infiltration and is naturally evapotranspired to the atmosphere.
- Intercept through infiltration and reuse entire rainfall for 75 – 85% of all daily events (i.e. no surface water leaves the site in these events which approximate with daily rain events < 10 mm).
- Optimise rainwater tank size to meet 60 – 80% of modelled demand with the remainder to be supplied by reticulated mains water.

Through meeting the above flow metrics, it is shown that water quality and quantity metrics are also met at a lot scale without the need for more maintenance intensive devices such as lot scale raingardens. This will enable development to support a more distributed catchment-based approach to stormwater management which reduces the requirements for centralised downstream devices in existing urban areas where spatial constraints make this unfeasible without substantial investment to purchase private land for treatment.

1.3. Consideration of alternatives

Analysis undertaken and resulting recommendations have been based on seeking a best practical option (BPO) to mitigate potential adverse development impacts whilst also supporting a range of complementary benefits as discussed in the Stage 1 report. This has considered alternative ways to manage site generated stormwater and current practice supported by WRC. Specifically, we have considered the ability for water quality and quantity objectives to be achieved through measures which are able to be reliably delivered by the development community and effectively maintained by homeowners. These assets are also able to be monitored for compliance readily by either HCC or WRC to provide confidence in performance and city-wide compliance with any consenting requirements. It is noted that these assets will not be vested to HCC (or a water utility) and will remain the responsibility of homeowners, meaning that maintainability is a key consideration.

The recommended provision of on-lot rainwater reuse tanks and soakage is also scalable to the associated development, meaning that stormwater benefits will occur in sync with development activity avoiding the staging complexities with more consolidated devices servicing large catchments with a mix of

development timescales. This also reduces the risk of poorly implemented development activities (earthworks) impacting on completed stormwater devices which can easily be compromised by uncontrolled sediment discharges etc. The recommended approach is also intended to respond to a range of urban water quality stressors rather than focussing solely on metals and sediments which are increasingly managed through the use of inert building materials. In particular, the use of rainwater reuse and soakage can effectively manage impacts from elevated temperatures, dissolved oxygen, and wind blown contaminants.

Alternative means to meet existing and future water quality and quantity requirements were considered. These included alternate on lot devices (such as lot scale raingardens) or increased reliance of more consolidated treatment devices in the road corridor or public realm. Experience has shown that on lot raingardens can be problematic in terms of both construction and maintenance with low levels of functional compliance observed in areas where these have previously been mandated (Rotokauri).

Consolidated treatment devices located either in the road corridor or in suitable areas of open space are compromised for small scale developments due to challenges with getting stormwater to suitable treatment locations and ensuring that development is appropriately treated prior to dilution with groundwater etc. In existing urban areas, where infill redevelopment is anticipated, the lack of existing public land would likely necessitate the procurement of large areas currently used for housing to be utilised for water management which would be both expensive and contra to aspirations for increasing housing. These consolidated treatment devices are further complicated by the challenge with constructing stormwater devices in catchments where development activity will continue over an extended timeframe with risks of high sediment and construction related inputs which could adversely impact device function.

This more consolidated approach is currently ‘standard practice’ in large greenfield development areas which are often subject to Integrated Catchment Management Plans (ICMP) to align with WRC rules and policies. This often includes raingardens within streetscapes and large sub catchment scale wetlands. These devices often struggle to fully meet the intended retention volumes and in many instances can significantly increase the maintenance costs to HCC from large numbers of small scale raingardens. For large developments subject to development of ICMP’s the opportunities to develop holistic solutions at a larger catchment scale are realistic and achievable and, in the future, may also adopt more on lot rainwater reuse to meet future hydrology drivers.

This work and the proposed rules it informs are however primarily focussed on smaller scale developments where it is considered that the implementation of on lot measures is the most practical and reliable means of providing a robust level of environmental protection.

2. Computational Modelling

2.1. MUSIC model

Modelling was performed using the continuous simulation package 'Model for Urban Stormwater Improvement Conceptualisation' version 6.3 (MUSIC) (eWater, 2017). All models were run at a 5-minute time-step to describe the variability within a single rainfall event and to define rainfall runoff from impervious surfaces and flow rates through stormwater devices. Continuous simulation (as opposed to single-event simulation typically used in flood studies) describes the full range of runoff characteristics for a particular catchment over the simulation period, including antecedent conditions (length of preceding dry and wet spells) which have a strong influence on device performance. Outputs were then extracted at a daily timestep for reporting.

MUSIC enables rapid evaluation of multiple configurations of on lot devices to enable recommendations to be based on optimised performance. The model allows stormwater management strategies to be tailored to achieve particular outcomes, such as an approximation of the pre-development mean annual runoff volume.

2.2. Model inputs

In order to generate runoff information, MUSIC requires rainfall and evapotranspiration data, the surface area and imperviousness of land cover categories, pervious surface runoff parameters, and data on household water demand which in turn depends on daily per capita water use and dwelling densities. Model inputs were sourced from a variety of agencies and reports and are described below.

2.2.1. Rainfall and evapotranspiration

A continuous 5-year sequence of observed rainfall depths (2006-2010) from the Ruakura rain gauge (Ruakura EWS Climate Station), recorded at 5-minute intervals, was used as the rainfall input. Table 1 and Table 2 provide a summary of the annual rainfall data for the timeseries.

Table 1 Summary of annual/daily rainfall depths

Year	Annual Rainfall (mm)	Minimum (mm/day)	Mean (mm/day)	Maximum (mm/day)
2006	1,063	0.03	2.9	49.9
2007	941	0.05	2.6	42.5
2008	1,186	0.02	3.2	56.0
2009	1,142	0.06	3.1	59.5
2010	1,076	0.03	2.9	50.2

Table 2 Summary of rainfall depth exceedances

Year	Annual Rainfall (mm)	>1 mm	>5mm	>10 mm	>25 mm
2006	1,063	129	65	33	5
2007	941	125	60	30	3
2008	1,186	124	69	40	12
2009	1,142	133	69	40	7
2010	1,076	116	72	32	8
Average 2006 - 2010	**1081**	**125**	**67**	**35**	**7**

The annual average over the 5 year period (1,081 mm) and rain days exceeding 1 mm, compare well with the Hamilton – NIWA Climate Summary which reports a mean annual rainfall depth of 1,190 mm and an average of 129 annual rainfall days >1 mm for the period 1970 -2000.

Analysis of rainfall determined that a daily rainfall depth of 10 mm is only exceeded on 20% of days where rain occurs (i.e. 80% of daily rainfall events are less than 10 mm depth). 10mm of daily rainfall was therefore confirmed as the preferred baseline for retention on lot, as this aligns with the natural interception rate of 60-70% of mean annual rainfall volume which does not discharge off site as overland flow.

Mean monthly potential evapotranspiration (PET) depths were taken from the NIWA Climate summary totalled as monthly values.

2.2.2. Development assumptions

Input assumptions were developed in collaboration with HCC staff and based on assumptions adopted in other water planning work, industry standards and expected future development scenarios for urban intensification. Table 3 summarises the input parameters applied in modelling.

Table 3 Input parameters for lot development

Parameter	Modelled Input
Lot size	100 – 500 m^2
Building (roof) site coverage	50%
Total lot imperviousness	70%
Average population density	2.7 persons/dwelling
Average water usage	230 L/person/day
Internal non-potable use (Toilets & Laundry)	40%
External non-potable use	15%

Internal water demand (representing toilet flushing and cold laundry taps) were modelled as a constant demand applied evenly every day, whereas the external demand (representing garden watering and other outside applications) was applied to vary across the year based on monthly evapotranspiration and rainfall. This means that the external demand is greatest during summer conditions as anticipated for garden watering etc.

Models were built for the lots varying from 100 – 500 m^2 with nodes to represent the corresponding roof area, paved areas (to total 70% impervious) and pervious land cover (gardens and lawns etc). These were then tested with a range of tank sizes to determine the optimum configuration to achieve the intended site water balance.

2.2.3. Stormwater management devices

Based on a consideration of constructability and lifecycle maintainability, rainwater tanks and on lot soakage devices were the preferred solutions to evaluate and promote as the optimal solutions for private on lot devices. The following input assumptions were applied;

- Rainwater tanks modelled from 1,000 L to 5,000 L.
- Rainwater tanks modelled without any attenuation function (i.e. all captured water held and available for re-use).
- Rainwater tanks configured to overflow to soakage devices.
- Soakage devices configured to receive runoff from impervious areas plus overflow from rainwater tanks.
- Soakage modelled as 900 mm diameter porous manhole with depth optimised to achieve desired infiltration volume.
- Infiltration rate of 10 mm/hr modelled from base of manhole and from unlined perimeter.
- Size of soakage optimised to support target hydrology in an efficient manner.
- Overflow from soakage device to lot outlet and combined with runoff from pervious landcover.

Figure 2 shows the general arrangement for modelling.

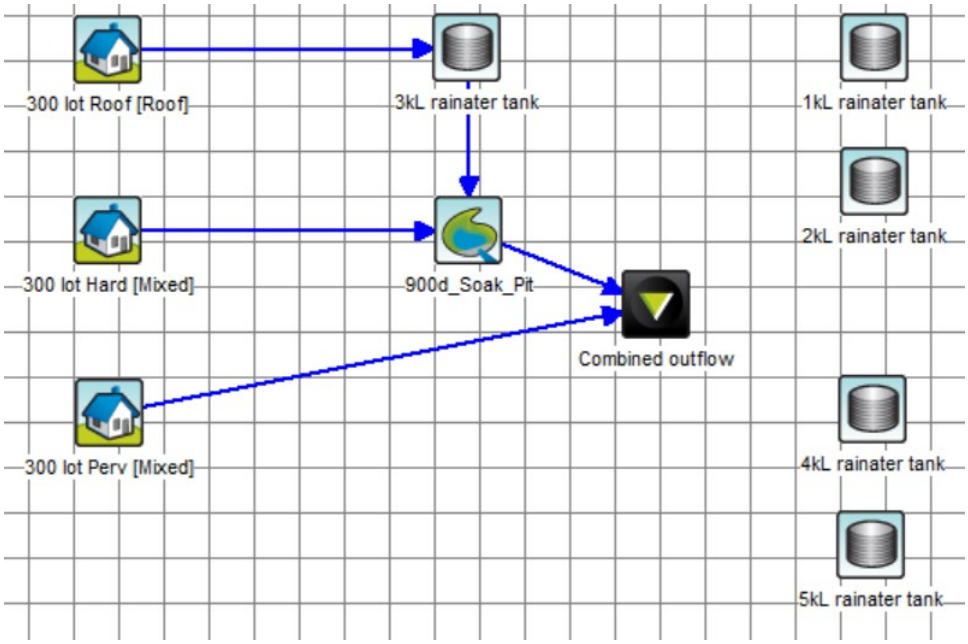

Figure 1 MUSIC model arrangement

Modelling of both rainwater tanks and soakage in series enables results to be considered in terms of both the overall reduction in stormwater volume and the proportion of this which is 'used' to replicate natural evapotranspiration. Modelling has therefore enabled the optimisation of rainwater tanks to meet reuse and soakage to optimise infiltration with the overall performance outcome at the lot scale a combination of the two.

