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Waikato District Council

Report for Tamahere Catchment

Stormwater Catchment Management Plan

March 2011

INFRASTRUCTURE | MINING & INDUSTRY | DEFENCE | PROPERTY & BUILDINGS | ENVIRONMENT

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1. Introduction

1.1 Brief

The Waikato District Council (WDC) has commissioned GHD to prepare the Stormwater Catchment Management Plan (SWCMP) for the Tamahere Catchment, for the following reasons:

- To support the Proposed Waikato District Plan –Tamahere Country Living Zone (TCLZ);
- To be implemented into the Structure Plan for Growth and Development in the Tamahere Country Living Zone;
- To guide Council and developers on stormwater requirements for both the present and future zoning conditions; and
- Inform stakeholders and the community on the stormwater management principles and practices that are to be applied and provided in the area.

The plan is to:

- Establish the spatial, historical and regulatory context of stormwater management in the area;
- Provide an overview of the drainage system and catchment runoff;
- Provide an understanding of the potential for flooding under future development;
- Provide an holistic view of how stormwater runoff impacts upon the environment;
- Identify management options to remedy, avoid or mitigate the effects of excess runoff; and
- Produce an Implementation Plan outlining work elements, responsibilities, timing and costs.

1.2 Scope of Plan Preparation

The work undertaken to develop the SWCMP's for the Tamahere Catchment includes:

1.2.1 Establishing the Area of Extent

Define the boundaries of the drainage area.

1.2.2 Study of Previous Reports

The Variation 1 to Proposed Waikato District Plan - Tamahere Country Living Zone document 13 August 2005, Bloxam Burnett Oliver (V1-TCLZ/BBO) has been referenced for this study.

1.2.3 Identification of Catchment Characteristics

Catchment characteristics within, or draining through, the drainage system were identified. The catchment characteristics identified were:

- Area;
- Slope;
- Vegetation cover;
- Zoning;
- Potential zoning;
- Groundwater occurrence;

- Soils; and
- Geology.

1.2.4 Field Assessment of Natural and Built Drainage Systems

Inspection of the public drainage system to assess:

- Current condition;
- Potential for erosion;
- Potential for blockage; and
- Overall capacity.

1.2.5 Estimation of Flows

Estimation of flows through the catchment for the 10 and 100-year Average Recurrence Interval (ARI) rainfall events for the catchment under the following scenarios:

- Maximum zoning imperviousness (MPD) permitted under the WDC District Plan for the 10 year ARI; and
- Maximum zoning imperviousness with and without climate change allowance (MPD+CC) for the 100 year ARI storm event based upon the Ministry for the Environment (MfE) July 2008 Guidelines.

1.2.6 Consultation

Consultation and discussions were undertaken with;

- WDC Council officers on previous historical knowledge of flooding in the catchment;
- Environment Waikato on information on soakage in the catchment; and
- A number of local residents nominated by WDC for historical knowledge on catchment issues.

Information on soakage and flooding hotspots was obtained through the consultations and discussions.

An initial draft model of the catchment was developed to identify flooding hotspot areas for use in the consultation and discussions.

1.2.7 Prioritisation of Improvement Works

Although there appears to be limited reticulated stormwater pipe systems in the catchments, there are many local minor open channels (too small in size to be picked up in the LiDAR information) in the catchment that are not mapped or incorporated in the WDC database. It is unclear whether any of these are public drains or overland flow path systems. Some new assets have been found during site visit (eg road drainage systems), which have not been included in the existing asset database provided by WDC. Minor open drains have been assumed to be blocked in the larger storm events. The results of this study are subject to further collection of asset data in the catchment.

It is proposed to undertake a survey of the stormwater assets in the catchment to map significant minor open drains and pipe networks in areas that are predicted to be flood prone. Upon collection of stormwater asset attributes the current model can be used to determine management options to mitigate flooding, and hence prioritisation of improvement works.

Priorities under this study are based upon the following criteria:-

- MPD Imperviousness;
- Overland Flowpath Availability;
- Depth of flooding;
- Risk Hierarchy (Personal Safety, Habitable Buildings and Property Damage); and
- The rate of Catchment Development.

1.2.8 Management Strategies

This SWCMP recommends strategies for stormwater management, including priorities for improvement works, which will be subject to the Annual Plan process. Priorities may change through that process and this plan should be updated to reflect any changes.

1.3 Objective

The objective of this SWCMP is to:

1. Comply with all relevant current National legislative requirements, Regional and Local Authority policy, plans, strategies, bylaws and statements.
2. Provide plans within the document that indicate the following: -
   – Drainage System;
   – Reticulated Public Stormwater Network Layout; and
   – Flood Hazards (Natural and Man-made eg detention ponds).
3. Produce the document in a user-friendly format for the end users. Council envisage that the users of the document will be:
   – WDC and EW Monitoring Officers;
   – WDC Customer Delivery Officers;
   – WDC Development Engineer(s);
   – WDC Water and Facilities Group;
   – Members of the public;
   – Consulting Engineers, Surveyors and Planners; and any
   – Other stakeholders.
4. Provide database of information in GIS format.

1.4 Statutory Framework

Council is required to play an active role in the stormwater management of the District by virtue of the Local Government Act 2002 (LGA) and the Resource Management Act 1991 (RMA).

1.4.1 Local Government Act 2002

Under the LGA, Council must provide all drainage works necessary for the efficient drainage of the area under its control. Council is required to make assessments of stormwater for all residents and communities in their district.

1.4.2 Resource Management Act 1991

The RMA requires Council achieve the integrated management of the effects of the use, development and protection of land.

The catchment modelling and the SWCMP will assist Council in meeting its responsibilities under these two Acts, which include the promotion of sustainable management of natural and physical resources through:

- Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonable foreseeable needs of future generations;
- Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and
- Avoiding, remedying, or mitigating any adverse effects of activities on the environment.

Measures available to Council to achieve the desired outcomes are controls on:

- Restrictions relating to earthworks and vegetation removal;
- Limitations on activities associated with subdivision; and
- Imposition of conditions of Resource Consents (RC) relating to stormwater control, detention, re-use, contaminant removal and erosion control.

The Resource Management (Energy and Climate Change) Amendment Act 2004 introduced a new “other matter” into Part II of the RMA, requiring particular regard to be given to the effects of climate change (Section 7(i)).

In the context of the RMA there are two ways in which particular regard may be given to the effects of climate change.

- As an integral part of making decisions on RC applications and notices of requirement under the RMA for which the effects of climate change may be significant; and
- In proactively assessing RMA policy statements and plans as they come up for review, or other changes are proposed, to identify whether more explicit and/or up-to-date policies are needed to address the effects of climate change than are currently provided.

1.4.3 Waikato Regional Plan

This plan highlights the following stormwater concerns;

- Heavy metal and sediment contaminant runoff;
- The past lack of controls for stormwater management;
- Contaminant contribution from point source accidental spills; and
- Disposal of waste into stormwater systems.

Policies within the plan are directed toward:

- Increasing public awareness of the effects of stormwater discharge and the disposal of waste into the stormwater system;
- The use of comprehensive stormwater management plans and long term consents as a vehicle to manage urban stormwater;
- Provision of safeguards against flooding and water quality deterioration; and

- Inclusion of water quality controls and the adoption of best management practice for stormwater management and design, including practices to minimise the discharge of contaminants from point source locations.

1.4.4 WDC District Plan

The District Plan contains a variety of objectives and policies that relate to stormwater management, viz:

- Expected development in the Tamahere Catchment will increase the built up area and put pressure on the stormwater system (proposed District Plan);
- Stormwater is a particular hazard in the district, stormwater drainage on development areas should be minimized and off-site effects of stormwater draining from a site should be mitigated;
- Systems are to be designed to minimise the effect on the environment, especially the contamination with heavy metals and to protect from accelerated erosion or sedimentation;
- Protect people from injury or illness caused by surface water, reduce risk of damage to properties;
- Controls are placed on the maximum allowable impermeable surface on a given site; and
- There is an expectation that low impact design (LID) principles will be incorporated into any new design and examination of the potential for on site mitigation and disposal is expected.

1.5 Matters to be Addressed in SWCMP's

Appendix 5 of the Waikato Regional Plan specifically details the matters to be addressed in a SWCMP. Table 1 summarises the requirements and references the sections where they have been referred to in this plan. The table also includes other regional and local policy matters that need to be addressed in the plan preparation.

Table 1 Waikato Regional Plan — Matters to be Addressed

Waikato Regional Plan Matters to be Addressed	SWCMP Location
A description of the catchment and the drainage areas.	Map Book & Section 2
The identification of existing drainage problems and potential flood hazards and other sensitive areas.	Map Book
The location of major drainage works and flood protection systems.	Map Book
Calculation of peak flood levels for waterways in the catchment.	Appendix A
Identification of stormwater quality controls required for each drainage area.	Section 4
Monitoring requirements for inlet and outlet structures, flow channels and stormwater quality.	Section 5
A maintenance programme for the catchment drainage system.	Section 4
Identification of management responsibilities for compliance with Regional Council (RC).	Section 4
Other policy matters to be addressed	**SWCMP location**
Does the SWCMP manage stormwater in a way that provides: Safeguards against flooding; and Maintains or enhances water quality.	Section 3 & 4

Does the SWCMP promote LID principles.	Section 4
Does the SWCMP promote practices that minimise contaminant discharge from industrial and trade sites.	Section 3 & 4
Does the SWCMP identify industrial, trade and hazardous storage areas and promote sound management and safeguards against contamination discharge.	Section 3
Does the SWCMP promote public awareness of the potential adverse effects of stormwater discharge.	Section 3 & 4
Does the SWCMP: • Recognise riparian margin vegetation; • Protect, manage or enhance riparian vegetation; and • Rehabilitate or create wetlands.	Section 3 & 4

1.6 Previous Investigations and References

Variation 1 - Tamahere Country Living Zone, 13 August 2005 has been prepared by Bloxam Burnett Olliver for Waikato District Council. This Variation to the Proposed Waikato District Plan provides background information on stormwater issues in the Tamahere catchment and sets out the stormwater management philosophy for the Tamahere catchment.

