



Dunedin 3 Waters Strategy



Mason Street Integrated Catchment Management Plan



Mason Street Integrated Catchment Management Plan 2010-2060

Contract No. 3206 Dunedin 3 Waters Strategy



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Executive Summary

The Mason Street Integrated Catchment Management Plan 2010-2060 (ICMP) is one of ten long term ICMPs to be developed as part of the 3 Waters Strategy recently undertaken by Dunedin City Council (DCC).

In 2007, short term stormwater discharge consents were granted by the Otago Regional Council (ORC), permitting stormwater discharges into the Otago harbour pending the development of stormwater catchment management plans. The emphasis of such plans is on monitoring stormwater quality and mitigating stormwater effects on the harbour's receiving environment.

Strategic objectives of stormwater management provide the overarching objectives that guide the development of this ICMP. These objectives are at the core of the relevant statutory and non-statutory documents addressing stormwater management, including the 3 Waters Strategic Direction Statement. These objectives have been developed with the aim of achieving benefits across the four 'wellbeings' (environmental, social, economic and cultural), within the context of a 50 year timeframe, and cover the following:

- Development;
- Levels of service;
- Environmental outcomes;
- Tangata whenua values;
- Natural hazards; and
- Affordability.

The Mason Street catchment is relatively large, covering an area of approximately 210 ha and incorporates the areas of South Roslyn and Bellknowes down to the harbourside, including parts of the CBD.

The natural stream network in this catchment comprises three streams with natural channels located within the Town Belt. The upstream sections of the channels are piped and receive flow from an urban residential area. Downstream, at the edge of the Town Belt, the flow within the stream channels is diverted via pipework to an outfall discharging to the Otago harbour.

The Otago Harbour is the receiving environment for the stormwater discharges from this catchment. It also receives stormwater and other discharges, at various points throughout the upper harbour. The harbour is 23 km long and has been heavily modified by reclamation, transport causeways and dredging. There are a number of stormwater and other discharge points into the upper harbour, carrying a variety of contaminants. The harbour is considered an important area for recreation and tourism and is also of great significance to local Māori.

Monitoring of the harbour environment has been carried out annually in accordance with the conditions of resource consent for DCC stormwater discharges. To date four rounds of biological, and stormwater quality monitoring have been undertaken (2007 to 2010). Variability in monitoring results and small datasets makes it difficult to establish stormwater quality and identify a link between the stormwater quality and the health of the receiving environment.

A linked 1 and 2-dimensional hydrological and hydraulic model of the Mason Street catchment and stormwater network was developed to replicate the stormwater system performance. The model also



predicts flood extents during a number of different land use types, storm events and climate change scenarios.

Flow monitoring was undertaken for this catchment and the model calibrated to replicate the observed flow, depth and velocity data as well as was possible, confidence in the model is considered to be moderate to high.

An assessment of environmental effects identified a number of stormwater related issues. This was based on the interpretation of the outcomes of the stormwater network hydraulic modelling; marine and stream assessments; information gathered during catchment walkovers; DCC flood complaints records; and information gathered during workshops with DCC Network Management and Maintenance staff,

Stormwater issues were prioritised, and management targets and catchment specific approaches were developed for the Mason Street catchment based on each issue, and the strategic objectives for stormwater management. Table ES-1 below summarises the key issues, effects, targets and catchment specific approaches for the Mason Street catchment.

The prioritisation score assigned to each issue indicates whether active or passive management is required. Active management indicates that DCC will seek to implement changes to stormwater management in the catchment, whereas passive management would tend more towards monitoring and review of existing management practices to ensure that the targets set can be met.

Of all of the issues identified in the catchment, only four issues were identified as requiring active management:

- High variability of stormwater quality results;
- Undefined effects on the Otago Harbour environment;
- Deep flooding (current and future); and
- Flood hazard (current and future 1 in 100 yr Average Recurrence Interval (ARI)).

The remaining issues were categorised as requiring passive management. This is predominantly due to the location, short duration, or shallow depth of predicted flooding in the catchment.

For the majority of the issues identified in this catchment a limited number of management options were available when taking into account the catchment specific approach and targets set. This resulted in recommendation of all options presented, with a priority placed in according to issue prioritisation.

Tables ES- 2 to ES-5 outline the recommendations, split into further studies, planning and education, operation and maintenance, and capital works tasks. The further studies recommended will assist in improving certainty around catchment management targets, or provide further information in order to develop options. Note that where a recommendation is to be resourced internally at DCC, a cost of \$0 has been assigned.