3. Results

3.1. Model outputs

Models were run at a 5 minute timestep with outflows exported at a daily timestep for analysis. MUSIC exports a range of flow and water quality measures which can be interrogated at different points of the proposed treatment train. It is therefore possible to quantify how much flow is managed by the rainwater tank alone or as a proportion of the total lot and then quantify the performance when combined with the soakage.

Analysis was undertaken on exported daily outputs using Microsoft Excel. This included the extraction of data for days where rainfall occurred and statistical analysis to calculate percentage measures of average performance in terms of site hydrology. Consideration was given to optimisation of tank and soakage sizes to ensure that recommended sizes were efficient and were not subject to diminishing returns whereby an increase in tank size corresponds with only a marginal increase in volume reduction. The recommended tank sizes are therefore considered to represent an appropriate minimum tank size relative to roof areas but would benefit from being bigger should a homeowner want to increase the reliability of a non-potable supply or include a volume of detention storage above the required retention volume.

As discussed in section 2.2.3, on lot stormwater was analysed for the separate rainwater tanks and soakage and performance for the combined system in series also reported; these are discussed below.

3.1.1. Rainwater tank analysis

Performance data for rainwater tanks (only receiving roof runoff) was undertaken to determine optimised average tank sizes. Based on analysis a range of tank sizes are recommended to align with the objective to intercept and retain a portion of the initial 10 mm of rainfall depth on roofs (through non-potable reuse) with the combined benefit being equivalent to 20 – 30% of mean annual volume from the full site. This mimics the proportion of rainfall which does not naturally contribute to infiltration and is naturally evapotranspired to the atmosphere.

Table 4 summarises the optimal rainwater reuse tank volumes relative to total lot size.

Table 4 Recommended rainwater reuse tank volumes relative to lot size

Equivalent lot size (m^2)	Required tank volume (L)
100	2,000
200	3,000
300	3,000
400	5,000
500	5,000

It is important to note that due to the coincidental occurrences where tanks are full or near capacity when rainfall occurs there are times when retention of the full 10 mm from roof areas is not practical. Whilst this will generally coincide with a prolonged period of rain resulting in temperatures dropping and contaminants already being flushed off surfaces the inclusion of rain tank overflow to on lot soakage provides additional redundancy to achieve the full 10 mm retention for approximately 85% of all rainfall days. These residual days where on lot measures do not prevent site runoff are generally at times when periods of prolonged rainfall would have saturated shallow soils and vegetative storage and surface runoff to streams would be expected to naturally occur.

The proposed rainwater tank sizes are the basis of the acceptable solutions provided in the HCC on lot practice notes and the costings for the s32 analysis and are considered to support the practical attainment of 10 mm retention. Alternative approaches may still be developed by applicants where they can demonstrate a comparable level of performance.

3.1.2. Soakage analysis

Soakage was modelled to directly capture runoff from areas of hardstand (driveways and parking areas) and receive overflow from rainwater tanks for larger lots. Soakage was modelled based on a standard 900 mm diameter porous manhole (as per HCC Practice notes) and was optimised to achieve the target hydrology outcomes. This resulted in on lot soakage that was sized to accommodate 100 mm rainfall depth from the entire hardstand area and 1/3 of the dwellings roof area (which discharges to soakage via the rainwater tank overflow). The daily soakage volume is able to infiltrate to ground over a 24 hr period. Table 5 summarises the required soakage volumes to be achieved in combination with the rainwater reuse tanks.

Table 5 Recommended soakage volumes relative to lot size

Equivalent lot size (m^2)	Required soakage volume (L)
100	370
200	735
300	1,100
400	1.45
500	1,850

3.1.3. Combined on lot measures

Based on modelled results it is determined that a combination of rainwater tanks and on lot soakage can support the intended water balance outcomes for stream protection and align with the retention of the first 10 mm of daily rainfall. With smaller lots (100 m^2 and 200 m^2) the performance of rainwater reuse is limited by the size of the connected roof area with no tangible benefits from providing addition soakage to compensate for excess roof runoff. Therefore, these sites can substitute permeable pavement as hardstand rather than the need for soakage. Table 6 presents the recommended configurations for variable lot sizes.

Table 6 Proposed on lot solutions

Equivalent lot size (m^2)	Retention of roof	Retention of hardstand
100	Reuse tank only	Permeable paving or soak hole
200	Reuse tank only	Permeable paving or soak hole
300	Reuse tank and overflow	Soak hole
400	Reuse tank and overflow	Soak hole
500	Reuse tank and overflow	Soak hole

Based on modelling and the resulting sizes in Table 6 it is shown that the retention, partial reuse and soakage of 10mm of daily rainfall depth on impervious surfaces at a lot scale will retain 60 – 70% of mean annual rainfall volume onsite and provide a robust level of hydrological protection to stream systems.

3.2. Building/property extensions

The potential impacts and feasible mitigation measures for building extensions were also modelled. This could include the construction of home extensions (including detached structures) or increased hardstands through the expansion of driveways etc. Consideration was given to the practicality of requiring these changes to be managed through installation of rainwater tank with reuse, but it was considered that in many instances the connection to internal uses, such as toilet flushing, will be impractical and cost prohibitive. It is therefore suggested that any increase in impervious cover (roof or hardstand) through extension to an existing property is mitigated through on lot soakage sized to capture 10 mm rainfall depth for at least the entire area of increased imperviousness. Any overflow will need to connect with approved reticulated stormwater. An exception is where increased hardstand comprises permeable pavement in which case no mitigation is required.

For a $25m^2$ impermeable surface extension, 250L of retention would achieve the intended water balance outcomes, which can be achieved with a 400 mm deep, 900 mm diameter porous manhole.

4. Discussion

4.1. Sensitivity testing

The modelling on proposed on lot measures is based on a number of assumptions and development scenarios which are intended to represent a range of 'average' scenarios which are realistic and support a clear and unambiguous rules framework in the District Plan to support development activities. Particularly with the use of rainwater tanks for reuse these assumptions and scenarios have direct influence on the performance. Key assumptions and scenarios tested include:

1. Catchment area (i.e. the roof area connected to tanks)
2. Storage (i.e. the rainwater tank volume)
3. Demands (i.e. the reuse demand which is directly related to the number of persons in dwellings and the assumed usage)

Sensitivity testing for variability in these inputs is complicated by the number of potential scenarios which in reality could play out in future developments. For example, increasing the roof area without changing the tank size or demands will increase the volume of rainfall captured per rainfall event and therefore increase the reliability of being able to service the demands. However, where the tank is already optimally sized for the connected roof and household demands, this change may only be marginal and may not compensate for the overall increased stormwater volume resulting from the increased catchment. Similarly reducing the number of assumed people in a dwelling (without change to other variables) will increase the reliability of meeting these residents demands but will reduce the overall volume reduction for the property as a whole.

It is therefore concluded that the proposed 'averages' provide a robust and realistic position which is in line with other HCC planning and should enable situations where assumptions differ to be moderated overall at a sub catchment or city wide scale.

4.2. On lot detention

The integration of peak flow attenuation (detention) on lot is not captured within the modelling undertaken for on lot retention. Where detention was a requirement, this would need to be included (likely through increased tank size or additional detention only tanks either above or below ground depending on site grades) in addition to the required volume for retention purposes. This is to account for the potential for the target peak rainfall event (typically 10% or 1% AEP) to occur at the same time as on lot reuse tanks are full and therefore unable to accommodate further inflows. It is however noted that at many times across the year excess volume is available within the tank. This effectively results in excessive redundancy whereby attenuation tanks remain empty whilst still requiring ongoing maintenance. Technological advancements in places such as Australia are now applying accurate real time weather forecasting and telemetry to enable retention tanks to be drawn down when peak rainfall events are expected. This approach negates the issue with redundancy and is likely to be available in the New Zealand market in coming years.

Further, the benefits of lot scale detention can often be complicated by the position of developments within a catchment and risks associated with coincidental peaks which can be worsened where detention in the lower portions of catchments results in flows coinciding with the arrival of peak flows from the upper areas of catchments. It has therefore been recommended that uniform on lot stormwater detention is not included within the District Plan with a preference for any requirements to be more robustly

informed by known flooding problem areas or network capacity limitations. The ecological benefits of detention are often overstated and with the preference for retention, these benefits are optimised through managing hydrology for the small to moderate rainfall events (approximately 80% of daily events).

4.3. Water Quality

Whilst typical urban surfaces (roofs and hardstands) generate less contaminants than high trafficked public roads, carparks or commercial buildings, they are still a source of contaminants (in particular wind-blown) and a range of other potential adverse impacts from temperature and water chemistry. It is therefore important to manage on lot generated stormwater for water quality in addition to water quantity.

The proposed approach to capture roof and hardstand water and retain on site, enables these contaminants to be managed through a combination of diversion to wastewater and removal through pre treatment sumps prior to soakage. Further reductions of any contaminants which persist in discharge to soakage will be achieved via passage through soil. Therefore, the retention of achievable stormwater volumes can be used as a proxy for contaminant removal.

On this basis, it is considered that a minimum of 60 – 70% of all site generated contaminants will be removed (in terms of load) and other development related contaminants (such as temperature) will be comprehensively mitigated. This is considered to be highly conservative estimate given that the proposed on lot measures will be most effective at capturing first flush runoff (particularly following sustained dry periods where contaminant build up will occur) and overflow events represent either prolonged rainfall events or back to back events when most contaminants could be considered to have been 'washed off' surfaces. It is therefore suggested that actual annual contaminant load reductions will be greater than 70% and will be an improvement on existing conditions.

Whilst analysis of pre and post development was not undertaken (due to the substantial variability of existing site coverage on lots prior to infill development) it is suggested that the residual contaminant loads following the proposed on lot measures will be substantially less than in the existing case and will represent a viable means to improve water quality in accordance with Te Ture Whaimana. For example, based on a post developed scenario of 70% total site coverage as per Table 3 and inferred 70% contaminant removal, the residual load discharging off the property would be the equivalent of that generated by the same lot with only 20% site coverage without the inclusion of any on lot measures. It is considered that the vast majority of existing lots across Hamilton have a site coverage of greater than 20%.

It is also noted that any residual contaminant discharges could be further mitigated through subsequent downstream consolidated treatment devices such as sub catchment scale wetlands which could initially be designed for reduced areas of redevelopment and progressively become less 'critical' as more of the contributing catchments are redeveloped with on lot provisions in line with these requirements.