Some of the graphics and text for this stormwater catchment management plan are based on or have been referenced from the Variation 1 document.

1.7 Existing Consents

The following resource consents are in place for stormwater discharges in the Tamahere catchment.

- Newells Road, Tamahere – WDC holds a consent to divert and discharge urban stormwater and associated contaminants to land and to an unnamed tributary of the Waikato River.

2. Description of the Catchment

2.1 Location

The Tamahere SWCMP catchment comprises approximately 1130 hectares of land adjacent to the eastern boundary of Hamilton City. The Waikato River, State Highway 21, Tauwhare Road, Matangi Road and a series of unnamed tributaries of the Waikato River form the boundaries of the TCLZ zone.

The study area boundary including the Tamahere Country Living Zone and Structure Plan area is shown in Figure 1A in the Map Book. For flow estimation purpose, the MIKE11 model network has been extended to include all contributing areas upstream of Mangaone Stream. This additional model extent is for flow calculation purpose in this study only and should not be used for any other purpose. No assessment outside the study area boundary has been carried out. Refer to Figure's 2A, 2B, 2C in the Map Book for subcatchment boundaries.

2.2 Natural Resources

Natural resources are discussed in the following sections which include information on the following:

- Climate (including rainfall);
- Soils and Vegetation;
- Groundwater;
- Geology;
- Topography;
- Zoning;
- Stream Assessments.

2.2.1 Climate

The Tamahere SWCMP catchment area has a temperate, damp climate, with about 1,184 mm of rainfall annually with most of it falling between June and September. Spring (October - December) tends to be sunny and humid and some rain can be expected most weeks. Fog in this area is most common about the river and extensive gully system. The catchment area shows the following characteristics:

- Summer daily air temperatures typically 22°C to 26°C, with a maximum of 30°C;
- Winter daily air temperatures typically 10°C to 15°C, with a minimum of -5°C;
- Mean annual rainfall in the catchment is approximately 1,184 mm;

2.2.2 Soils & Vegetation

The soils (Ref V1-TCLZ/BBO) in flat areas are alluvial deposits with variable drainage, and the low hills consist of very poorly draining clayey soils. The incised gullies typically cut through relatively weak deposits that are easily erodible, and are boggy based.

Vegetation within the zone is predominantly a combination of exotic and native plantings around houses and through the gully systems. More information on soil and vegetation in the catchment can be found in the following website.

http://www.ew.govt.nz/environmental-information/Environmental-indicators/Land-and-soil/

2.2.3 Groundwater

Groundwater as defined by Environment Waikato is as follows:

Groundwater is rainwater that has travelled through the soil to underground aquifers. It makes up about 90 percent of the region's fresh water resource.

There is no detailed information on any aquifer systems within the Tamahere Catchment. Refer to the following website for more information;

http://www.ew.govt.nz/Policy-and-plans/Regional-Policy-Statement/Operative-Waikato-Regional-Policy-Statement-October-2000/RPS-343/

2.2.4 Geology

The Tamahere Stormwater Catchment is located in the Waikato Lowlands. It is characterized by large gullies, peat soils and Hinuera formation, flat or gently rolling land.

The Stormwater Catchment lies mainly on sandstone (Q2ah) and mudstone (Q1al) grounds, with small parts of the area covering ignimbrite (eQali) and sandstone (Q1at) strata.

In terms of the Auckland Regional Council Technical Publication 108 Guidelines these materials are best regarded as Group C soils (mudstone/sandstone). These materials have less infiltration capability with high runoff. The geology of the catchments in this study is shown in Figure 1B in the Map Book.

2.2.5 Topography

The topography of the zone is predominantly flat river terraces, bisected by a number of incised gully systems, draining the area to the Waikato River, which forms the western boundary.

During a significant rainfall event the problem of erosion can occur because of concentrated flow through the gully system, increased flow velocities from section development and/or inadequate piping of watercourses and drains.

2.2.6 Zoning

2.2.6.1 Existing Development (ED)

The existing land use was assessed from aerial photography supplied by Council. The aerial photographs indicate most of the areas in the Tamahere Catchment are sparsely developed when compared to an urban area. However there are a number of localised areas that have concentrated development.

Detailed analysis of the existing imperviousness of the catchment was not undertaken as the catchment modelling for the existing condition was not part of this study. The sub catchments along with aerial photographs are shown in Figure's 2B and 2C in the accompanying Map Book.

2.2.6.2 Maximum Probable Development (MPD)

The future development potential was assessed for each subcatchment based on the District Plan and structure plan change information provided by WDC. This was required to make an assessment of the potential increase in impervious surface and the maximum demand likely to be placed on any stormwater system. The future recommended permitted impervious area percentages (Ref V1-TCLZ/BBO) and Structure Plan Change information, are listed in Table 2 below.

Table 2 Future Recommended Permitted Impervious Area Percentages

District Plan Zone	Maximum Permitted Impervious Area
Country Living	700 m² per allotment (14% for 5,000 m²)
Tamahere Village Investigation Area	100%

2.2.6.3 Tamahere Catchment MPD Zone Distribution

Summarising the information in Table 2 for the Tamahere Catchment the distribution of land utilisation under the various zones is presented in Table 3 below.

Table 3 Distribution of Zoning Categories within the Catchments

District Plan Zone	% of Total Catchment Area
Country Living	95.3
Tamahere Village Investigation Area	4.7

The District Plan Zoning for the Tamahere Catchment is shown on Figure 1A in the Map Book.

2.2.7 Key Stakeholders

There are approximately 1824 landowners (source: Land Information New Zealand) of various categories within the Tamahere Catchment, of which some are lifestyle owners while others are businesses.

2.2.8 Subcatchment Details

Contained within the Map Book are the following:

- Subcatchment Boundaries, Figure 2A, 2B, 2C;
- Catchment Geology, Figure 1B; and
- District Plan Zones, Figure 1A;
- Soakage Map, Figure 1C.

Contained within Appendix A are the Subcatchment Parameters for the MPD scenario.

2.2.9 Secondary Receiving Environment Assessment

No receiving environment assessment has been carried out in this study. The catchment flows from the Tamahere catchment drain to the Waikato River.

2.2.10 Primary Receiving Environment Assessments

There are a number of waterways flowing through the Tamahere Catchment which are shown in Figure 3A, 3B and 3C in the Map Book. There has been increasing awareness in recent years of the role that gullies can play in improving and maintaining the natural and physical environment, particularly in areas like Tamahere that are being converted to rural residential land use.

Waterways are an important feature in the urban and rural landscape as they serve a number of purposes including the safe conveyance of stormwater, filtering and detaining stormwater, preserving biodiversity, providing increased amenity values and promoting ecosystem functioning through ecological corridors.

Residential development in Tamahere will increase the impervious area in the catchment and put further pressure on the stormwater system as well as add to the nutrient and sediment volumes which are entering the drainage system.

Stream bank erosion and water quality assessment was not carried out at this stage of the study, however with the built environment steadily encroaching on these waterways it becomes increasingly important that the waterway systems; water, substrate, riparian vegetation and flora and fauna are afforded suitable protection from the impacts of such development.

2.2.11 Existing Flood Hazard

There has been no known major flood incident which has caused significant damage to properties in the catchment. During the significant rainfall event of 1998, drains in the area were seen to be running at capacity and localised flooding occurred but no buildings were inundated.

However, there are several low-lying areas in the catchment which get soggy during storm events. Insufficient reticulated drainage systems leading to ponding in storm events appear to be a contributing cause of sogginess of the ground.

2.3 Primary Receiving Environment

The primary receiving environment is typically flat with occasional low hills and incised gullies. A number of waterways within the catchment presently receive stormwater runoff both from developed and undeveloped rural areas. These flows ultimately discharge into the Waikato River.

2.4 Receiving Environment Sediment Quality

No sediment quality assessment was carried out in this study.

2.4.1 Potential Hazards

Potential stormwater hazards have been identified in this catchment as part of the fieldwork and catchment analysis through a visual site inspection. The potential hazards are:

1. Flood hazards to people and property due to increased overland flows;
2. Flood hazards to motorists due to increased overland flows;
3. Human health hazards due to overflow of wastewater system (septic tanks) effluent into floodwaters;
4. Stream (waterway) health hazard due to sedimentation and erosion.

2.4.2 Areas Prone to Surface Flooding

Given the generally flat nature of the Tamahere area, it is expected that significant rainfall events will cause water to pond in low-lying areas. This is considered acceptable as long as property floor levels are not flooded, given the rural living concept of this area. However, ponding in large areas may be perceived to be a major flooding issue by residients.

There are three main locations of poorly drained land comprising the Airport Road end of Newell Road, Newell Road from Birchwood Lane to Hart Road, and in the vicinity of Annebrook Road and Poplar Lane (Ref V1-TCLZ/BBO). All these areas have an established network of drains and gullies running through them.

2.4.3 Wastewater Overflows

There is no reticulated sewage or stormwater disposal system within the Tamahere Catchment. Currently sewage disposal is via on site systems such as septic tanks or their more comprehensive equivalent for businesses or activities such as the Tamahere Eventide Home. There may be potential issues with contaminated flood water.