The implementation of these recommendations will be determined by the 3 Waters Strategic Plan, which will assess all of the ICMPs developed by DCC, and develop a prioritised programme of works across the city.



Table ES 1: Mason Street Catchment Issues, Approach and Targets Summary

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the Resource Management Act. Ensure stormwater discharge quality does not deteriorate.	Manage Actively Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Develop method for determining linkages between stormwater management and harbour environment. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality. Undertake monitoring to ensure stormwater quality does not deteriorate over time. Incorporate a feedback process to the ICMP if / when monitoring indicates potential adverse effects from stormwater discharges.	Robust city-wide monitoring framework developed and implemented by 2012. Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 7 parcels affected by deep flooding during 1 in 10 yr ARI rainfall event; rises to 24 properties during 1 in 50 yr ARI rainfall event in current and future planning scenarios. Large number of properties affected during extreme climate change scenario. Flooding during low frequency events mostly predicted exterior to buildings (although surveys not yet undertaken).	Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Reduce number of properties predicted to flood during a current 1 in 10 yr ARI rainfall event. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 24 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event by 2060. Undertake habitable floor survey and / or damage assessment of potentially flooded properties. > 65 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.
Flood Hazard – Current and Future 1 in 100 yr ARI	Areas of 'significant' flood hazard in roadways, mostly in central city, predicted during current event. 'Significant' flood hazard in roadways in central city, with increased flood extent, predicted in the future (2060) event predominantly due to tidal inundation, exacerbated by predicted climate change effects.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc.) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas will be available. Develop a better understanding of the likely effects and magnitude of climate change.	Develop a catchment specific emergency response plan by 2012. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Potential Wastewater Contamination	High microbial contamination of stormwater, particularly in 2010, may be cause for concern.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	Manage Passively Undertake targeted monitoring to enable better understanding of potential catchment contamination. Investigate potential sources of wastewater contamination. Develop appropriate management options to remediate problem where necessary.	Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012. Implement management options to remediate problem where necessary.
Network Maintenance	Flooding extents and durations in the Mason Street catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013. Develop list of key stormwater assets in Mason Street catchment requiring additional cleaning and maintenance checks by 2013.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Blocking / Maintenance of Intake Structures	Potential blockage of inlet screens at Queens Drive / Serpentine Avenue and Canongate Road could exacerbate downstream flooding.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Work with property owners to ensure intakes and screens are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets in the catchment (in conjunction with city-wide criteria) by 2012. Develop list of key stormwater intake structures in Mason Street catchment requiring additional cleaning and maintenance checks by 2013. Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Low Level of Service	General low level of service of stormwater network (less than 1 in 10 yr ARI), driven by both pipe capacity and tidal influence. 18 % of manholes predicted to overflow during a current 1 in 10 yr ARI rainfall event, pipes flowing full throughout a large proportion of system. Overflow is currently occurring, no capacity for climate change effects. Effects mainly nuisance flooding, affecting approximately 1 % of the catchment currently, and 2 % of catchment in future 1 in 10 yr ARI rainfall event.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Maintain or improve existing level of service in network – ensure no increase in the number of stormwater manholes predicted to overflow in a 1 in 10 yr ARI rainfall event. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Use customer complaints and residents' opinion survey (ROS) to gauge satisfaction with the stormwater system performance.	> 65 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. < 18 % manholes predicted to overflow during a 1 in 10 yr ARI rainfall event by 2060. < 1 % of catchment surface predicted to flood during a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Nuisance Flooding	Nuisance flooding on regular basis in a small number of areas, particularly tidally influenced locations. Causes some partial road blockages. Affects < 0.05 % of catchment during 1 in 2 yr ARI rainfall event, and 1 % of catchment during a 1 in 10 yr ARI rainfall event.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Passively Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 0.02 % of catchment surface area predicted to flood during a 1 in 2 yr ARI rainfall event by 2060. > 65 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate existing / historical contaminant issues. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	Manage Passively Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.