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FINAL REPORT

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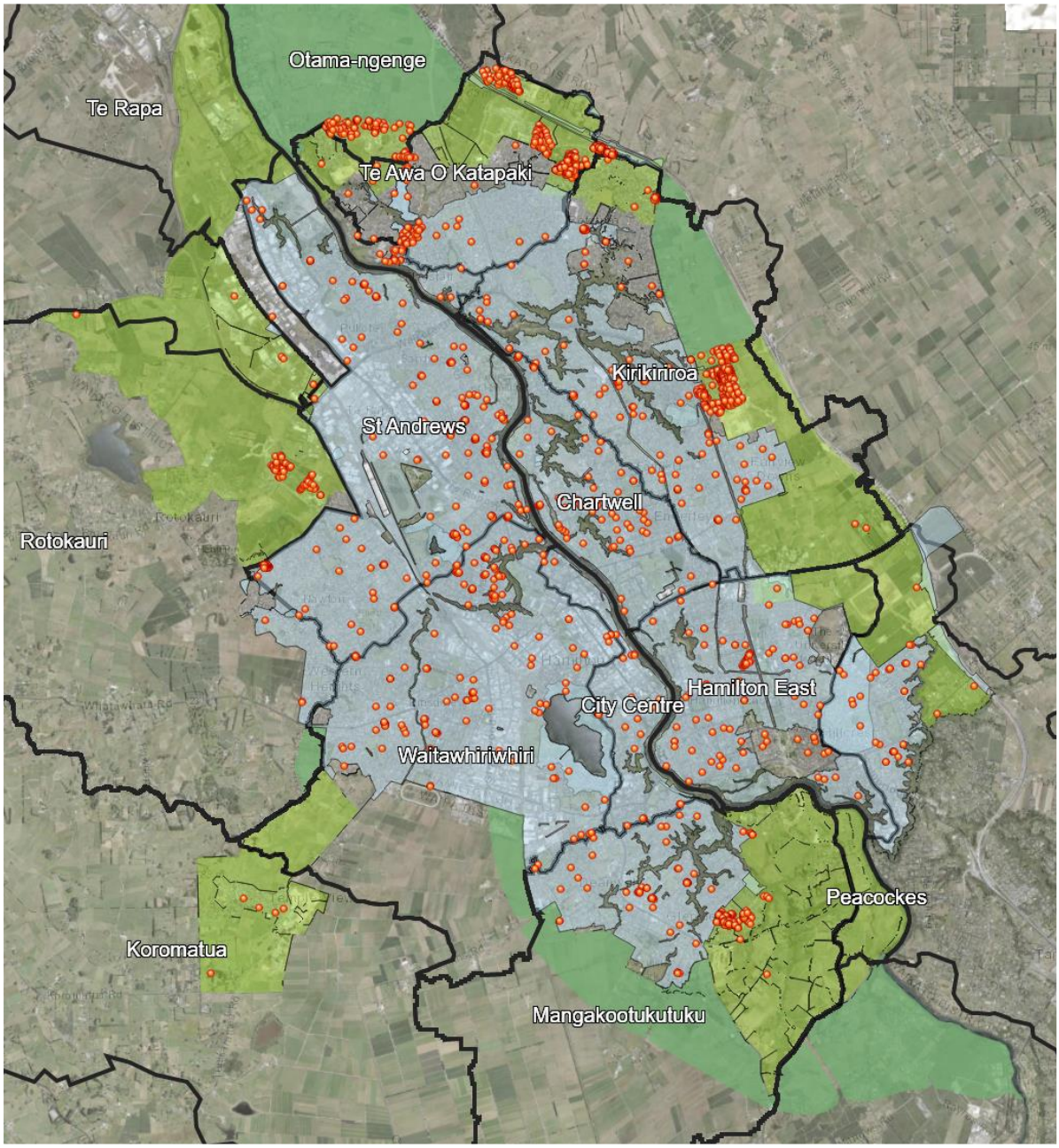
Recommendations for Inclusion of On-Lot Stormwater Management Measures

Prepared for Hamilton City Council

Prepared by SCO Consulting Ltd & Morphum Environmental Ltd

07 June 2022



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1 Executive Summary

HCC are in the process of confirming specific strategies and options to address stormwater management issues across the wider Council service area, including greenfield areas subject to development and infil/re-development of brownfield areas. Specific drivers include:

- Management of stormwater quality and quantity as required to enable the vision and strategy of Te Ture Whaimana o te Awa o Waikato
- Compliance with the conditions of the Comprehensive Stormwater Discharge Resource Consent (CSDC)
- The HCC Stormwater Bylaw 2021
- Recommendations developed as part of HCC's Stormwater Master Plan v2
- A recent assessment of issues and gaps identified as part of the District Plan stormwater rules review and proposed amendments process

One of the key strategies assessed by HCC for managing stormwater going forward is the continued application of on-lot options as a cost-effective means of mitigating effects and enabling waterway outcomes to be achieved over time. On-lot options are devices which are implemented on private property to enable management of stormwater runoff at source, before it enters the public drainage system and natural waterways. These devices serve to mitigate the effects of changes to natural stormwater processes of absorption, evaporation and runoff – mainly caused by development activities including the addition of impervious surfaces. These changes result in both quantity and quality effects to the natural waterways systems.

HCC have extensive experience with the application of on-lot devices across the Hamilton service area, primarily in greenfield development areas. The existing District Plan rules and technical guidance documents provide requirements and specifications for a number of typical on-lot devices including:

- Rain tanks
- Soakage pits
- Permeable pavement
- Rain gardens
- Detention storage

Experience to date shows that while there are issues and gaps in the current process of implementing on-lot stormwater devices – evidence clearly shows that they form an effective part of a stormwater treatment train if designed, implemented and maintained properly. In some cases, on-lot options provide the only practical means of mitigating stormwater quality related effects, particularly in high density developed areas where space for centralised systems is limited or does not exist. Options such as reuse rain tanks also provide other parallel benefits beyond stormwater effects management. HCC engaged SCO Consulting and Morphum Environmental to conduct a detailed assessment of current practices to determine if on-lot stormwater options should continue to be required for development activities, and if so what changes in policy and technical practices should be made to enhance the value of these devices.

SCO and Morphum have completed a detailed assessment of:

- current HCC on-lot stormwater management practices including District Plan rules and supporting technical practice notes;
- specific on-lot options based on HCC's experience to date;
- relevant case study best practice from other councils and stormwater utilities; and
- optimised on-lot device configurations and performance specifications using detailed simulation models and sensitivity testing around key variables such as the size of rooftops, water reuse demand rates, rain tank volumes, etc.

SCO and Morphum have presented their findings and recommendations to HCC staff, and based on a collaborative process of challenges and reviews the following key conclusions have been agreed regarding on-lot stormwater management options:

1. On-lot stormwater devices should continue to be required as part of a holistic strategy to mitigate stormwater effects resulting from development and re-development activities. This includes development in greenfield areas, and re-development of existing brownfield areas. This recommendation is supported by HCC's experience to date, evidence from relevant case studies, and detailed technical assessments of optimised on-lot device configuration to achieve cost-effective stormwater performance measures in line with enabling Hamilton's waterway outcomes.

2. On-lot stormwater devices comply with HCC's best practicable options (BPO) test in that they are:
    a. Practically implementable and maintainable – as proven by numerous examples across Hamilton and other Councils in New Zealand – as well as overseas
    b. Required to give effect to Te Ture Whaimana o Te Awa o Waikato, aligning with the agreed vision of "a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come"
    c. Provide benefits beyond just the management of stormwater including reducing the use of potable water for non-potable uses, enhanced resilience to climate change effects, and raising community awareness and care through opportunities for education and re-connection with natural stormwater processes.
    d. Align with other key drivers including WRC requirements and existing
    e. Are considered best practice across New Zealand and overseas in Countries like Australia, the United States, and the United Kingdom

3. HCC should continue to register and spatially record on-lot options as they are implemented, and use the results of the ongoing pilot inspection programme to confirm how on-lot options will be periodically assessed to ensure target performance measures are continually met. This could include the application of a "warrant of fitness" process in the future which would certify that on-lot options continually meet targeted performance measures.

4. Changes to current District Plan rules are recommended to address issues and gaps for current on-lot stormwater management requirements. Specific changes which are recommended include:
    a. All new developments, regardless of the size, will require retention of the first 10mm of runoff occurring in any 24-hour period for impermeable surface areas (e.g. rooftops, driveways, other hard stand areas, etc.). Note that this is a change from the current requirement of a single 'water efficiency measure' which includes one of three options, of which detention is the most common, but does not address water quality.
    b. All re-developments will require retention of the first 10mm of runoff occurring in any 24-hour period for additional impermeable surface areas added, and when the total new/redeveloped impermeable areas exceed 50% of the existing impermeable area, 10mm retention will be required for 20% of existing areas and all of the new areas added.
    c. Additional on-lot measures beyond a 10mm retention minimum requirement may be required when:
        i. The existing conveyance network is capacity constrained, and other measures such as detention or soakage for up to a 10 year ARI event are feasible.
        ii. Developments occur in areas where an ICMP has been developed. The ICMP will provide details on all requirements.
        iii. Developments are of a larger/more significant scale, triggering the need to develop either a site-specific stormwater assessment or an ICMP.

5. Technical analysis including detailed modelling and sensitivity testing has resulted in the following agreed recommendations for specific on-lot options to best achieve a 10mm retention requirement:
    a. **Rain re-use tanks** – implementation of rain tanks in greenfield and brownfield areas across New Zealand, Australia and overseas has rapidly accelerated over the past decade primarily due to water supply resilience issues and the need to reduce potable water demand. Rain re-use tanks capture runoff from rooftops and supply this water for flushing toilets, garden irrigation and laundry. While recent studies in New Zealand have concluded that rain tanks alone do not eliminate drought risk, this ignores the wider benefits they do provide including:
        i. Reduced water demand
        ii. Retention of stormwater runoff from rooftops
        iii. Elimination of stormwater first flush contaminants from rooftops
        iv. Community awareness and re-connection to rainfall/runoff processes – as opposed to "out of sight, out of mind" when stormwater simply disappears down a drain
    b. **Soakage pits** – Overflows from reuse rain tanks can be connected to soakage devices to feasibly achieve a 10mm retention requirement. Soakage pits have proven to be cost-effective to implement and maintain, and by having rain re-use tanks ahead of them first flush contaminants can be removed for rooftop runoff. Soakage pits can also be used for runoff from ground level hard surfaces such as driveways, and pre-treatment for this runoff can be achieved with basic catch pit ahead of the soakage pit.
    c. **Pre-treatment** – pre treatment of stormwater in the form of first flush diversion or in-line sumps may be required to mitigate contaminant risks and to enhance long-term performance of on-lot measures.
    d. **Other measures** – Other measures such as permeable pavement can be considered on a case by case basis to achieve the 10mm retention requirement, and specific technical guidance is provided for this in HCC practice notes and the RITS.

6. The typical cost for installation of a rain re-use tank including materials and installation is approximately $10,000. Rain tanks are now fabricated in a number of shapes and sizes, including "slimline" ranges which easily fit into small properties in high density urban areas.

7. The typical cost for a soakage pit to be installed is $3,000 to $4,000.

8. Permeable pavement cost is approximately $240/m2, or around $90/m2 more expensive than standard concrete driveways.

Figure 1 on the following page provides an overall illustration of the recommended on-lot option configuration to achieve 10mm retention for new development and re-development of existing properties, as well as other intervention measures which will be implemented by HCC. This includes a rain reuse tank connected to an infiltration soakage device via an overflow arrangement.