3. Catchment Analysis

3.1 Water Quantity

This section investigates the theoretical capacity of the Council's stormwater network for various rainfall scenarios (i.e. 10 and 100-year ARI events) and imperviousness scenarios (MPD) as defined in the District Plan and Structure Plan Change. The effects of Climate Change were also investigated based upon the MfE 2008 Guidelines.

The investigations were undertaken using the Danish Hydraulics Institute (DHI) software package MIKEFLOOD incorporating MOUSE for the simulation of stormwater pipe reticulation, MIKE11 for simulation of waterways and MIKE21 for simulation of floodplain flows. Various aspects of modelling are explained in detail in the following sections.

3.1.1 Hydrology

Hydrology is the study of rainfall and the runoff process and covers the evaluation of peak flows and flow volumes. Mathematical computer models are used to simulate the physical processes involved in runoff generation due to the interrelationship between runoff, stream flow, pipe flow and flow distribution across overland flowpaths and floodplains.

The hydrology of the catchment area has been assessed using MOUSE and MIKE11. The key features are:

- Runoff rate and volume are calculated with the MIKE11 Unit Hydrograph Surface Runoff Module using:
  - Subcatchment length;
  - Subcatchment slope;
  - Impervious and pervious areas;
  - Curve Number;
  - Initial loss;
  - Lag Time;
- A separate subcatchment analysis of pervious and impervious components;
- For pervious area, there are two different type of soils referring to "well drained soils" and "poor drained soils" (Refer to Figure 1C in the Map Book). CN number of 74 has been assigned to "well drained soils" and 85 has been assigned to "poor drained soils";
- Estimation of the areas of different zone categories;
- Subcatchment slope calculated using the Equal Area Method; and
- The design rainfalls derived from HIRDS model based on NIWA rainfall records.

3.1.2 Catchment

The hydrological component of the MIKE11 Runoff Model represented the Tamahere Catchment as 256 subcatchments connected to source points included within the MIKE21 overland flow model. Stormwater manholes and inlets (limited stormwater pipe networks were modelled due to insufficient asset attributes) in the Mouse model have been linked to MIKE21 surface model.

The subcatchments were delineated with consideration of:

- Stormwater network configuration;
- Catchment contours;
- Catchment characteristics;
- Property boundaries;
- Soil types; and
- Zoning.

Subcatchment delineation undertaken primarily involved the use of aerial photographs, LiDAR data and the District Plan designations. Site walkover information was utilised to refine the subcatchment boundaries.

3.1.3 Rainfall

Design rainfalls of specific intensity and duration were used to drive the catchment runoff using the MOUSE/MIKE11 Urban Model B Module. These design rainfalls have been derived from the HIRDS model based on NIWA rainfall records that allows point rainfalls to be estimated for any latitude and longitude around New Zealand.

The temporal rainfall pattern is based on the assumption that 50% of the rainfall event will coincide with half of the storm duration. The 24-hour total rainfall depth for the three catchments generated using HIRDS and used in the model are presented in Table 4. This approach has been adopted to give the best available estimate of rainfall in the catchments. The distribution of rainfall has been adopted as there is no analysis available on the temporal distribution of rainfall events in the Waikato Region. The use of a 24-hour storm duration is an accepted convention that allows the effects of all intensities and durations to be incorporated into an assessment of catchments that have varying times of concentration.

Table 4 HIRDS 24-hour total rainfall depth for various ARI rainfall events

ARI Rainfall Event	24-Hour Total Rainfall (mm)	
	Without Climate Change	With Climate Change
5-Year	77.9	86.8
10–Year	91.0	103.0
100–Year	149.2	174.3

The rainfalls and their 24-hour temporal distribution for the Tamahere Catchment are graphed in Figure 1 and Figure 2.

Figure 1 Various ARI Design Rainfalls without Climate Change for Tamahere

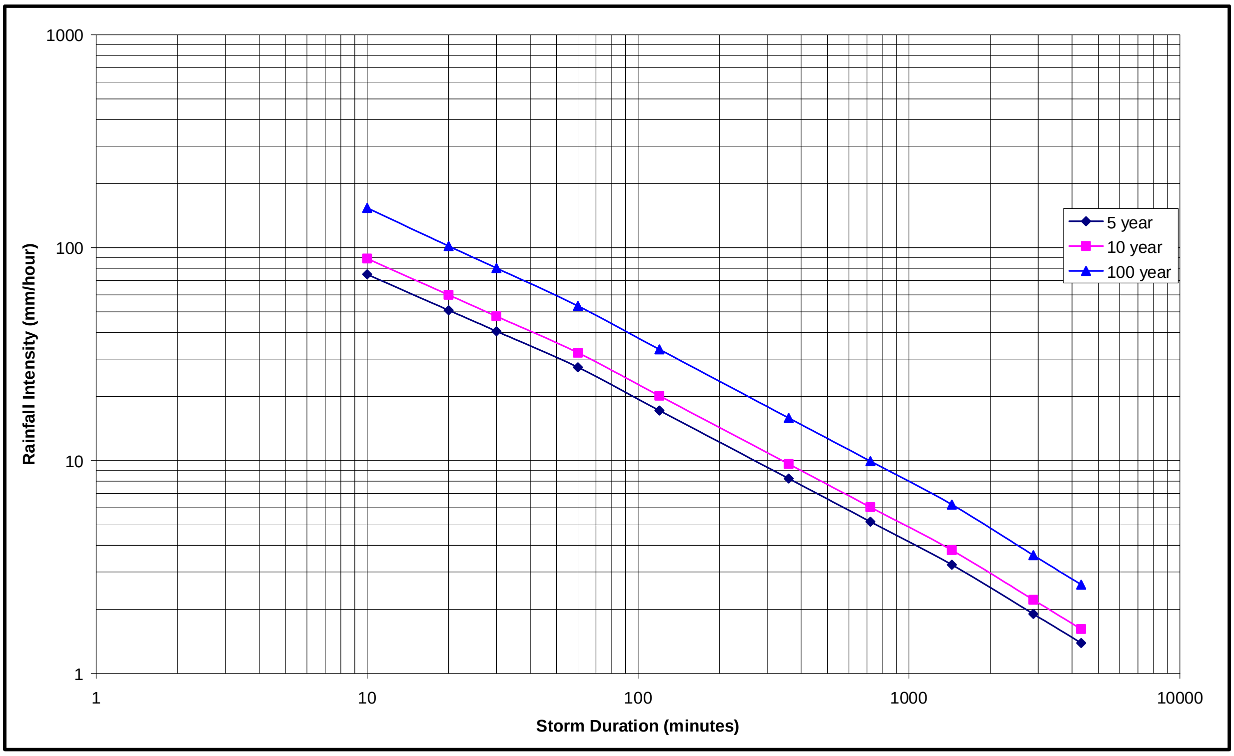
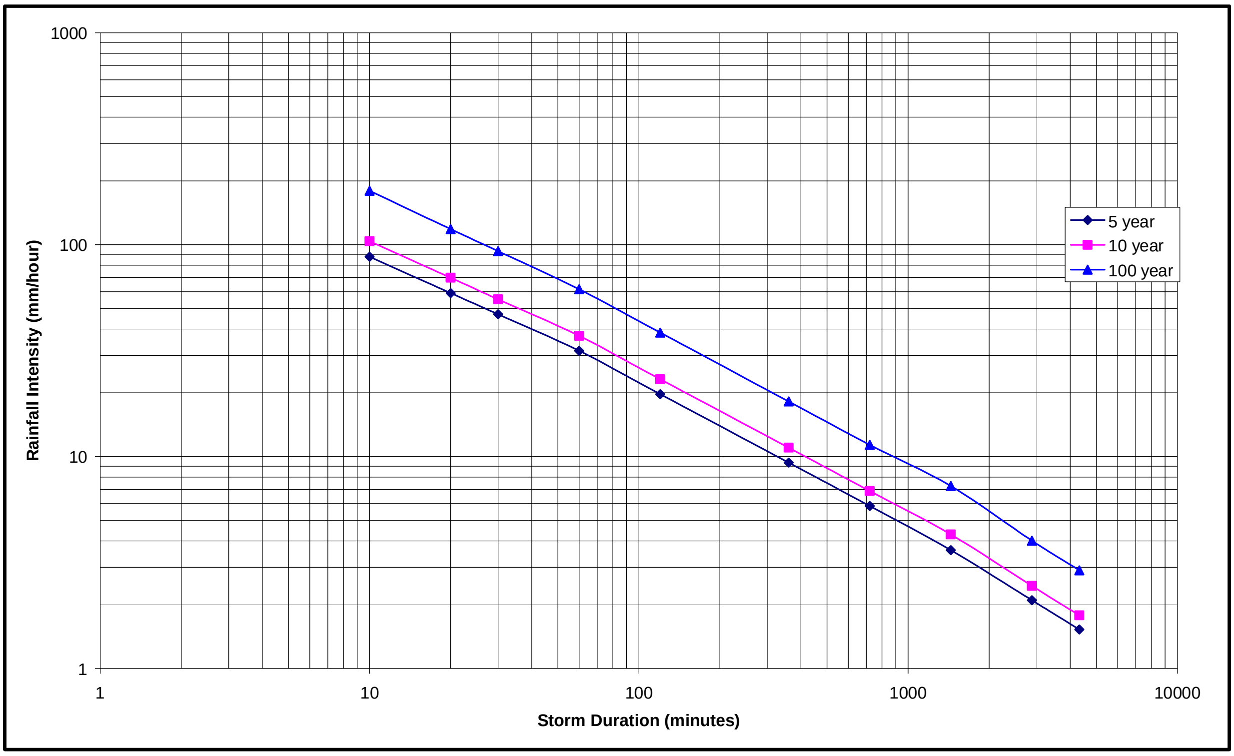


Figure 2 Various ARI Design Rainfalls with Climate Change for Tamahere



3.1.4 Tidal Boundary

The Tamahere Catchment is elevated with respect to the Mean High Water Spring level at Port Waikato where the Waikato River discharges. The Tamahere Catchment flows discharge into the Waikato River.