Table ES 2: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	\$ 20 k	3 - 6 months
50	Undertake further stormwater monitoring to investigate the extent of potential wastewater contamination and likely sources within the catchment.	\$ 20 k	6 - 8 months
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	\$ 0	Ongoing
80	Improve quality of stormwater network data (through level survey, GIS (geographic information system) confirmation, CCTV (closed circuit television)).	\$ 0	Ongoing
80	Undertake feasibility study to optimise capital works and enable design of the most robust, long term solution for resolving catchment flooding.	\$ 100 – \$ 150 k	tba
80	Identify and undertake floor level survey and damage assessment of properties potentially internally affected by deep flooding (up to a 1 in 50 yr ARI).	\$ 20 k	3 - 6 months

Table ES 3: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
70	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	\$ 0	6 - 12 months
70	Develop an emergency response plan for the catchment to ensure evacuation from flooded areas is possible during a large storm event.	\$ 0	6 - 12 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	\$ 0	2 months
40	Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.	\$ 20 k	6 months



Table ES 4: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Implement the revised city-wide monitoring framework.	\$ 25 k	Annual
50	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include the Queens Drive / Serpentine Avenue and Canongate intake screens.	\$ 5 k	2 months
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	\$ 20 k	2 months

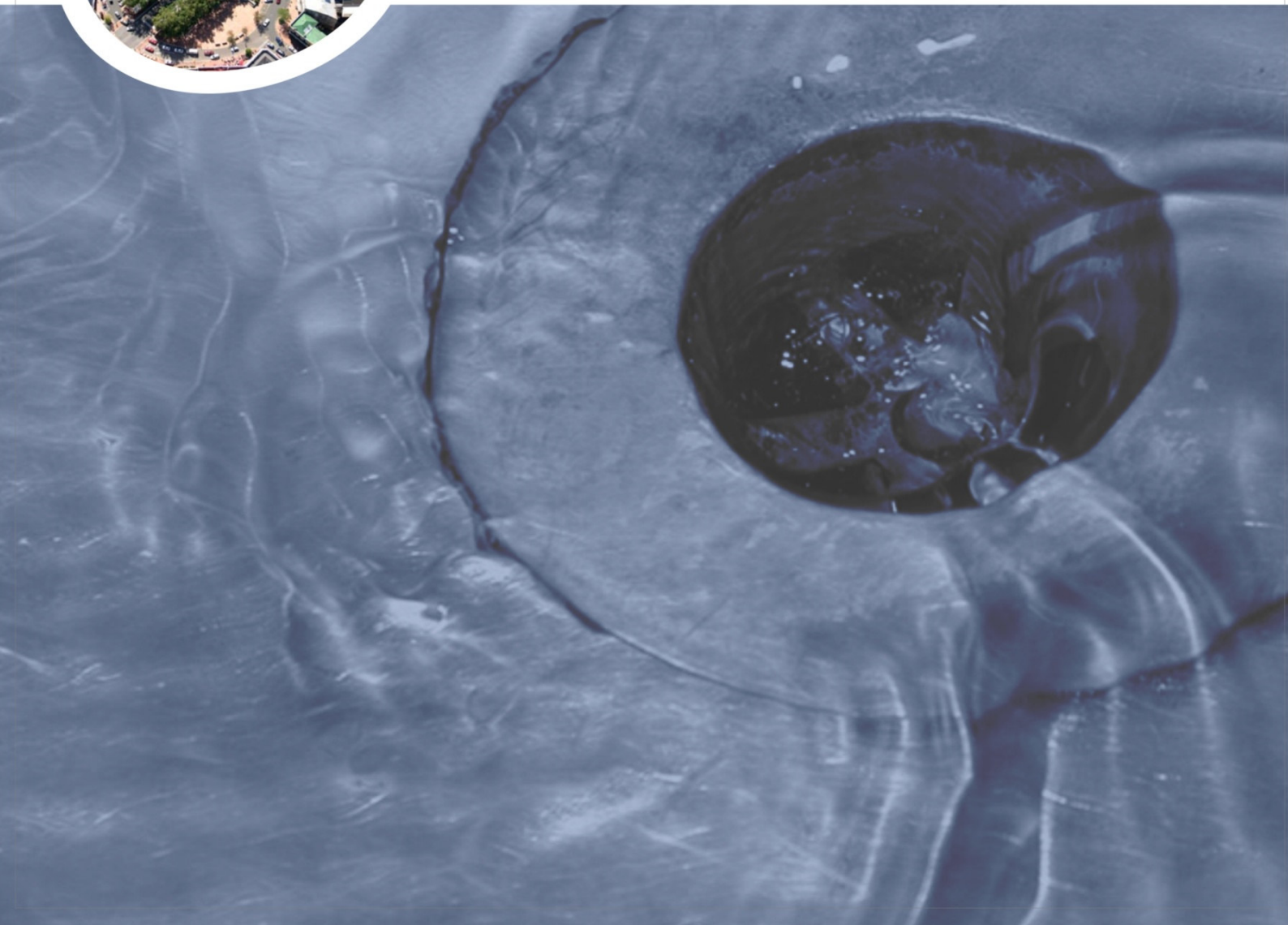
Table ES 5: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
80	Include additional or improved catchpits in all stormwater capital works.	tba	Ongoing