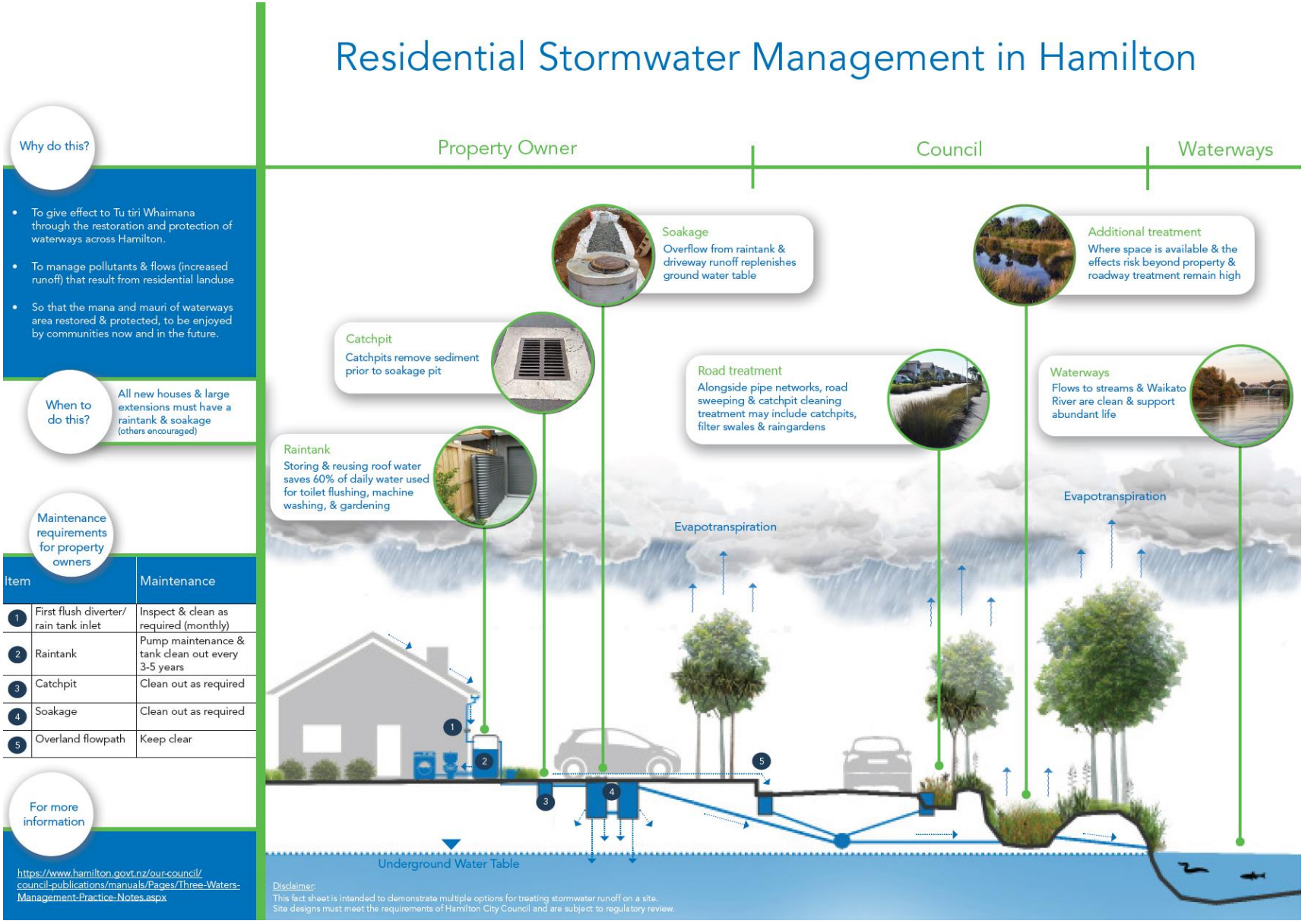

Figure 1 - General overview of stormwater on-lot management options

In summary, the following key points are provided to answer a fundamental question of "why should on-lot stormwater management measures be required going forward?":

1. Detailed technical analysis confirms that a minimum requirement of retention of the first 10mm of rain occurring every 24-hour period can be practically achieved for new development and re-development sites.
2. Retention of 10mm of rain provides the following water quality benefits:
    a. Significant reduction of contaminants associated with the 10mm first flush runoff from impermeable surfaces. Many of these contaminants (e.g. heavy metals) are highly toxic to waterway ecosystems and are extremely persistent once they get into the environment.
    b. Reduced effects of changes to natural waterway patterns resulting from development activities, including elevated temperature of water running off of warm impermeable surfaces and stream hydraulic pattern changes in frequently occurring rain events.
3. On-lot options are the preferred initial "line of defence" for management of stormwater pollution for both greenfield and brownfield developments/re-developments. In some cases, particularly in dense brownfield areas, on-lot options provide the only feasible means of mitigating stormwater quality effects due to limited space for other larger scale public treatment systems.
4. Field inspections and modelling confirms that a combination of rain reuse tanks and infiltration soakage devices can achieve a 10mm retention requirement for most days of the year. Furthermore, following extended dry periods when rain tanks are empty retention of up to the first 25mm of rain is possible – and it is during these drier periods that the additional retention is most beneficial in terms of contaminant capture and protection of waterways with lower assimilative capacity. This can reduce the required size of downstream treatment devices and in some cases reduce or eliminate the need for stormwater retention along roadways.
5. On-lot options such as rain reuse tanks provide community benefits beyond the management of stormwater quality effects, such as reduced potable water demand for non-potable uses (e.g. toilets, laundry, garden irrigation, etc.).
6. By implementing on-lot requirements using best practicable options, HCC is leading the way for stormwater best practice measures and aligning with the vision and strategy of Te Ture Whaimana o Te Awa o Waikato.

2 Purpose of Report

This report is primarily intended to answer the question "Should on-lot stormwater devices continue to be required as part of an overall treatment train to mitigate water quality effects on Hamilton's waterways?". And secondary to this, if the answer is yes, what performance measures should be required in the revised District Plan rule and what practical options could achieve the agreed requirements? To answer these questions HCC engaged SCO and Morphum to:

- conduct a detailed assessment of Hamilton's current on-lot stormwater practices including field investigations of existing on-lot devices
- assess relevant case studies from other councils on best practice for on-lot measures
- complete detailed technical analysis including modelling to confirm specific on-lot measures and particle options which can be implemented to achieve these measures
- support HCC in the assessment of existing District Plan rules to identify gaps for on-lot option requirements and revise the rules to address any gaps
- develop recommendations for actions going forward based on the conclusions reached from the above work scope

3 Overview and Context

HCC engaged SCO Consulting and Morphum Environmental to conduct a detailed assessment of current practices to determine if on-lot stormwater options should continue to be required for development activities, and if so what changes in policy and technical practices should be made to enhance the value of these devices. HCC's existing rules,

policies, technical guidelines and options for on-lot stormwater management are extensive and based on a considerable body of experience, expertise and best practice experience. However, HCC and their consultants have confirmed that further work is needed to refine stormwater management on-lot rules, technical details, options "toolbox" and the supporting implementation/monitoring approach for delivery of agreed outcomes in both greenfield and brownfield areas. In terms of managing stormwater effects, brownfield areas are more complex than greenfield development areas due to such issues as:

- Legacy of high-risk pollution sources due to the age of previous development and lack of historical stormwater pollution controls/management
- Higher density of pollution generating sources (e.g. cars, older rooftops, etc)
- Smaller scale developments meaning broader stormwater management rules and consent requirements not triggered
- Prevalence of less experienced developers with less understanding of emerging practice in stormwater
- Limited space to implement public stormwater treatment systems
- Higher cost of retrofit solutions (working in built environments = higher construction cost)
- Impact of "urban waterways syndrome" making outcomes harder to achieve without a comprehensive treatment train approach working within the constraints of brownfield areas

As such policies, rules and technical guidance developed to address stormwater management needs in brownfield areas require careful consideration of the challenges and risks to ensure outcomes are achieved with practical, affordable and maintainable measures. Inclusion of on-lot options and requirements in greenfield areas is equally important to ensure that development results in no further degradation of waterways or existing stormwater asset performance.

HCC, along with most Councils across New Zealand and stormwater utilities overseas, have confirmed that a multi-barrier approach in the form of a treatment train is required to deliver agreed outcomes for urban waterways and receiving environments. In Hamilton this includes existing open streams (gully systems), the Waikato River, lakes/wetlands and tributaries which have historically been piped. The first part of the treatment train typically consists of on-lot measures which serve to control any discharge of stormwater into the public system aligned with targeted water quality effects measures. It is important to note that on-lot generated stormwater can impact stream, lake and river quality through the generation of contaminant loads (e.g. heavy metals) and/or changes to runoff patterns that disrupt natural waterway flow patterns. Examples of typical effects for unmitigated on-lot stormwater generation include:

- Disruptions/changes to natural runoff and groundwater processes which impact stream flow patterns including peak and base flows. These changes can have a substantial impact on ecosystem health and result in other effects such as erosion and degradation of amenity values. These effects are a function of both the volume and rate of stormwater discharge from contributing areas.
- Contaminants such as bacteria, heavy metals, sediments, etc are present in on-lot stormwater runoff from various sources, and if not mitigated are released into natural waterway environments where they can greatly reduce the ecological health and other associated values. Once these contaminants are released into the environment, it is much more difficult and expensive to mitigate the effects – and in many cases is no longer feasible. Therefore mitigation of contaminants at source through on-lot measures is not only cost effective, in some cases it is the only viable option if public stormwater treatment systems are not viable due to such issues as available land space. Even when public stormwater treatment systems are present, on-lot measures can serve to improve their performance by addressing first flush contaminants.

This means that on-lot control rules and requirements must consider both quantity and quality measures.