It has been assumed that there is no backwater effect at the discharge point at the Waikato River where the lowest bed level in the channel is RL 13.597m. Compared to this level, the Mean High Water Spring (MHWS) is RL 1.6m at Port Waikato. For climate change scenario, the Mean High Water Spring (MHWS) is RL 2.1m at Port Waikato. The highest river water level recorded at Victoria St Bridge in Hamilton City is RL 16.72m on 15/07/98.

3.1.5 Flow Estimation

3.1.5.1 Method Used

For this investigation the hydraulic models used were the MOUSE, MIKE11 and MIKE21 Hydrodynamic (HD) Module which incorporates:

- The main stormwater network;
- Overland flowpaths; and
- Streams.

For the purpose of flow estimation, the MIKE11 model network has been extended from study area to include all upstream area contributing to Mangaone Stream. The extended model is for flow calculation in this study only and is not suitable for any other purpose. The area of the extended model extent is provided in Figure 2A in the Map Book.

3.1.5.1.1 Nodes

MOUSE model nodes were utilised to represent the stormwater system attributes. Node inverts in MOUSE were obtained from data provided by WDC and corrected using the LiDAR data where data from WDC was not available. Node losses were assigned according to the hydraulic process to be represented.

Generally all outlet nodes were assigned as ‘Round-edged’ (Default Km=0.25). The Km values for other selected nodes including culvert nodes were derived from manhole loss calibration following the process outlined in the Culvert Manual.

The catchment model does not include:

- Formal soakage nodes;
- Pump stations; and
- Special hydraulic structures.

3.1.5.1.2 Network Development

The modelled stormwater network was developed from the asset data and interpolated between known levels as required.

The main waterways were modelled as open channels in MIKE11 with cross sections generated from LiDAR (Refer to Figure 2A in the Map Book).

All other waterways were modelled as open channels in MIKE21 based on LiDAR data.

3.1.5.1.3 Ponding and Storage

Ponding and storage within the catchment were included in the MIKE21 overland model as grid cells generated using the LiDAR data.

3.1.5.1.4 Soakage

A soil drainage map included in Appendix 5 (Ref V1-TCLZ/BBO) has been utilised to estimate runoff from the subcatchments (Refer to Figure 1C in the Map Book). There are two soil types, which are classified as “well drained soils” and “poor drained soils” in this catchment. “well drained soils” represent good infiltration while “poor drained soils” indicate low infiltration. This philosophy has been used in model development to describe soakage in the catchment. CN number of 74 has been assigned to “well drained soils” and 85 has been assigned to “poor drained soils”, which means in “well drained soils” area, less runoff will be generated as more rainfall will infiltrate into ground water and in the “poor drained soils” area, more runoff will be generated as less rainfall will infiltrate into the ground.

3.1.5.1.5 Assumptions

During the modelling process assumptions were made in order to appropriately represent the flow situations. Furthermore, the models as currently developed are also subject to limitations, which must be kept in mind when interpreting results.

- Stormwater catchpit inlet control was not modelled for stormwater reticulation. This effectively assumes that catchpit capacity is equal to or greater than pipe capacity;
- No Blockage has been assumed in manholes, pipes, culverts and entry points into the piped stormwater system;
- The Main waterways were defined as open channels in MIKE 11, with cross sections generated from LiDAR. Refer to Figure 2A in the Map Book for the MIKE11 network;
- Minor open channels not identified from LiDAR were assumed blocked and not functional during storm events;
- An outlet near Parklea Drive draining into a watercourse was modelled as a stormwater pipe connected to the MIKE21 model;
- No account has been taken of the execution of any operations and maintenance works that may affect system performance (ie open channel cleaning may indicate a serious deficiency in the network or effecting changed hydraulic conditions);
- There have been no checks on whether physical changes in the system have occurred (renewals or realignments) since the asset data collection that may need to be reflected in a completed model in future;
- It has been assumed that all culverts are large enough to not create constrictions to the flow in the channels; and
- It has been assumed that there is no backwater effect at the discharge point at the Waikato River where the lowest bed level in the channel is RL 13.597m. Compared to this level, the Mean High Water Spring (MHWS) is RL 1.6m at Port Waikato. For climate change scenario, the Mean High Water Spring (MHWS) is RL 2.1m at Port Waikato. The highest river water level recorded at Victoria St Bridge in Hamilton City is RL 16.72m on 15/07/98.

3.1.6 Capacity Assessment

The ability of the stormwater network to convey the design flows (10 and 100-year ARI rainfall events) was assessed using the MIKEFLOOD for the MPD imperviousness scenarios.

Climate Change effects, as defined in the Ministry for the Environment (MfE) 2008 Guidelines, were also modelled for the design flows.

The main criteria for Climate Change identified in the 2008 MfE Guidelines were:

- A temperature rise in the range of 0.6 - 5.6^{o}C with an average rise of 2.1 ^{o}C for the Waikato region is likely during the period 1990 – 2090;
- A 24-hour 100-year ARI rainfall event is predicted to be an 8.0% increase in intensity per ^{o}C; and
- A rise in the tidal boundary of MHWS + 0.5 m.

For the modelling of Climate Change a 2.1^{o}C temperature rise was considered, which equates to:

- A 16.8% increase in the 100-year ARI HIRDS 24-hour intensity; and
- A tidal boundary of RL 1.6 m, relative to Mean Sea Level (MSL), for the MPD scenario.

MPD levels were considered because they represent the potential change in imperviousness, increased runoff and subsequently raised floodplain levels. Existing Development levels were not considered as it was not part of this study.

3.1.7 Hydrological Parameters

The descriptions of the hydrological parameters used in the MIKE11 Runoff Model are presented in Table 5.

Table 5 Model Hydrological Parameters

Input	Descriptor
MPD	The Maximum Probable impervious surface % permitted in the District Plan and Structure Plan Change.
Catchment	The stormwater runoff collection area that is defined by a ridgeline from which water flows to the lowest point at the outlet.
Area (ha)	A measurement of the land that makes up a catchment.
Roofed Area (ha)	The area covered by building footprint in a catchment.
Sealed Area (ha)	The impervious area within the catchment covered by roads, driveway and parking areas.
Pervious Area (ha)	The area other than roofed and sealed surfaces.
Wetting (m)	One-off loss accounts for wetting of the catchment surface.
Storage (m)	One-off loss defines the precipitation depth required for filling the depressions on the catchment surfaces prior to the occurrence of runoff from sealed and pervious areas.
Manning's Number	A separate model parameter that is used to describe the effect of surface for roofed area, sealed surface and pervious area.
Catchment Slope (0/00)	The change in elevation over a standard horizontal distance.
Catchment length (km)	The length of flow channel for catchment.

The hydrological parameters for each subcatchment are provided in Table A1 of Appendix A for the Maximum Probable Development scenario.

3.1.8 Hydraulic System

The stormwater system in the catchment consists of the elements identified in Table 6 below.

Table 6 Stormwater Network Components

System Components	Primary System Design Event 10-year ARI	Secondary System Design Event 100-year ARI + CC
Capture	Road Carriageway	Road Carriageway
	Private Property	Private Property
	Cesspits / Catchpits	
	Roadside Drains	Roadside Drains
Conveyance	Piped Network	
	Culvert	Culvert
	Open Drains	Open Drains
	Attenuation Devices	Attenuation Devices
	Watercourses/Waterways	Watercourses/Waterways
	Private Property Drains	Private Property Flow Paths/Ponding Areas
Discharge	Ponds	Ponds
	Watercourses/Waterways	Watercourses/Waterways
	Waikato River	Waikato River

3.1.9 Hydraulic Parameters

Pipe roughness was represented using Manning's roughness (n) in MOUSE while floodplain roughness in MIKE21 was represented using Manning's number (M) which is reciprocal of Manning's roughness.

The roughness values for the surface model were assigned to each grid cell based on aerial photographs, site inspections, literature values and modelling experience.

The pipes were assigned a constant friction coefficient.

The following Table 7 lists the adopted roughness values:

Table 7 Adopted Manning Roughness Values

Channel/Bank Status	Manning's Roughness 'n'
Stream/Open Drains	0.050 -0.070
Floodplain	0.050 to 0.070
Concrete Pipes	0.013
Roads	0.020

3.1.10 Model Outputs

The model outputs provide an overall picture of the performance of the network based on the physical attributes as described earlier. The outputs best represent the capability of the network to perform when subjected to storm flows, so that elements such as pipe flow and overflow can be assessed. Table 8 describes the various parameters of the model output.

Table 8 Model Outputs

Output	Descriptor
Q_{10}	The peak flow that will occur in a 10-year ARI rainfall event
Q_{100}	The peak flow that will occur in a 100-year ARI rainfall event
Q_{100} + Climate Change	The peak flow that will occur in 100-year ARI rainfall event and climate change influence

3.1.11 Overland Flowpaths

Overland flow is a natural occurrence when rainfall lands on the ground surface and flows downhill regardless of the surface of the ground. The route taken by the overland flow is referred to as the flowpath. This flow increases as it makes its way downhill following the path of least resistance towards streams, watercourses or the foreshore. In some cases, the overland flow will pond if there are no routes to downstream waterways.