Part 1

Introduction





1 Introduction

1.1. Background

Dunedin City Council (DCC) is currently in the process of implementing an integrated approach to asset management, and a business improvement project in order to meet capital and operational delivery targets. The process has two main components. The first; review of the existing business structure was completed in 2009. This established a better alignment between people, processes and outcomes. The second; to undertake a significant strategy development project incorporating the three water networks; water supply, wastewater and stormwater. The 3 Waters Strategy project Phases 1 and 2 were completed in 2011, and included the development of hydraulic models examining the entire water cycle within Dunedin's urban catchments, providing critical information on the performance of the networks. The 3 Waters Strategy outcomes are used to inform decisions on future capital expenditure programmes to address the following:

- Current known issues in the networks;
- Urban growth;
- Climate change; and
- Environmental sustainability (particularly in relation to new stormwater consents).

As part of this future strategy the 3 Waters Strategy project has been developed with the aim of providing an integrated decision making process for DCC.

The objectives of the 3 Waters Strategy are:

- Determine required levels of service for each of the three waters networks.
- Determine capital and operational costs associated with improvements to the three waters networks, including priorities and phasing for investment.
- Develop a greater understanding of the operations of the three waters networks through targeted asset and flow data collection.
- Develop decision support tools including network models.
- Develop Integrated Stormwater Catchment Management Plans.
- Provide sufficient data to support the development of council's Annual Plan and Long Term Plan (LTP).

To achieve the objectives of the Strategy the project comprises a three phase process:

Phase 1: Development of capital and operational investment needs at a macro level, determine the needs for more detailed investigations to be carried out in Phase 2, and determine high priority capital and operational works for major infrastructure items to be carried out in Phase 3.

Phase 2: Detailed investigations to determine capital and operational needs at a catchment or zonal level.

Phase 3: Implementation of capital and operational works to realise the required level of service improvements.



1.2. Context

The development of the Mason Street Integrated Catchment Management Plan (ICMP) 2010-2060 (ICMP) is part of the 3 Waters Strategy being undertaken by DCC, as described above. This ICMP is one of ten long term plans to be developed to fulfil consent requirements relating to the discharge of stormwater to the Otago Harbour, as well as to provide future direction for DCC's stormwater management at a catchment specific scale.

In 2007, short term (5 year) stormwater discharge consents were granted by the Otago Regional Council (ORC), permitting stormwater discharges into the Otago Harbour pending the development of stormwater catchment management plans. The emphasis of such plans is on monitoring stormwater quality and mitigating adverse stormwater effects on the harbour's receiving environment. These short term consents will be replaced with long term (35 year) consents following the completion of ICMPs.

Appendix A contains the short term stormwater discharge consents granted for the Mason Street catchment (via one outfall). The consent (Consent No. 2002.097) has a condition which states the following:

"In consultation with the Consent Authority, the consent holder shall prepare and forward to the Consent Authority within four years of the commencement of this consent, a Long Term (35 year) Stormwater Catchment Management Plan for the foreshore catchment that shall contribute to the effective and efficient management of stormwater in that catchment to minimise contamination of stormwater and mitigate any adverse effects caused by contaminant discharge and accumulation in the receiving environment..."

In 2008, a high level Quadruple Bottom Line (QBL) assessment of the ten largest stormwater catchments discharging to the harbour was undertaken, and identified South Dunedin as the highest priority catchment in terms of stormwater issues (refer 'Dunedin 3 Waters Strategy, Stormwater Catchment Prioritisation Framework'; URS, 2008). Following the development of the ICMP for South Dunedin, the remaining stormwater catchments were re-prioritised, whereby the economic, social, cultural and environmental aspects of the catchments' assets were gauged based on 12 QBL indicators. The four QBL 'wellbeings' (categories) and 12 indicators were each defined and weighted in consultation with DCC Water and Waste Business Unit to ensure that indicators which are considered most important have a greater impact on the final score than indicators which are considered less important at this stage. Each of the remaining nine catchments were then scored against the indicators on a scale of zero to five (zero representing 'no issue' and five, a 'significant issue'), thus producing a final weighted score and ranking of the catchments. The results of this QBL prioritisation assessment are presented in Table 1-1 and further details can be found in the report: 'Phase 2 Stormwater Catchment Prioritisation Framework' (URS, 2009).