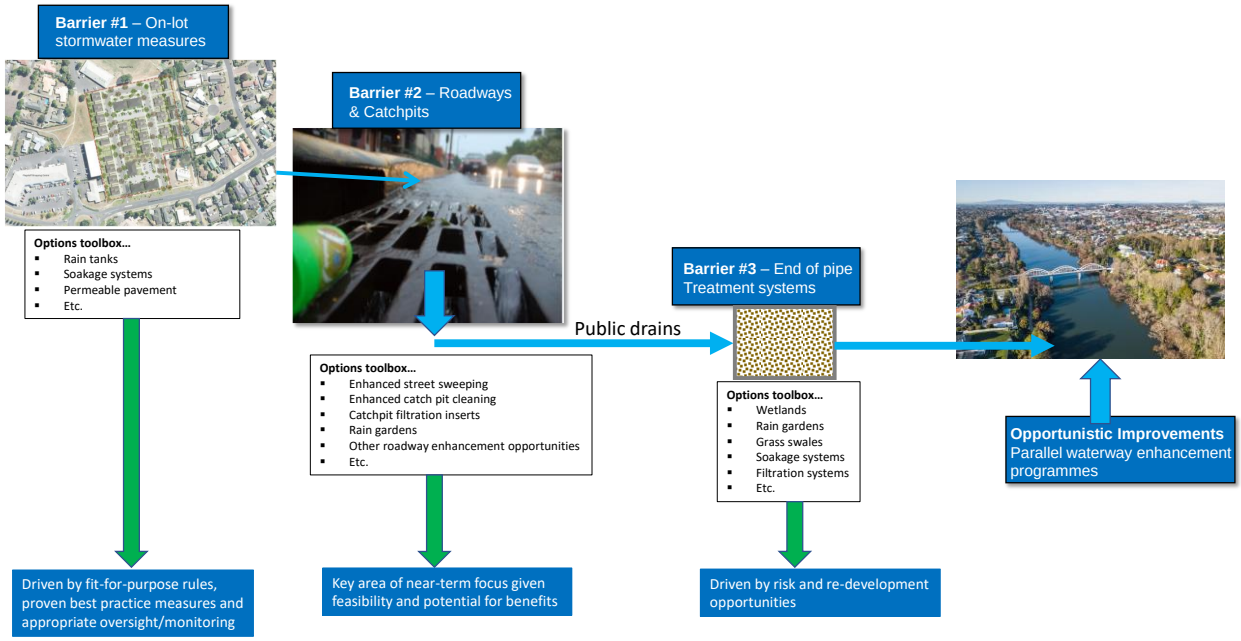

Figure 2 - HCC Brownfield Stormwater Treatment Train Approach

The objective of this report is to verify the need for inclusion of on-lot stormwater measures in the greenfield and brownfield areas of Hamilton, and to provide HCC with recommendations for enhancing the existing on-lot programme to ensure targeted waterway outcomes and the vision and strategy of Te Ture Whaimana o te Awa o Waikato are achieved. To date, technical work has been completed to analyse various configurations of on-lot measures which has confirmed the recommendation of a 10mm retention requirement through the use of rain reuse tanks in combination of soakage pits. A summary of the analysis is included in this report (see Section 4.3). This work will inform the development of specific technical on-lot options configurations, as well as refinement of technical practice notes and guidance for the selection, design, installation, and ongoing monitoring of on-lot stormwater management options.

4 Summary of Key Drivers for Consideration of On-lot Option Recommendations

The following provides a summary of key drivers which have been considered in the development of recommendations for on-lot stormwater options.

- Infill development will increase the impervious land cover in already stressed catchments
- Increased roof/paved areas will be a source of contaminants which will be discharged to public SW networks
- Increased impervious surfaces will result in increased stormwater volumes and significantly increased flowrates in small to moderate rainfall events which would otherwise be subject to evapotranspiration and/or infiltration
- Limited public space exists in existing urban areas for the retrofit of centralised stormwater management devices to manage public and private stormwater
- Land values are increasingly prohibitive for HCC to strategically purchase private land to develop sub catchment scale stormwater management assets
- HCC has limited capacity to undertake increased maintenance of stormwater management devices
- Opportunity to use expected increase in urban intensification as means to address historical mis-management of stormwater and better align with Te Ture Whaimana o te Awa o Waikato and NPS-FM
- Opportunity to use on-lot private stormwater management devices as tool to inform and educate communities on connection between urban development and natural environment
- Opportunity to integrate other co-benefits such as community resilience and enhanced water efficiency management

5 General Recommendation for Inclusion of On-Lot Stormwater Measures Going Forward

As shown in Figure 2 above, HCC have confirmed that a multi-barrier approach to addressing stormwater pollution effects is required to achieve agreed long-term waterway outcomes inclusive of giving effect to Te Mana o te Wai and Te Ture Whaimana o te Awa o Waikato. In some cases, where it is practical and feasible, all barriers may be required in the form of a treatment train to meet targeted waterway outcomes. HCC and their supporting consultants have confirmed that an essential component (i.e. the first barrier) of the stormwater treatment train is the inclusion of on-lot stormwater option requirements going forward. The recommendation for inclusion of on-lot stormwater options is based on the following evidence:

- Best practice experience from other councils and stormwater utilities – in New Zealand and overseas
- Conclusions reached from detailed stormwater master planning completed by HCC
- Assessment of data gathered from sampling and modelling work completed by HCC and their consultants
- Experience with on-lot options implemented to date as discussed below
- Given the spatial and financial constraints of public stormwater management in brownfield areas (retrofit), in some cases on-lot options may be the only practical means of controlling stormwater discharge to prevent downstream effects from occurring
- Case study experience shows that certain on-lot options (e.g. reuse rain tanks) provide a highly effective means of eliminating first flush stormwater contaminants from the environment whilst providing other benefits for the community that go beyond stormwater management

More specifically, SCO and Morphum have completed technical analysis which confirms that 10mm of stormwater retention for all new developments and additional impermeable areas added with re-developments is recommended as a minimum performance measure. Details of this technical analysis (see Section 6.3 below) have been presented to HCC, resulting in a confirmed recommendation of 10mm retention requirement best achieved by a combination of rain reuse tanks and stormwater soakage pits.

As stated previously, HCC and their consultants have a considerable body of experience with on-lot stormwater options. In recent years HCC have facilitated the implementation of numerous on lot stormwater measures in both green and brownfield areas. These measures have included various options such as soakage systems, rain gardens, and rainwater reuse/detention tanks. Figure 2 below shows a map of known on-lot stormwater devices located in greenfield and untreated brownfield areas, generally those added since 2017 when on lot measures were required through the District Plan, and recording of them started. More information about implementation of on-lot measures is available in building consent documentation where further details are recorded. In addition, HCC have developed a series of detailed technical practice notes which provide guidance on on-lot stormwater requirements, options selection/technical design criteria, etc. The Regional Infrastructure Technical Specifications (RITS) have been adopted by the Hamilton City Council in June 2018, but the elements have been in use by HCC since at least 2003 through previous versions (e.g. Development Manual, ITS). The RITS sets standards for design and construction of public infrastructure (vested to HCC) and is intended to provide clarity and consistency for contractors, developers, and consultants in the Waikato region. It includes standards for earthworks, transportation, water, wastewater, stormwater, landscapes, and accepted materials – and specifically the required standards for stormwater on-lot options. The RITS therefore provides good guidance for new greenfield developments and large scale brownfield developments but is less aligned with requirements for smaller redevelopments of existing urban land including infill developments. With the current pressures on the New Zealand housing market and the directives from central government to facilitate increased intensification of urban centres there is a clear need to ensure that the expected significant increase of infill development does not adversely impact on freshwater values or place unrealistic burdens on HCC to mitigate impacts from infill development via centralised public infrastructure. The current lack of stormwater treatment in existing urban areas would necessitate the expensive purchase of currently private land for construction of public stormwater devices such as constructed wetlands. In June 2020, HCC completed version 2 of their system wide Stormwater Master Plan which identified catchments across the city which currently discharge to stormwater treatment, this identified the lack of treatment in the majority of existing urban areas (grey shaded

areas in Figure 2 below) other than recent greenfield developments which are considered less likely to be subject to infill in the short to medium term.

Based on this body of experience and robust evidence, HCC are now working with their consultants to enhance the benefits of on-lot stormwater measures implemented in areas subject to development and re-development. This includes the District Plan rules, technical guidance provided and ongoing inspections/monitoring to ensure on-lot devices perform to meet defined quantity and quality measures.

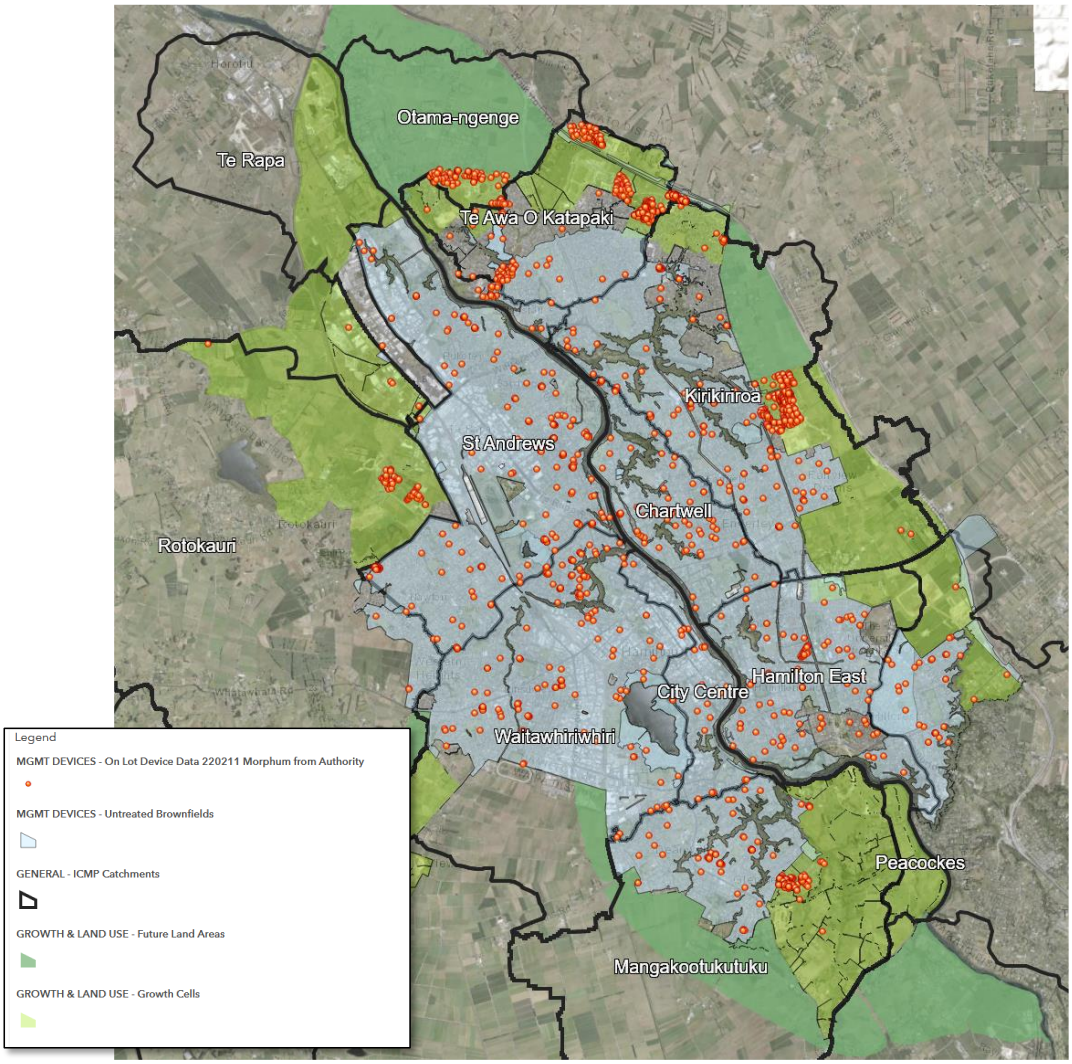

Figure 3 - Existing on-lot stormwater devices

6 Specific Recommendations for Enhancement of the Existing On-Lot Programme to Address Brownfield Issues

As stated in Section 2 above, HCC's extensive experience with existing on-lot stormwater management options provides a basis for enhancing the value that can be derived from implementing them in brownfield areas going forward. The following provides a summary of recommended changes to current practices for implementation and long-term oversight of on-lot stormwater options. These recommendations draw from experience within the

Hamilton area, as well as relevant case study experience from other councils including best practice and key lessons learned.