Overland flow is captured and conveyed to a discharge point via open drains, catchpits and pipes.

Any development within the catchment is required to take into consideration overland flowpaths. The simple act of obstructing the flowpath can cause damage, or nuisance, to properties immediately downstream or adjacent to the obstruction.

An assessment of the overland flowpath alignments was undertaken utilising the LiDAR in MIKE21 model assigning grid elevation from LiDAR.

3.1.12 Flood Level Analysis

Given the typically flat nature of the Tamahere area, it is expected that significant rainfall events will cause water to pond in low-lying areas. All areas described as poorly drained in Figure 1C in the Map Book should expect regular surface flooding. There are three main locations of poorly drained land comprising the Airport Road end of Newell Road, Newell Road from Birchwood Lane to Hart Road, and in the vicinity of Annebrook Road and Poplar Lane.

3.2 Definition of a Floodplain

A floodplain adjacent to a waterway or stream is flat or nearly flat land that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows and the flood fringes, which are areas covered by the flood, but do not experience a strong current.

For the purpose of this catchment management plan, the extent of overland flowpaths through the catchment is also defined as the floodplain.

The extent of the floodplain areas was determined in the 2-D Model MIKE21 based on grids generated using LiDAR data.

Maximum water depths and water levels were extracted in dfs2 format from the MIKE21 model results using the MIKEZero facilities. This dfs2 result file was then exported into ASCII format for import into ArcGIS format for plotting.

Maximum flood depths and flood levels are shown in Figures 4 to Figures 7 in the accompanying Map Book.

3.3 Floodplain within the Catchment

An analysis of the predicted flooding within the catchment was undertaken in order to estimate the total area and total number of properties within the floodplain (based on parcels) during various ARI rainfall events. These are summarised in Table 9 and Table 10 below:

Table 9 Summary of Flooding within the Tamahere Catchment

ARI Events	No. of Properties within Floodplain		Floodplain Area (ha)	
	MPD	MPD+CC	MPD	MPD+CC
10-year	687	N/A	64.96	N/A
100-year	740	760	104.27	123.86

Table 10 Floodplain Effects for the 100-year ARI MPD Event

Descriptor	**Value**
Total No. of Properties in the Catchment	852
% Properties (Parts of Land) in the Floodplain	84.27
% Catchment in Floodplain	10.96

Note: Buildings within the floodplain extent are not necessarily flooded as the building floor levels might be above predicted flood levels. Number of properties flooded shown in the Table 9 may be affected partly or entirely.

3.4 Significant Flooding Impacts

"Significant" floodplain areas have been identified for the 10 and 100-year ARI rainfall events using the MPD and MPD+CC scenarios and the flood extents are indicated in the Map Book.

The impact of flooding in the catchments shown in Figure 3A, 3B and 3C in the Map Book and is tabulated in the following Table 11**.**

Table 11 Types of Flooding Impacts (Quantity) in various Subcatchment Groups

Subcatchment	Types of Flooding				
	Property	Waterways	Floor Level	Road Flooding	Localised Ponding
A	√	√	**TBD**	√	√
B	√	√	**TBD**	√	√
C	√	X	**TBD**	√	√
D	√	X	**TBD**	√	√
E	√	X	**TBD**	√	√
F	√	X	**TBD**	√	√

Properties flooded within the floodplain extent as indicated in Table 11 includes properties that are partly flooded.

3.4.1 Waterways Flooding

The flood maps show that streams and waterways in the Tamahere catchment generally have adequate capacity for stormwater flows in all three storm events. This is evident from the limited extent of flood overflows along the streams in the flood maps.

A specific flooding issue has been identified for the 100 year ARI and 100 year ARI plus climate change storm events along State Highway 1 at the Annebrook Road intersection area. About this point waterways from both sides of the State Highway converge. Extensive flooding is indicated on the flood maps in this area. It is predicted that the flooding extent and levels shown on the flood maps at this point could be further affected adversely if the waterway along the boundary of the Tamahere catchment at the Hamilton City end is flooded simultaneously during peak flows in the Tamahere waterways. Flows from the North along this waterway at the boundary have not been included in the model. It is not envisaged that backwater effects from the Waikato river will have any additional adverse effects, however this should be checked should models/modelling results of the Waikato river be available.

It is important to note that the modelling for this project has been limited to within the Tamahere catchment boundary as shown on the flood maps but includes MIKE11 models of the waterways from the North East upper catchments and the South East upper catchments. The contributing upper catchments are shown in Figure 2A in the Map Book.

3.4.2 Widespread Localised Flooding

The flood maps show widespread localised flooding in the catchment. This confirms that there is insufficient pipe drainage network and both, designed and natural overland flowpaths in the Tamahere catchment. There appears to be sufficient flow capacity in the main waterways leading out of the catchment however the distances are significant between localised flooding areas and the waterways.

The depth of flooding in many areas is only up to 300 mm but the flood extents in these localised areas are very large.

In a number of areas the depth of flooding is up to a metre. These are contained to smaller pockets within the catchment.

The contributing factors for the widespread localised flooding appear to be;

- Insufficient stormwater pipe drainage networks leading to the main waterways;
- Insufficient natural or designed overland flow paths leading to the main waterways;
- The general flat topography of the catchment; and
- Poor soakage in parts of the catchment.

3.5 Water Quality

Water quality issues result from contaminants (i.e. suspended solids, nutrients and toxic substances, metals) that may be transported in stormwater. These contaminants may affect water quality in receiving environments adversely affecting the healthy living environment and disrupting the natural ecology. Contaminant sources are either specific locations such as spill or overflow points or wide areas with diffuse runoff such as from roads, roofs and farm paddocks. Based on flooding and future development potential, the expected water quality issues related to subcatchment groups are listed in Table 12 below:

Table 12 Potential Impacts of Flooding on Water Quality

Subcatchment	Types of Contamination Impacts					
	Farm Effluent	Stream Erosion	Sediments	Road Contaminants	Roof Contaminants	Sewerage
A	√	√	√	√	√	√
B	√	√	√	√	√	√
C	√	√	√	√	√	√
D	√	√	√	√	√	√
E	√	√	√	√	√	√
F	√	√	√	√	√	√

3.5.1 Point Source – Pump Station Overflows

There are no pump stations in the Catchment.

3.5.2 Point Source - Industrial and Business Runoff

There is currently no industrial or business zone located in the catchment.

3.5.3 Point Source - Septic Tank Effluent

The Tamahere catchment does not have a reticulated sewage network. All sewage disposal is via septic tanks. Septic tank effluent is the waste water that is discharged or flows out of a septic system.

Wastewater may contain contaminants that are harmful to humans, animals and plants; therefore it is important that wastewater is treated adequately before it is released into the environment. A septic system is a simple, yet effective means of treating wastewater.

A septic system consists of two main components, the septic tank and a drain field. A septic tank is a large, waterproof container that is generally located below ground level, although some locations may require an above ground system. The septic tank acts as the holding area for the wastewater produced by a home or business. As water enters the tank, bacteria in the tank start to break down solids present in the wastewater.

As solids in the wastewater are broken down, the wastewater in a septic tank divides into three main parts. The first consists of solids, known as sludge, that sink to the bottom of the tank. The second component consists of particles and foam that float to the surface of the water, which are typically known as scum. In between the scum layer on the surface and the sludge on the bottom is a layer of partially treated water.

When a septic system is working properly, the water is released into the drain field while the solid matter remains in the tank. The drain field is the area where septic tank effluent is released. As new water enters the tank, it displaces the water already in the tank and forces it out in the drain field. A drain field typically consists of a series of buried perforated pipes that septic tank effluent flows through. The small holes in the pipe allow the septic tank effluent to slowly drain back into the ground, where the treatment process continues as effluent filters through the soil and back into the groundwater supply.

Over time the solids in the tank will build up, therefore it is critically important for the overall operation of the septic system and the well-being of anyone close to the septic system, that the contents of the tank are pumped out and removed on a consistent basis. An improperly maintained septic tank system can lead to waste flowing back into a building or in wastewater flowing into the drain field at a rate higher than the field can effectively absorb. When this occurs the area above the drain field may be flooded with improperly treated septic tank effluent.

With widespread localised flooding and ponding predicted, contamination of the flood waters with sewage effluent is a possibility. The location of sewage effluent fields in Tamahere catchment is not mapped but it is highly likely that some of the flooding areas are in sewage effluent disposal areas and that sewage effluent in the groundwater may interact with flood waters.

3.5.4 Non Point Source – Rural Runoff

Rural runoff is in general diffuse entering streams and waterways at multiple locations.

Rural activities include the use of fertilisers, pesticides and herbicides.

- Fertilisers contain nutrients that can potentially impact on the health of the stream, potentially causing imbalance between Nitrates and Phosphorus, which in extreme cases these imbalances can lead to algal proliferations; and
- Pesticides and herbicides contain chemicals that can be toxic to some species of aquatic organisms.

The Tamahere catchment is mainly zoned country living with minimum lot size of 5,000 m^2. Activities in this zone may include farm activities with likely contamination of flood waters.

3.5.5 Non Point Source - Sediment and Erosion Control

Sediment from land development/operation activities can potentially impact on the health of streams and waterways.

- Sediment, in large volumes, can smother the streambed and impact on the ability of aquatic organisms to function by reducing the amount of light and thus the ability of plants to photosynthesise; and
- The majority of solids discharged from stormwater drainage systems settle in the vicinity of the outfall, which leads to localised sediment contamination.

Sediment supply varies depending on the rainfall pattern.

A prolonged period of dry weather will allow urban sediments to accumulate and be subsequently transported with the next rainfall event, whereas frequent rainfall events clear the sediment so that the subsequent storms may not contribute a significant load, regardless of the severity of the rainfall event.

The major source of erosion and sediment generation from land stripped of vegetation is through activities such as:

- Subdivisions;
- Roads;
- Other developments.

Without protection measures the execution of these activities can result in significant onsite erosion and sedimentation of local streams and main rivers.

It is therefore important that:-

- All land disturbance activities must incorporate erosion and sediment control; and
- Erosion and sediment controls should be in place before earthworks commence and removed only after the site has been fully stabilised.

With the lack of pipe network systems in the Tamahere Catchment, it is not expected that sediments in large volumes from development activity will reach the streams and waterways, however developments along waterways may cause the transport of large quantities of sediments into the waterways. During the site visit for this project, there were visible signs of large quantities of sedimentation from development activities along the waterways.

Where there are existing pipe networks, the stormwater collection systems may not be designed to collect and trap sediments.

3.5.6 Non Point Source - Road Carriageway Runoff

Stormwater run-off from road carriageways is a source of heavy metal contaminants in an urban environment. Table 13 identifies the contaminants and their related causal activity.

Table 13 Vehicular Contamination

Vehicular Activity	Contaminant
Exhaust Emission	Benzene, Toluene, Ethyl Benzene, Xylene (BTEX)

Vehicular Activity	Contaminant
Tyre Wear	Zinc (Zn)
Brake Wear	Copper (Cu)
Acceleration	Lead (Pb)

The concentration of metals is dependent on the following factors:

- Traffic density;
- Season;
- Climate;
- Human street activity;
- Removal of dust by wind;
- Traffic turbulence;
- Street cleaning; and
- Stormwater runoff.

In addition, wear and tear of the carriageway itself can present contaminants such as hydrocarbons that can be flushed into stormwater drains and ultimately the receiving environments.

New Zealand Transport Agency (NZTA) have been investigating the effects of vehicular contaminants in stormwater runoff for some time, the research to date has indicated that the concentration of these contaminants does not become an issue until 10,000 vehicles per day per lane is achieved.

The runoff from State Highway 1 will have a detrimental effect to the health of the waterways if this is not controlled and managed. Information on the management of the State Highway runoff was not available for this study.

3.5.7 Non Point Source – Roof Runoff

Roof contaminants are in the form of dissolved metals. A pipe system in the catchment can contribute to contaminants accumulating in the waterways at specific points over a long period of time. In the Tamahere catchment, the roof runoff is generally detained on site and any contaminants will be spread across a large area and will not accumulate in specific points.

3.5.8 Discharge and accumulation of Litter

Gross pollutants (i.e. plastic bottles, bags, food wrappers, household rubbish) can also be found along the waterways impacting on the amenity value of the area and introducing potentially harmful aquatic organisms. These are generally from the limited number of existing pipe networks that are in the Tamahere Catchment.

3.5.9 Fish Passage

The Waikato District is an important area for native fishery within the Waikato Region. The presence of harbours, large river systems, wetland habitats and areas of indigenous forest provide a range of potential fish habitat. The major rivers (Waikato and Waipa) are still uninterrupted by dams in this area and allow unimpeded access to the sea. The distance from the sea throughout most of the district is less than 100 kilometres which makes much of this habitat within the swimming capabilities of many native fish (EW Technical Series, 2007/03).

Throughout the district many fish habitats exist and native fish use these main rivers to access the sea. Given the districts proximity to the marine environment it is essential to keep fish passages unobstructed. In order to mitigate the obstruction of fish movements the WDC provides, as part of an ongoing asset upgrade improvement, fish passages through culverts, where practicable.

3.5.10 Waikato River Water Quality

The following information has been collated from the Environment Waikato website.

Environment Waikato is working with Waikato-Tainui and other iwi to achieve the shared vision of a clean and healthy Waikato River. That vision is set out in the agreement between the Crown and Waikato-Tainui over management of the Waikato River between Karāpiro and Te Pūaha o Waikato (Port Waikato).
The agreement sets up a Waikato River Authority made up of Crown,iwi-appointed members and local communities.
The authority will contribute to cleaning up the river and monitor the direction-setting Vision and Strategy document, Te Ture Whaimana, which aims to restore and protect the Waikato River. The Vision and Strategy will form part of the Waikato Regional Policy Statement (RPS) and be given effect through all councils' plans under the Resource Management Act.

Careful management of the Tamahere Catchment stormwater discharges - in terms of water quality - should be considered in the light of the above management strategy for the Waikato River.

3.5.11 Groundwater Quality

Groundwater quality assessment has not been included in this study.

3.5.12 Flooding/Overflows

Flooding represents risks to human health and safety, buildings and infrastructure. From an environmental perspective flooding can lead to erosion of stream banks, scour and land instability.

The modelling of the Tamahere Catchment has highlighted areas throughout the catchments where flooding is an issue and typically these are in low lying areas or where there is poor soil soakage. As the catchment develops, the volume and frequency of overland flows increase. Where the overland flows discharge in streams and waterways, erosion of stream banks, scour and land stability can occur. Flooding is predicted in many low lying areas and any remedial works to improve the flow of stormwater to streams and waterways should be accompanied with measures to prevent adverse effects.

3.5.13 Loss of Habitat

Development places pressures on the natural environment. Reducing the amount of riparian vegetation can cause a loss of shading, which results in higher stream temperatures, less oxygen and growths of nuisance organisms such as algae. Stream banks also become unstable and erode causing sediment to enter the stream environment thus reducing the amenity value of the area or stream.

Protection of native vegetation has become increasingly important in the whole Waikato District. Native vegetation is the centre of native animal habitats and the loss of it automatically leads to the loss of biodiversity. Its protection therefore is part of the Proposed Waikato District Plan.

The Tamahere catchment has opportunities for habitats along its waterways. During site visits native animal life such as pheasants was visible.

4. Management Options

4.1 Introduction

The purpose of this section is to provide an approach to the development of stormwater management options.

Management options may include the following:

- Engineering work;
- Changes to operations and maintenance plans; and
- Changes to rules and regulations
- Education.

4.2 Management Options Development

The development of a comprehensive strategy for the management of stormwater runoff requires consideration of catchment values and the stormwater problems within the catchment. This applies to both the present day and potential future development. Environmental assessments of waterways and stormwater quality studies are not part of this study however any management strategies should incorporate environmental considerations.

Management strategies available in the country living areas of the Tamahere Catchment include:

- Maintaining the status quo;
- Reducing runoff;
- Increasing system capacity;
- Increasing attenuation; or
- Providing flood protection.

Various mechanisms are available to achieve these objectives but they essentially fall into two categories, engineered works or non-engineering solutions (e.g. education). The most common mechanisms are discussed below.

4.2.1 Engineering

Engineering solutions primarily involve building new structures or improving the performance of existing structures. Such things include:

- Increasing pipe size and/or network extensions;
- Reducing tailwater depth;
- Improving hydraulic efficiency of existing drainage system;
- Provision of new or improved overland flowpaths;
- Installation of pumping systems;
- Application of Low Impact Design (LID) principles;
- Detention/Retention dams;
- Diversion systems; and

- Flood proofing of buildings.

The runoff from developed areas will be increased due to an increase in imperviousness. This will cause erosion of the existing gully drains and sediment will be carried to the river. Therefore, the outflow from these areas should be maintained at its pre-development stage by providing stormwater detention systems to control stream bank erosion.

4.2.2 LID Principal

A sustainable stormwater management strategy involves use of low impact design (LID) to minimize the generation of stormwater runoff and to treat pollutant loads where they are generated. This can be accomplished by directing storm water towards small-scale systems that are dispersed throughout the catchment with the purpose of managing water in an evenly distributed manner. These distributed systems will allow for downsizing or even elimination of large storm structures such as ponds and filter devices saving cost on infrastructure.

The LID principal includes structural measures such as rain gardens, biomediafiltration, painting of building roofs using zinc and copper leaching sealer, as well as non-structural measures such as catchpit cleaning and catchpit filter devices.

LID principles should be applied in the Structure Plan area. These could be implemented by developers in these areas. A number of measures suitable to the Tamahere catchment have been mentioned in V1 – TCLZ/BBO such as soakage, swale drains, wetlands and ponds. However other measures that have been mentioned may be less effective and/or costly. These include rain tanks which may be partially full during storm events and roof gardens and permeable pavement where there is good soakage on large lots. Reference to LID guidelines is provided in the Rules and Regulations section below.

4.2.3 Operation & Maintenance

Regular operation and maintenance of a system ensures that gross pollutants and debris are removed and ensures that the system operates as designed during storm events. Specific and detailed maintenance programmes need to be developed for all areas to ensure that the investment in the asset achieves the desired levels of service.

It is considered that integration of the asset data captured in the GIS system and the maintenance monitoring undertaken will allow effective management of pipe assets and overland flowpaths within the catchment area.

The open channels and waterways are part of the stormwater network as well as natural resources of potential value. On going maintenance will mitigate the following:

- Blockage of structures such as gates and culverts;
- Sedimentation;
- Weed build up in channels;
- Damming effect of trapped debris; and
- Maintenance of bank vegetation.

WDC is required to undertake activities to ensure that the stormwater system is functioning to an acceptable level of efficiency. Currently, planned activities by WDC to ensure this standard of system operation include:

- Inspection of culverts to ensure that blockages and overflows are limited in occurrence;
- Inspection of catchpits to ensure that blockages and overflows are limited in occurrence;
- Cleaning of kerb and channels, including water table drains to minimise the flushing of contaminants into the natural streams;
- Cleaning of the catchpit sumps to reduce the conveyance of silt through the pipelines; and
- Cleaning and maintaining of open channels (in conjunction with Local Drainage Boards).