6.1 Relevant case study examples and lessons learned

The following provides a summary of relevant on-lot stormwater management case study experience from other councils which has informed the recommendations developed for changes to HCC's current on-lot stormwater management practices.

6.1.1 Auckland Council

As part of the development of Auckland's Unitary Plan, region-wide stormwater management rules were implemented "to protect and enhance Auckland's rivers, streams and aquatic biodiversity in urban areas" given that "values are threatened by the effects of ongoing urban development." This resulted in the adoption of control measures defined by two types of stormwater management areas – Flow 1 and Flow 2 (aka SMAF1 and SMAF2).

- Flow 1 are those catchments which discharge to sensitive or high value streams that have relatively low levels of existing impervious area. This would essentially encompass greenfield development areas.

- Flow 2 areas typically discharge to streams with moderate to high values and sensitivity to stormwater, but generally with higher levels of existing impervious area within the catchment.

The objectives and policies are then defined on the basis of development activities being located in a SMAF1 or SMAF2 area, including the discharge consenting activity status and provisions set forth in the stormwater bylaws. These rules pick up on development and re-development in brownfield areas, and include requirements for on-lot stormwater measures driven by stormwater quantity and/or stormwater quality measures.

Technical requirements and guidelines for management of stormwater in development and re-development activities are provided in Stormwater Management Devices Guide (*GD01*) and Water Sensitive Design Guide (GD04). These documents provide specific details around stormwater quantity and quality requirements for any development activities (residential, commercial, industrial), including roadway corridors and parking lots. They are aligned with Unitary Plan requirements and the Auckland Stormwater Bylaw.

The following provides a summary of key findings for Auckland Council's on-going on-lot device implementation and oversight programme.

- Auckland Council not only requires the use of on-lot stormwater devices, they give priority to it as per the following statement in the GD01 document:
  "Managing stormwater at source where possible: The overall preference is for stormwater to be managed as close to source as possible. This requires careful consideration of the wider use of smaller devices (such as rainwater tanks, pervious paving, swales and rain gardens) in preference to larger devices such as wetlands. These at-source devices are most efficient at improving water quality and reducing runoff flows and volumes from frequent short- and medium-duration events but may incur more maintenance costs over the life of the device."

- Auckland Council promotes a treatment train approach for management of stormwater in brownfield areas, but offer the following recommendation in terms of the hierarchy of management options:
  "Reducing stormwater contaminants and flows at source where possible, is generally considered a more efficient and cost-effective method of reducing adverse effects than end of pipe solutions."

- Key drivers and benefits linked to on-lot stormwater management options include
  - Reducing pollution and erosion, protecting marine and freshwater systems, reducing flooding, and allowing urban development while preserving and restoring land and waterways
  - "In addition, the water sensitive design approach encompasses liveability objectives including cultural significance, connected and empowered communities, biodiversity, enhanced public green space and healthier waterways."

- "Some of the key pollutants associated with stormwater include sediment, nutrients, bacteria and viruses, oil and grease, total and dissolved metals, organics, pesticides and gross pollutants. An additional impact of

urbanisation is an increase in water temperature."

- "Managing water quality also requires an understanding of the "first flush" where the initial runoff from a surface contains (by volume) the highest proportion of contaminant load compared to runoff in the remainder of the storm. Best practice for water quality improvement therefore promotes the capture and treatment of the first flush, where practicable, as this is often more practical and cost effective than treating flow volumes from the entire storm event."

- While water quality target measures are focused on high contaminating generating car parks and roads, many of the recommended on-lot options serve to reduce contaminants as well as manage stormwater discharge quantity (e.g. reuse rain tanks, rain gardens, permeable pavement).

- Development and re-development activities which add any impermeable area trigger requirements to manage site stormwater runoff - and the requirements are defined for the SMAF1 and SMAF2 areas.

- Redevelopment which adds impermeable surfaces must provide stormwater management options to address the added impermeable areas. If redevelopment results in a site exceeding 50% total impermeable area, then management options must address all impermeable surfaces – not just the surface added.

- On-lot devices considered acceptable for managing stormwater include rainwater tanks (with reuse), bioretention systems, living roofs, permeable paving, and infiltration devices.

- Redevelopment stormwater management in SMAF1 and SMAF2 areas requires retention of the first 5mm of runoff for added impermeable areas, unless redevelopment exceeds 50% total impermeable area and then retention of the first 5mm must be provided for all impermeable surfaces (existing plus additional).

- Redevelopment stormwater management in SMAF1 and SMAF2 areas requires detention as follows:
    - SMAF1 – detention of the 95th percentile rainfall = post development runoff volume – pre-development runoff volume – retention volume
    - SMAF2– detention of the 90th percentile rainfall = post development runoff volume – pre-development runoff volume – retention volume

- Most recently Auckland Council are promoting/encouraging the uptake of rain tanks in the central urban areas for existing properties and re-development activities. This aligns with Watercare's water efficiency strategies around reducing use of potable water for non-portable needs. As an incentive Auckland Council have now waived the cost to get a resource consent for rain tanks in brownfield areas. Further incentives may be developed to include waiving building consent fees. Uptake of rain tanks in Auckland can result in immediate customer benefits for reduced water and wastewater bills given that all properties have water meters.

- Experience in Auckland shows that further steps are required to ensure the long-term performance of on-lot measures. While requirements are in place regarding ongoing operations and maintenance of on-lot devices, it is understood that there is insufficient funding and resources to drive an effective compliance monitoring and testing programme.

6.1.2 Hastings District Council

Hastings District Council currently requires on-site stormwater detention for residential development/re-development which is triggered when the total impermeable area exceeds 50%. They provide an on-line calculator to determine the amount of storage needed, and the size of the outlet orifice for the detention storage. The following provides an example of a residential detention storage requirements using the HDC on-line calculator:

- Section size = 450 m2
- Roof area = 200 m2
- Driveway area = 30 m2
- Other hard stand area = 50 m2
- Total impermeable area = 62%

- Detention storage volume required = 1000 L
- Restricted outlet flow rate = 0.8 l/s, tank orifice outlet diameter = 15mm

Hasting District Council are now in the process of lodging their new stormwater discharge consent, and as part of this looking at enhancements to on-site/on-lot options to better address stormwater quality and quantity management issues.

6.1.3 Wellington Water

Wellington Water (WWL) manage stormwater networks for local councils across the region including Wellington City Council, Porirua City Council, Hutt City Council and Upper Hutt City Council. Public assets remain in the ownership of constituent councils with WWL being responsible for the planning, delivery and operation of public stormwater assets and approvals for land developments which connect to the public reticulated network. Greater Wellington Regional Council (GWRC) are responsible for regulation around freshwater outcomes. Historically the region has had very limited clear policies and rules relating to urban stormwater management with the result being unmitigated stormwater discharge from even large developments and significant adverse impacts on urban streams including habitat loss, sediment transport and degraded water quality. Consents for operative stormwater discharge are only captured by GWRC via earthworks consents triggered at 3,000 m2 with very limited oversight of smaller infill and redevelopment of smaller projects. Recent works by GWRC to align with NPS-FM has resulted in a number of recommendations relating to the need to improve the implementation of urban water initiatives including on lot management of stormwater.

WWL do not require on lot stormwater management for environmental outcomes but do have clear requirements for what is termed 'hydraulic neutrality'. This term effectively only covers peak flow control with a requirement to meet pre development peak flowrates for 10% and 1% AEP events. 'Approved solutions' to meet the targeted peak flow requirements are documented in the guideline Managing Stormwater Runoff (2020). This includes general sizing and specifications for either lot scale rainwater detention tanks or below ground modular detention tanks. These are both attenuation tanks only and are not intended to support environmental outcomes and in practice have potential to result in adverse outcomes due to extending the duration of moderate events with resulting in stream scour and ecological stressors (including transport of contaminants). Rainwater detention tanks will typically be between 2,000 and 5,000 l and are suggested to include 15%-25% as retention storage but there are no requirements for this to be connected to any specific non potable re-use demands so in practice is likely to only support resilience during loss of water supply events (such as large earthquake) and in most instance will effectively reduce the detention volume achieved. Anecdotally, an increasing number of developers are choosing to not use lot scale approved solutions and are opting for consolidated detention in underground modular systems and oversized pipe chambers. Work is currently underway to investigate the benefits on on-lot retention tanks (with connection to internal non potable demands) which will include consideration of both water quality and quantity benefits.

Requirements for developments to meet GWRC water quality outcomes (which are themselves not currently well defined) have increasingly resulted in consolidated water quality treatment devices (raingardens/wetlands) which are typically vested to councils (public) although there is push back from some councils which results in a need for private ownership via body corporate arrangements or similar.

6.1.4 Kapiti Coast District Council

Kapiti Coast District Council (KCDC) is not included within WWL but is part of GWRC jurisdiction in terms of water quality requirements.

KCDC is subject to extensive population growth and identified the significant risk to water supply (including dams and groundwater) and wastewater management as a result. This triggered extensive investigations to look at options to either increase water supply sources or reduce demands. This identified that residential water use was especially high and that measures to mitigate this could reduce the need to develop additional water supply sources such as catchment dams.

These investigations resulted in the following;

- Implemented district wide water metering and volumetric charging

- Implemented district wide program to repair private and public water leaks (prior to charging coming into effect)
- Update District Plan to include requirements for rainwater tanks with reuse and/or on lot greywater management

The District Plan presents two minimum acceptable solutions which are required on all new dwellings. These are either;

a) 10,000 litre rainwater storage solution, connecting to all toilets and outdoor taps; or

b) 4,000 litre rainwater storage, connecting to toilets and outdoor taps and a greywater diversion device to on lot soakage.

This means that all dwellings (regardless of roof area) have either a 10,000 or 4,000 L tank. Water quality benefits of the use of on-lot rainwater collection and retention are not typically measured although GWRC considers it when looking at consents for operative stormwater discharge. Anecdotally there has been only limited resistance to the requirements for on lot rainwater tanks but there is also limited understanding of the ongoing levels of compliance or performance.

Traditionally KCDC has also supported deployment of other private stormwater measures including on-lot soakage (in free draining sands) and shared stormwater ponds. In the case of ponds these were often developed in response to a need to raise ground levels above designated flood extents with ponds dug as a source of sand fill and integrated with flood detention requirements which engage footprint above permanent open water ponds. These ponds often receive inflows from a number of adjacent properties and in many instances the public reticulated network as well. Ponds are located within private properties (generally multiple) with ongoing maintenance obligations on these private landowners. In recent times water quality has been observed to be in decline in many of these and it has been recognised that the lack of provision for effective maintenance (often with no formal access even provided) is an ongoing significant risk.