The Tamahere Drainage Board has a role in the catchment. This role involves the clearing of the open drainage channels in the catchment. This role should be documented and expanded if possible.

4.2.4 Rules & Regulations

Regulation can be used to complement capital works as a means of managing stormwater within an urban area. This can be a very cost effective means of achieving objectives. Such measures, which would be implemented through changes in the District Plan, could include:

- Management of overland flowpaths by identifying and designating flowpaths. Rules should then be formally established to prevent obstructions from being built across the flowpaths;
- On site stormwater management practices such as the discharge of over flow from rain tanks;
- The setting of development standards for new developments for the following measures;
  - Treatment ponds
  - Source control of metal contaminants from roof surfaces using roofing materials with a permanent leaching sealer or zinc leaching paints
  - Attenuation ponds
  - Swales
  - Permeable pavements
  - Soakage devices
  - Planting including riparian planting
  - Erosion and sediment controls
  - Rain water tanks for attenuation purposes

  The V1 – TCLZ/BBO refers to the New Zealand Water Environmental Research Foundation (NZWERF) guidelines “On-Site Stormwater Management Guideline” 2004. The Auckland Council has identified Low Impact Design – best practice documents (January 2009). The following is a link to the documents.

  http://www.arc.govt.nz/environment/water/stormwater/low-impact-design---best-practice-documents.cfm

- Reconsideration of permitted levels of imperviousness in the District Plan and minimum lot sizes in flood prone areas. The V1 – TCLZ/BBO mentions that Environment Waikato requires a minimum lot size of 2,500 m² if on-site sewage effluent fields are proposed. The flood prone areas in the catchment are large and may interact with sewage effluent fields;
- Monitoring of catchment imperviousness for illegal impermeable surfaces.; and
- Changes to WDC development standards and improved consenting and processes to ensure compliance.

4.2.5 Education

Education initiatives are necessary for the following reasons:

- To develop an awareness of how the local stormwater system operates especially in flood conditions;
- To promote an understanding of development practices that allow for stormwater controls;
- To promote understanding that hard-surfacing large parts of a section leads to excessive runoff;
- To develop an awareness of the values of the stormwater systems, especially the open waterways and to discourage in-filling or blockage of such systems
- To promote awareness and understanding of the causes and extent of stormwater contamination; and
- To promote community behaviour that improves runoff quality by encouraging pollution prevention.

Stormwater management principles may not be well understood by the community and so education initiatives could include:

- A workshop with District Councillors and Community Committee members to outline this plan and the principles upon which it was developed;
- Technical workshops for WDC Regulatory team on the implications and issues relating to the implementation of this plan;
- Technical workshops for designers to ensure that appropriate methodologies are adopted to ensure the implementation of this plan;
- Manned display stands in public areas where people can discuss the plan with experts; and
- Broad sheet literature to outline total drainage concepts so that people can appreciate the unique nature of the drainage system, the WDC level of service and the need to be custodians of the waterways by protecting flowpaths from non point source contaminants and the maintenance of riparian margins.

4.3 Management Options Recommendations

4.3.1 Sub Catchment Management Options

The catchment analysis and the previous sections form the basis of an assessment of stormwater management options for the future. The assessment addresses the issues outlined previously in terms of the management options and understanding of the drainage system. The assessment of options is undertaken on a catchment-wide basis so that all options can be considered in an integrated manner. The key issues and options for the catchment are covered in the following tables.

Table 14 Key Issues and Options – Flooding from Waterways

<table>
<tr><th>Catchment</th><th>Issue/Descriptor</th><th>Management Options</th></tr>
<tr><td>Sub Catchment A & B</td><td>Infrastructure Capacity

A specific flooding issue has been identified for both, the 100 year ARI and 100 year ARI plus climate change storm events along State Highway 1 at the Annebrook Road intersection area. About this point waterways from both sides of the State Highway converge. Extensive flooding is indicated on the flood maps in this area. It is predicted that the flooding extent and levels shown on the flood maps at this point could be further affected adversely if the waterway along the boundary of the Tamahere catchment at the Hamilton City end is flooded simultaneously during peak flows in the Tamahere waterways.</td><td>Further Assessments

The following assessments are required to understand the flood risk;
◗ Identify the flood risk area in greater detail (this will include assessment/adoption of vertical and horizontal freeboards and further assessment of waterways at the boundary of the Tamahere catchment).
◗ Undertake a detailed flood risk/damage costs assessment.

Engineering

The following remedial work options can be investigated to assess whether these are feasible and can reduce the flood extents and/levels;
◗ Storage/detention of stormwater in the upper catchments through construction of ponds and wetlands.
◗ Increase the capacity of waterways/culverts and or configuration of the waterways at the critical downstream points and in the flood affected areas.
◗ Construction of stop banks at critical locations along the waterways.

Operation & Maintenance

The following management option can be implemented to mitigate flood risks;
◗ Include flood risk management plans for the area in Civil Defence Planning and Operations procedures.

Rules & Regulations

The following management option can be implemented to mitigate flood risks;
◗ Restrict new buildings and infrastructure in the flood risk area.

Education

The following management option can be implemented to mitigate flood risks;
◗ Include the flood zone on the WDC website as information for the community.</td></tr>
</table>

Table 15 Key Issues and Further Assessments Option – Widespread Localised Flooding

Catchment	Issue/Descriptor	Management Options
All Catchments	**Infrastructure Capacity** The flood maps show widespread localised flooding in the catchment. This indicates that there is insufficient piped or natural/designed overland drainage, in the Tamahere catchment. There appears to be sufficient flow capacity in the main waterways leading out of the catchment however the distances are significant between localised flooding areas and the waterways. The depth of flooding in many areas is only up to 300 mm but the flood extents in these localised areas are very large. In a number of areas the depth of flooding is up to a metre. These are contained to smaller pockets within the catchment. The contributing factors for the widespread localised flooding are most likely; ◗ Insufficient stormwater pipe drainage networks leading to the main waterways ◗ Insufficient natural or designed overland flow paths leading to the main waterways ◗ The general flat topography of the catchment ◗ Poor soakage in parts of the catchment	**Further Assessments** The following assessments are required to understand the capacity of pipe systems, open drains, soakage and overland flow paths in more detail; ***Asset Data Collection*** ◗ Locate and survey pipe network systems. ◗ Locate and survey open drains that convey flows to pipe networks and waterways. ◗ Locate and survey or obtain information of drainage system from NZTA for SH1. ◗ Undertake soakage tests in flood prone areas. ◗ Locate and map sewage effluent fields in flood prone areas. ◗ Survey existing house floor levels in flood prone areas. ***Master Planning*** ◗ Master Planning of the stormwater network to determine and design the drainage network for the entire catchment. The Map Book identifies flooding areas in the catchment and indicates opportunities for a number of overland flow path systems to be improved and designated. Consultation with property owners will be required to designate the overland flow paths. Improved overland flow paths can significantly reduce widespread flooding in the catchment. Master Planning will enable decision-making on engineering remedial works and in the building consenting process and takes into account the development of the wider catchment. The plans would need to be well detailed so they can be used as a tool by Council staff to manage future development. Master Planning will lead to changes in the flood extents shown in the Map Book allowing greater flexibility for developers in building within a site in terms of building locations and floor levels. The identification of overland flow path corridors within the master planning will also enable the protection of the overland flow path systems. Engineering works should only be undertaken after master planning in the particular subcatchment is completed.

Table 16 Key Issues and Engineering Option 1 – Widespread Localised Flooding

Catchment	Issue/Descriptor	Management Options
All Catchments	**Infrastructure Capacity** *As in table 15 above*	**Engineering** ***Option 1 - Piped Drainage Network*** Due to the general flat topography of the catchment, the distances from the flood areas to the main waterways and the minimum lot size 5000 m², there would be a high cost per property to pipe the entire catchment. New pipe networks should only be considered to mitigate flooding in localised areas for the following cases; ◗ Roads and properties in the vicinity of the main waterways. ◗ For connection of overland flow path systems to the main streams. ◗ As a connection between channels, swales and overland flow path systems.

Table 17 Key Issues and Engineering Option 2 – Widespread Localised Flooding

Catchment	Issue/Descriptor	Management Options
All Catchments	**Infrastructure Capacity** *As in table 15 above*	**Engineering** ***Option 2 – Identify, Designate, Design and Construct Overland Flow Path Systems*** Overland flow paths, swales and open channels to convey the catchment flows through the catchment seem to be the most logical option to manage and mitigate localised flooding where a suitable route to the main waterways exists. However, there are a number of difficulties in implementing this option as follows; - Any overland flow path systems need to be specifically designated, protected and maintained to ensure they are in working order during storm events - Many of the overland flow path systems are on private property and consultation with property owners will be required to ensure that these systems remain and are maintained as part of the drainage system for the catchment - Some of the overland flow path systems may be located near sewage effluent disposal fields. Environment Waikato requires 2,500 m^2 minimum lot size to be provided if sewage effluent fields are proposed (Ref V1 – TCLZ/BBO) - Existing overland flow paths systems will need to be assessed for capacity and where possible enhanced and improved through re-shaping of ground, piping under roads and driveways and connecting various sections of the overland flow path - Improvements to the overland flow path system may mitigate flooding only in part and will need to be considered in conjunction with other options - Many flood areas do not have suitable overland routes to the main waterways.