6.1.5 New South Wales

As a result of the severe droughts in New South Wales, re-use rain tanks have been essentially mandated for new and redevelopment for the past several years. The key drivers are around water and energy efficiency targets. BASIX or Building Sustainability Index is a scheme introduced by the government of New South Wales (NSW), Australia in 2004 to regulate the energy efficiency of residential buildings. This resulted in a substantial increase in the implementation of rain re-use tanks, primarily driven by compliance requirements. In discussions with NSW water service providers, it is understood that key lessons learned include the following:

- Mandating re-use rain tanks without a robust community education programme increases the risk that rain tanks will not be maintained over time as their value is not fully understood.

- Specified rain tank water reuse pumps were oversized, expensive, difficult to maintain and had a significant impact on annual energy bills.

- Registration of rain tanks along with a warrant of fitness programme and required compliance monitoring funding would greatly reduce the likelihood of rain tank operational failures over time.

The following provides a summary of the current NSW rain tank programme.

<u>Water Tank Requirements in New South Wales</u>

The NSW Government has implemented residential building requirements that aim to deliver sustainable water and energy, known as BASIX. BASIX assessment is required for:

- new buildings that consist of one or more dwellings
- conversions of an existing building to a building that consists of one or more dwellings
- additions and/or alterations to buildings that consist of one or more dwellings with an estimated work cost of $50,000 or more

- swimming pools with capacity of 40,000L or more.

BASIX aims to achieve a 40% reduction on the consumption of potable water against the state benchmark. Rainwater harvesting systems are a great way to achieve BASIX certification for your proposed development. Rainwater collection is assessed based upon:

- the capacity of the rainwater tank being installed
- roof catchment area that will be connected to the rainwater tank
- how the tank water is used
- running overflow from your rainwater tank to another tank for collection and re-use.

In NSW you must also comply with the development regulations articulated in the State Environmental Planning Policy. Many specific requirements are provided depending upon whether your rainwater tank in installed above or below ground. Some of these include:

- plumbing your tank into your house and/or interconnecting to mains water needs to be carried out by a licensed plumber
- your water tank cannot be placed on the footing of an existing building
- screening against mosquitoes and other insects breeding inside is ensured
- the overflow of the tank is connected with an existing stormwater drainage system
- the water tank is placed in the rear yard, behind the building line
- protection against vermin entering the water tank is ensured
- protection against ingress of stormwater and ground water if the tank is partially or completely buried in the ground is ensured.

6.2 Addressing gaps in current policies, rules and guidelines

HCC have engaged SCO and Morphum (along with other experts) to review the existing policies, rules and guidelines for on-lot options against stormwater management needs in the brownfield areas. This includes the existing District Plan, Stormwater Bylaw and relevant technical practice notes – as well as consideration of WRC policies and views towards the use of on-lot devices. Figure 3 below provides an overview of the current on-lot stormwater management framework with identified gaps in brownfield areas (in red text). HCC are now in the process of developing proposed revisions to District Plan stormwater rules and enhancing technical practice notes to eliminate gaps for brownfield areas. This includes detailed technical assessments of specific on-lot stormwater option typologies to further define required quantity and quality measures.

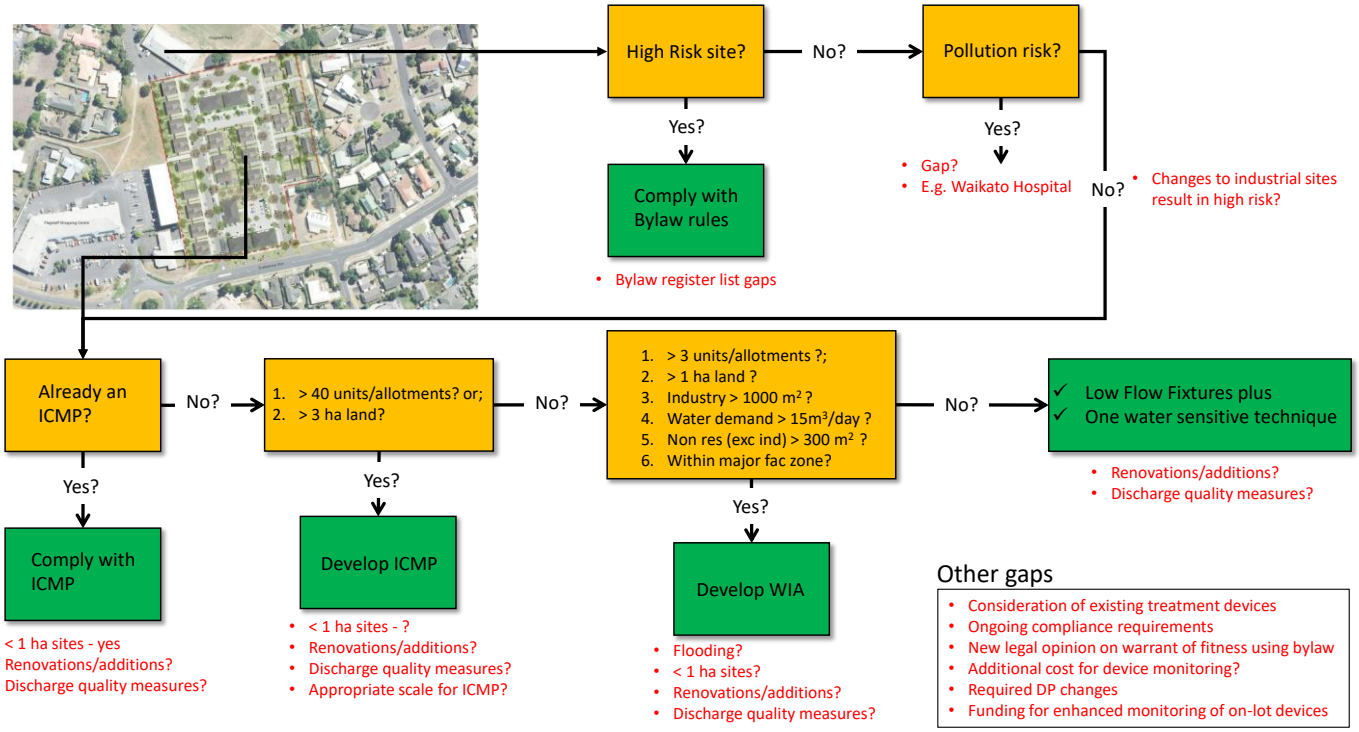

Figure 4 – Development and re-development stormwater on-lot management requirement gaps

Our gaps analysis of existing District Plan rules resulted in the following key conclusion – which are currently being implemented in proposed rule changes:

- Measures to address developments less than 4 units
- Measures to address re-development of existing site which adds additional impermeable area
- Minimum retention requirements for all development and re-developments regardless of size

Through detailed discussions, workshops and supporting technical analysis HCC, SCO and Morphum confirmed the following proposed changes to the District Plan rules to address gaps and incorporate recommended on-lot measures.

a. All new developments, regardless of the size, will require retention of the first 10mm of runoff occurring in any 24-hour period for impermeable surface areas (e.g. rooftops, driveways, other hard stand areas, etc.).
b. All re-developments will require retention of the first 10mm of runoff occurring in any 24-hour period for additional impermeable surface areas added, and when the total new/redeveloped impermeable areas exceed 50% of the existing impermeable areas, 10mm retention will be required for 20% of existing areas and all of the new areas added.
c. Additional on-lot measures beyond a 10mm retention minimum requirement may be required when:
    i. The existing conveyance network is capacity constrained.
    ii. Developments occur in areas where an ICMP has been developed. The ICMP will provide details on all requirements.
    iii. Impermeable surfaces are larger than 1,000 m2 in total area, triggering a consent and the need to develop either a Site-Specific Stormwater Management Plan or an ICMP.

6.3 Technical work to confirm target performance measures and refine on-lot options "toolbox"

The attached Morphum Technical Summary Report contains hydrological analysis undertaken to quantify and validate provisions for the management of site generated stormwater within private lots, to address potential for adverse environmental outcomes close to source and reduce the requirements for large, consolidated stormwater treatment systems to manage impacts from private developments. That modelling shows that the retention and partial reuse of 10mm of daily rainfall depth on impervious surfaces at a lot scale will retain 60 – 70% of mean annual rainfall volume

onsite, and achieve a minimum of 20% reduction in mean annual runoff volume for the total lot. This closely aligns with the estimated rainfall interception and loss (evaporation) in a natural catchment condition.

Figure 5 below provides an illustration of options which form HCC's on-lot options toolbox to meet site discharge performance measures.

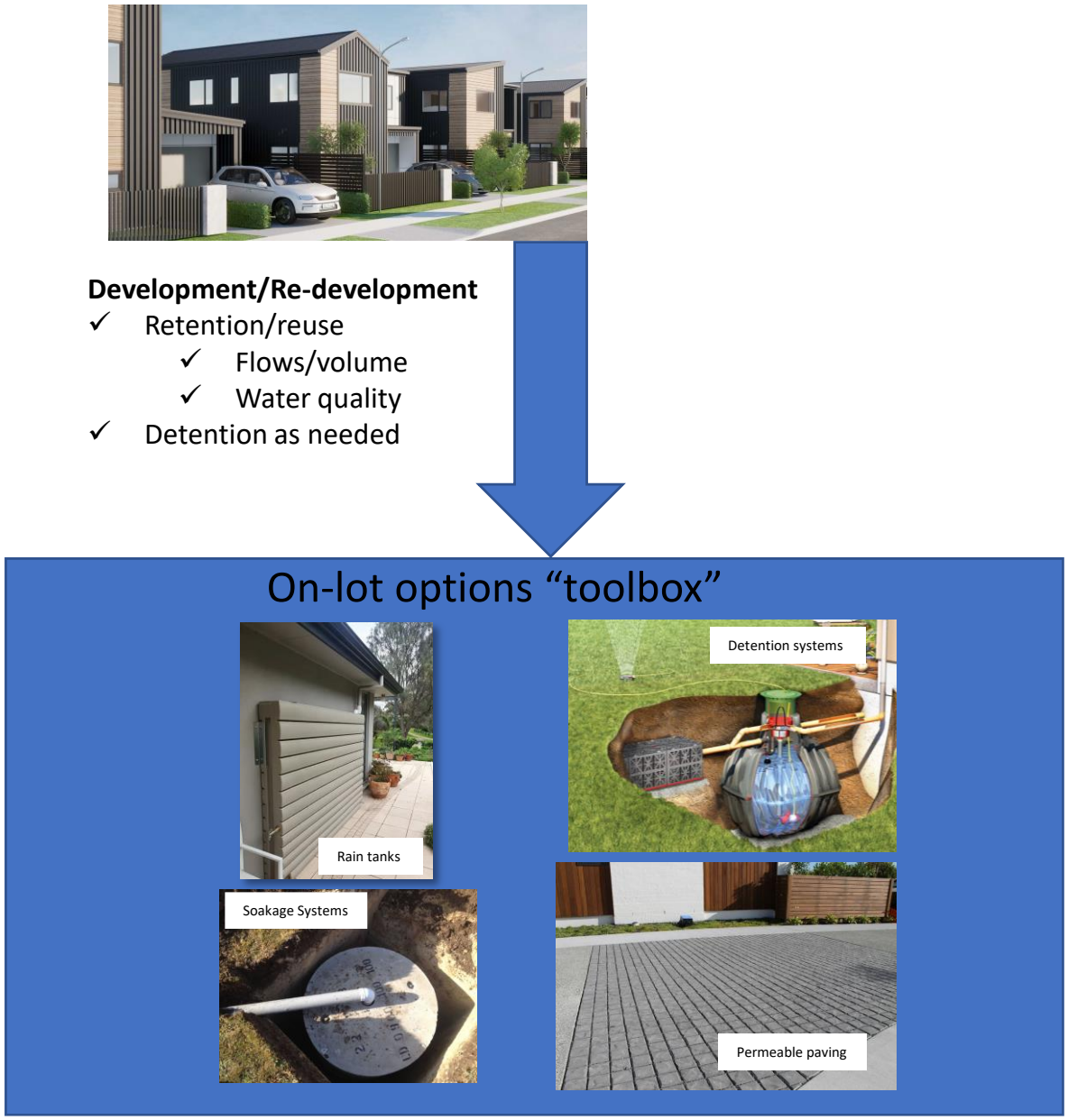

Figure 5 – On-lot Options Toolbox

6.4 Summary of On-Lot Option Cost Estimates

Cost estimates for a typical lot and roof size have been developed and are presented on Table 4 below. These estimates should be used as an approximate guide only, as local site conditions and other market influences will impact the actual cost on each property.