Table 18 Key Issues and Engineering Option 3 – Widespread Localised Flooding

Catchment	Issue/Descriptor	Management Options
All Catchments	**Infrastructure Capacity** *As in table 15 above*	**Engineering** ***Option 3 – On-Site Stormwater Control & Catchment- Wide Attenuation*** On-site detention and soakage of stormwater will alleviate flooding by preventing runoff to collect in localised ponding areas. The main issues with on-site detention as an option to mitigate flooding are listed below; ◗ In this catchment, the percentage of roof area on each lot will be small when compared to the total lot area. Both the roof stormwater runoff and the site stormwater runoff should be considered for the on-site detention option. This will require larger detention systems. ◗ If the discharge from on-site detention is to an overland flow path system that discharges to a stream or watercourse (rather than to soakage), the downstream properties along the overland flowpath should in some cases not be required to detain stormwater on site. ◗ Where discharge from on-site detention is to ground soakage, information on soakage rates and groundwater issues should be investigated to ensure soakage is available. ◗ The net effect of on-site detention on flooding for individual subcatchments should be investigated prior to incorporating this option in WDC policy and standards. On-site stormwater control can be combined with catchment-wide in-line attenuation, storage and wetland creation. Wetlands can be created in the large areas that are flood prone. The main issues with this are; ◗ Some of these large flood prone areas may be in private property and land acquisition may be required. ◗ The existing gullies are well incised and generally have adequate capacity. Damming of parts of the gullies may be possible but these will need specific designs with full account of any environmental issues. ◗ Wetlands and attenuation ponds require high levels of maintenance and monitoring.

Table 19 Key Issues and Non-Engineering Options – Widespread Localised Flooding

Catchment	Issue/Descriptor	Management Options
All Catchments	**Infrastructure Capacity** *As in table 15 above*	**Operation & Maintenance** The following management option can be implemented to help mitigate flood risks; ◗ Pipe and culvert inlets to be regularly cleared to ensure that blockages do not occur during flood events. ◗ The capacity of open channels is to be maintained through regular cleaning. **Rules & Regulations** The following management option can be implemented to mitigate flood risks; ◗ Designing and building floor and road levels well above the predicted flood levels is the most feasible and reliable flood mitigation measure for the Tamahere catchment in terms of meeting the flood protection level of service for building floor levels and roads. As the minimum lot size is 5000 m² and in many areas, the flood depths are around 300 mm, buildings can either be positioned away from flood areas or built on a platform that is higher than the flood levels. However, the location of sewage effluent fields may be a critical factor in some cases. ◗ In some areas of the catchment where there is widespread localised flooding, the minimum lot size of 5,000 m² may not be feasible due to flooding and interaction of stormwater with sewage effluent. The minimum size of lots in these areas should be increased. **Education** The following material can be provided to guide developers; ◗ Guidelines on stormwater control methodologies. ◗ Guidelines on building in flood prone areas.

Table 20 Key Issues and Options – Ecological & Environmental

Catchment	Issue/Descriptor	Management Options
All Catchments	**Ecological & Environmental Values** The Tamahere catchment has many unnamed waterways that may be of significance in terms of ecological and environmental values. Increased development will increase stormwater runoff into these waterways potential causing erosion, sedimentation and accumulation of pollutants. The Tamahere catchment flow discharges into the Waikato River. Environment Waikato is working with Waikato-Tainui and other iwi to achieve the shared vision of a clean and healthy Waikato River. That vision is set out in the agreement between the Crown and Waikato-Tainui over management of the Waikato River between Karāpiro and Te Pūaha o Waikato (Port Waikato). It is anticipated that there will be strict rules on future development activities in catchments discharging to the Waikato River.	**Further Studies** Further studies are required to assess environmental issues in the Tamahere catchment as follows; - An ecological and environmental assessment of the waterways in the Tamahere catchment. - A fish passage assessment. - An assessment of the agreement between the crown and Waikato-Tainui over management of the Waikato River between Karāpiro and Te Pūaha o Waikato (Port Waikato) and how it impacts structure planning in the Tamahere Catchment. **Engineering** Future development in the catchment to be undertaken with mitigation of flows with a target of hydrologic neutrality to protect the gully streams in these catchments from erosion. LID principles to be applied to control runoff at source, as the first choice option. **Operation & Maintenance** Pipe and culvert inlets to be regularly cleared to ensure that blockages do not occur during flood events. **Rules & Regulations** Review of permitted impervious surface areas with a view to reducing maximum allowances, thus reducing runoff from new developments. Early checking and monitoring of a site's impervious surface areas. **Education** Undertake community wide stormwater appreciation programme with emphasis on benefits of controlling non-point source runoff, protecting stream banks with planting, the alternatives to hard surfaces to reduce runoff and the effect on capital works of accepting safe overland flow during infrequent events.

5. Implementation Plan

5.1 Introduction

Section 4.3 recommends a range of stormwater management options for the Tamahere Catchment. These management options have been discussed with WDC in terms of;

- Who will implement it;
- What it will cost to implement;
- The priority order in which it should be implemented;
- What monitoring will be undertaken to ensure the effectiveness of each strategy or action;

These options include both engineering works and initiatives that are of a non-engineering nature. The Management Options Implementation section below discusses the priority of the options and identifies options that are to be implemented.

5.2 Management Options Implementation

The stormwater management options from section 4.3 are summarised below with implementation actions that have been agreed with WDC.

5.2.1 State Highway / Annebrook Road Flood Mitigation Options - Table 14

Table 14 recommends further studies, engineering options, operations and maintenance procedures, rules and policies and education to mitigate flooding impacts from the waterway along State Highway 1 at the Annebrook Road intersection area.

Further studies and engineering is not a priority for WDC as the flooding impacts mainly on the State Highway.

Operations and maintenance procedures, rules and regulations and education as recommended in Table 14 should be implemented immediately by WDC utilising internal resources to manage the flooding risk.

5.2.2 Asset Data Collection & Master Planning Options - Table 15

Table 15 recommends asset data collection and master planning to understand and manage widespread localised flooding.

Asset data collection and master planning as recommended in Table 15 is a high priority for WDC. The studies can be staged depending on availability of budgets and timing of structure planning processes and rate of development in the catchment. The first stage of the studies should be identified through development of a project brief by WDC and implemented immediately.

Asset data collection should be undertaken utilising internal resources.

The indicative cost of the master planning is between $100,000 and $150,000. The cost estimate includes consultation with property owners, identification, modelling and concept design of overland flowpaths, pipes and ponds.

5.2.3 Engineering Flood Mitigation Options - Tables 16, 17 and 18

Tables 16, 17 and 18 recommend 3 engineering options to manage widespread localised flooding as follows;

- Option 1 - Piped Drainage Network
- Option 2 – Identify, Designate, Design and Construct Overland Flow Path Systems
- Option 3 – On-Site Stormwater Control & Catchment- Wide Attenuation

A combination of all three options should be implemented to manage widespread flooding in the catchment. Master Planning as discussed above will optimise the combined options and should be undertaken prior to any decision-making on the options. Catchment-wide in-line attenuation, storage and wetland creation as discussed in Table 18 is not recommended due to property acquisition requirement; however this should be considered where there are viable sites and as part of larger developments where there is Developer cost contribution.

The combined 3 options provide the general philosophy for flood mitigation in the catchment. Primary flows will be managed through on-site stormwater detention and soakage. Secondary flows will be managed through overland flow path systems through the catchment.

Cost estimates for engineering remedial works are dependant on the master planning study.

5.2.4 Non – Engineering Flood Mitigation Options - Table 19

Table 19 recommends operations and maintenance procedures, rules and policies and education to manage widespread localised flooding.

The rules and regulations recommendation in Table 19 is the most cost-effective flood risk mitigation option for the Tamahere catchment. The flood maps provided in the Map Book should be used to determine building platform location and levels for all new building consents. This option should be implemented immediately through a workshop on the findings of the study with WDC building consent personnel and the use of the electronic flood maps on WDC GIS database. The costs associated with this option should be minimal.

The operations and maintenance recommendations in Table 19 should be implemented through an internal review and update of operations and maintenance procedures for the Tamahere catchment. A robust Operations and Maintenance plan should be developed for the catchment that identifies critical drainage channels, inspection regimes and work programmes.

The education recommendations in Table 19 should be implemented through an internal review and update of WDC guidelines provided for developers.

5.2.5 Ecological & Environmental Protection Options - Table 20

Table 20 recommends further studies, engineering options, operations and maintenance procedures and education to manage the ecological values of the waterways.

The priority of this option is low at this stage in terms of the other recommendations above and should be reviewed after the completion of the asset data collection and master planning options.

Cost estimates for the recommendation in Table 20 will be dependant on master planning of the drainage network, directives arising from the Crown/Waikato-Tainui agreement on management of the Waikato

River, rate of development in the catchment and Environment Waikato / WDC policies on environmental protection.

5.3 Catchment Management Plan Update

5.3.1 Introduction

This Stormwater Catchment Management Plan for the Tamahere catchment has been prepared based on the scope and objectives discussed in section 1 and availability of data at the date of preparation. Management options that are to be implemented have been discussed and agreed with WDC. This Stormwater Catchment Management Plan is a live document and updates are to be managed in this section. Updates are required if there are any changes that impact the findings of this Stormwater Catchment Management Plan and as implementation actions are completed. A number of changes can significantly impact on this Plan and can include changes to WDC objectives, plans and policies, catchment characteristics and legislative requirements.

Appendix A

Subcatchment Parameters

Appendix B

Map Book

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Document Status

Rev No.	Author	Reviewer		Approved for Issue		
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