Table 1 - Summary of cost estimates for various on-lot stormwater options

Lot Size (m2)	400	
Roof Size (m2)	200	
Driveway Size (m2)	60	Assumed to be 50% of remaining impervious area (80% total impervious)

Item	Cost (ex GST)	Source
Soakage (1 manhole 1.8m deep)	$3,100	Average of 2 drainlayer quotes (2021)
Soakage (2 manhole 1.8m deep)	$4,350	Average of 2 drainlayer quotes (2021)
Soakage (3 manhole 1.8m deep)	$5,600	Assumed from above rows
Rain tank	$10,500	Wainui 2014 study & Beca raintank study (5,000L tank) Cost from Wainui study = $10,300 (assuming 10y escalation at 4%) Cost from Beca study = $10,500
Permeable Paving	$89	Per m2 rate, based on increase from concrete Concrete assumed to be $150/m2 Permeable paving assumed to be $238.5/m2 based on average of 'high' and 'low' TAC from Sue Ira work
Detention tank	$5,000	Approximate estimate

Option	Description	Total Cost	Comments
Baseline'	Detention tank	$5,000	
1	Soakage only - roof & external surfaces	$5,600	Assumed 3 manholes
2	Roof soakage + permeable paving	$9,660	Assumed 2 manholes + permeable paving
3	Rain tank + external surface soakage	$13,600	Assumed tank + 1 manhole
4	Rain tank + permeable paving	$15,810	

6.5 Other Barriers and Issues to Address

6.5.1 Alignment with WRC goals and objectives

HCC are in the process now of working with their consultants to confirm how on-lot options will result in compliance with WRC stormwater management requirements, such as requirements beyond 10mm retention and consideration of the presence of downstream treatment devices (or lack thereof). HCC and their consultants are now in consultation with WRC to confirm technical aspects of on-lot options performance measures, as well as the process for ongoing inspection and compliance assessments. The objectives are to ensure:

- that WRC are in agreement on the use and benefits of on-lot options as part of an overall treatment train approach for cost-effective stormwater management
- that HCC can meet the conditions of the stormwater discharge consent as issued by WRC

6.5.2 Installation and ongoing compliance monitoring to ensure performance measures are met

HCC and their consultants have conducted preliminary assessments of existing on-lot stormwater management systems and have identified potential issues with maintaining targeted performance requirements. Some of the key issues identified impacting the status and performance of on-lot systems include:

- Ability to observe that performance has degraded
- Efficient access for inspections and maintenance
- Disruption/displacement of on-lot options resulting from property ownership change and/or site modifications
- Lack of consistent/ongoing inspections and compliance monitoring to ensure on-lot options meet required stormwater discharge measures

To address this, HCC have initiated a pilot programme to inspect/audit 50 on-lot systems this year and to use the results to confirm an ongoing inspection/audit programme and inform changes to how on-lot options are designed and registered – including a warrant of fitness which would need to be renewed periodically. Initial investigations have resulted in the following conclusions:

- Rain tanks appear to be working well, and in general the community member who have them are positive about them.
- It is important that soakage systems are not buried and that access remains available for maintenance and inspections.
- There are many issues with on-lot rain gardens in terms of the design and maintenance (or lack thereof), and in many cases they are likely not meeting the intended functional performance measures.
- Education and awareness are a crucial part of ensuring ongoing performance measures are met. For example a system of QR code signs deployed for on-lot devices may be an effective way to highlight the presence of on-lot devices – and link them to information on recommended inspections and maintenance.

6.5.3 Funding and resources

Planning, implementing and monitoring effective on-lot stormwater measures will require additional resources and funding to ensure targeted outcomes are achieved and maintained over time. Figure 6 below provides a summary overview of the key steps to implement and manage an effective on-lot stormwater programme. HCC are now in the process of developing/confirming the scope of each of these steps including required resources and funding, as well as options for various funding mechanisms.

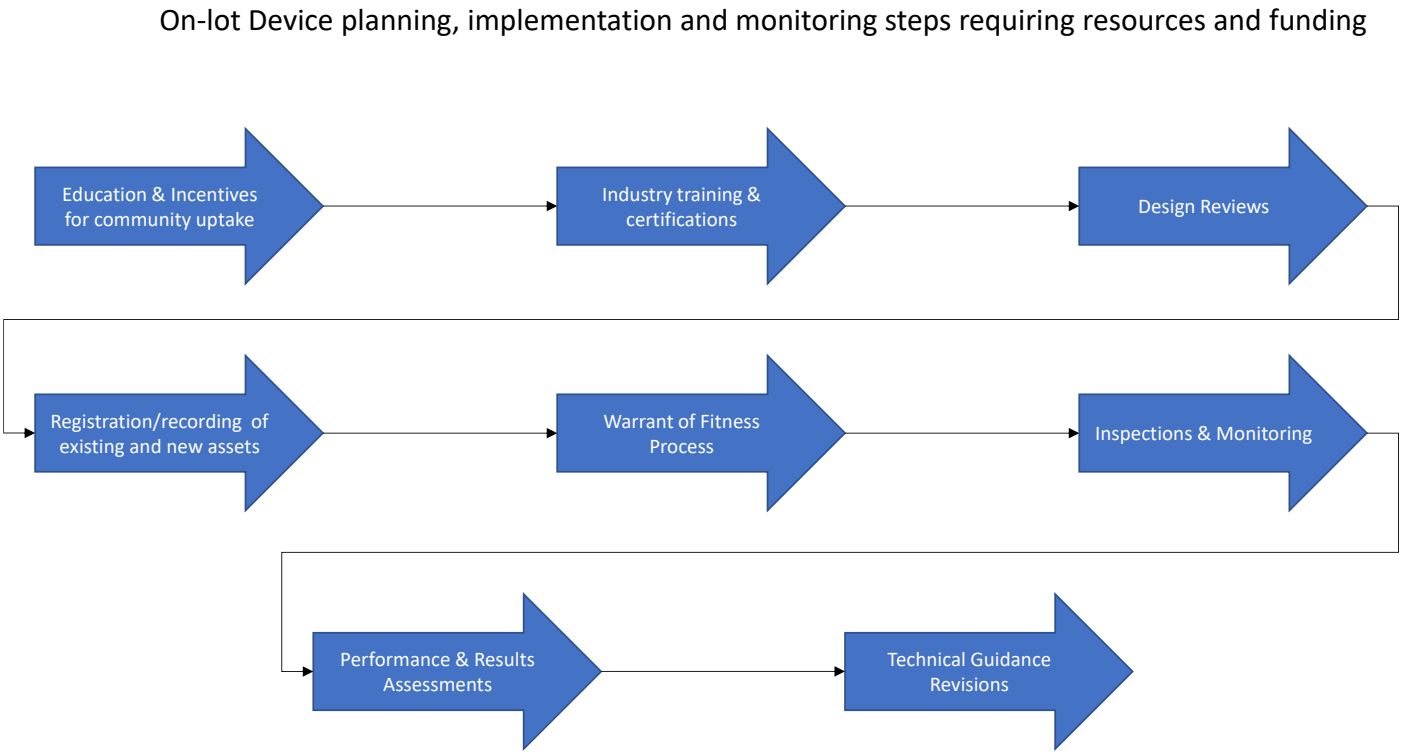

Figure 6 - Steps for on-lot device programme management requiring resources and funding

6.5.4 Community engagement, education, and incentive strategies

As per other experiences across New Zealand and overseas, a crucial element to the success of on-lot stormwater programme is implementing an effective community engagement and education programme. Community engagement involves working collaboratively with members of a community to effect change. It is important because it builds trust and leads to better decisions and outcomes, by fostering richer ideas for strategies and solutions. The more that a community understands and connects with the needs and benefits for managing stormwater on-lot, the more they will be incentivised to support the programme and ensure long-term success.

The Corporative Research Centre (CRC) for Water Sensitive Cities based in Australia conducted extensive research on the role and benefits of a robust community engagement and education programme to increase interest and support for stormwater management – including uptake of on-lot options. The following summarises their key findings:

- Understanding methods of community engagement is as important as the engineering and science. Engagement establishes effective and productive relationships to enable a shared understanding or commitment to change.
- C**ollaboration**, **co-design** and **co-governance** techniques require careful planning, but they are powerful game changers in transitioning to water sensitive cities.
- Community engagement is essential if we are to transition large cities and communities, and achieve the water sensitive cities vision.
- Understanding knowledge awareness and behaviours (water literacy and champions) in your community will give context, shape objectives and lead to successful projects.
- It is important not to assume pre-existing knowledge and to make information relevant for the target group.

Figure 7 below was developed by CRC as a result of their research on the benefits of developing and implementing a robust community engagement and education programme.

Figure 7 - CRC study on the benefits of community engagement and education

7 Summary of Recommended Actions

The following provides a summary of key recommendations and actions.

- Include on-lot options as part of the overall stormwater management treatment train for Hamilton.
- Complete technical analysis to confirm on-lot stormwater management measures, and to refine supporting practice notes and options implementation guidance.
- Complete ongoing consultation with WRC and other key stakeholders to confirm an agreed approach for ongoing implementation of on-lot options, including specific technical requirements beyond a minimum of 10mm retention.
- Confirm an agreed approach for how on-lot options are registered and inspected to ensure performance measures are continually met.

- Refine District Plan rules to address existing gaps, and to enhance the value of on-lot options through more targeted requirements that are based on practical stormwater management measures.
- Utilise results of ongoing pilot inspections/audit project to enhance how on-lot options are designed, implemented and monitored to enhance the long-term performance and resulting benefits.
- Confirm scope, resources and funding required to address the key steps illustrated on Figure 6 above.