The Mason Street catchment ranked third out of the nine studied, with particularly high scores relating to water quality incidents and wastewater / stormwater system interaction.

The scope of works for this ICMP was developed to collect sufficient information about current stormwater management in the catchment, as well as the effects of current practices. Objectives for stormwater management have been set by the 3 Waters Strategic Direction Statement in conjunction with objectives for water supply and wastewater management. Recommendations for future stormwater management are required to meet these objectives, based around avoiding, remedying or mitigating adverse effects of stormwater discharges on both the catchment itself and the receiving environment. Integration of stormwater, wastewater and water supply management is a key



consideration throughout this ICMP, and further opportunities for integrated solutions in this catchment between the water supply, wastewater and stormwater networks, is likely to be in the co-ordination of the DCC capital works programme.



Table 1-1: Phase 2 Catchment Prioritisation

QBL Category	Label	Indicator	Main Weighting (%)	Sub Weighting (%)	Halsey Street	Orari Street	Mason Street	Kitchener Street	Shore Street	Port Chalmers	Port of Callaghan	Port of Taranaki	Port of St Clair
Economic	1A	Annual OPEX	35	100	3	2	0	0	0	0	0	0	0
Social	2A	Community Pressures	-	-	-	-	-	-	-	-	-	-	-
Cultural	3A	Iwi (Kāi Tahu) considerations	20	100	4	4	4	4	4	4	4	4	3
Environmental	4A	Sensitivity of Receiving Environment	45	10	3	3	3	3	4	3	3	3	1
	4B	Asset condition / age / capacity restraints		25	3	3	3	3	3	3	1	1	3
	4C	Reported Flooding incidents		10	4	2	3	1	2	1	1	3	2
	4D	Reported Water Quality incidents		10	4	2	4	3	1	3	1	0	2
	4E	Presence of point source pollution sources		20	3	2	3	3	1	2	4	4	1
	4F	Presence of diffuse pollution sources		10	3	2	3	3	2	0	5	3	1
	4G	Development proposed within catchment		-	-	-	-	-	-	-	-	-	-
	4H	Sediment generating / erosion areas		10	3	2	2	1	2	1	0	0	2
	4I	Potential for waste / stormwater system interaction		5	4	3	4	2	2	4	1	1	2
Weighted Score:					3.31	2.58	2.17	1.95	1.77	1.75	1.7	1.43	
Rank:					1	2	3	4	5	6	7	8	9



1.3. Overview

This ICMP comprises six parts:

Part 1 – Introduction. This section provides the background to the study, and outlines the planning and statutory requirements of DCC with respect to stormwater discharge management.

Part 2 – Baseline. This part of the report describes the stormwater catchment as it is now – topography, land use, receiving environments, stormwater discharge quantity and quality. The stormwater network is also described and current operational and capacity issues discussed.

Part 3 – Analysis. Stormwater management problems and issues are identified in this section, by analysing the results of contaminant and network modelling, flood hazard mapping and other information collated in previous sections.

Part 4 – Targets. Catchment stormwater management approaches and SMART targets are outlined in this section, as determined by the priority of each issue, and DCC's stormwater management objectives.

Part 5 – Solutions. This section describes a number of potential solutions to the issues identified (stormwater quantity and quality).

Part 6 – Way Forward. A prioritised programme of works is outlined, based on the Optimised Decision Making Framework developed for the DCC 3 Waters Strategy.

Figure 1-1 presents the scope of work for the stormwater component of the 3 Waters Strategy, including prioritisation of the catchments.

Figure 1-2 provides a process diagram of the ICMP process used for this project. The figure also indicates the position and influence of stakeholder consultation within this process. Ongoing consultation ensures that the project advances in a way that meets the needs and expectations of all parties involved. It can also significantly benefit the project by providing invaluable local knowledge and assist in identifying significant issues. Furthermore, successful consultation during development stages can often assist implementation of the ICMP.

An ICMP document is designed to accommodate a number of changes during its useful life, via monitoring and review processes (refer Section 17). Changes within the catchment, results of monitoring, or improved system knowledge are a number of things that may prompt a change in the ICMP.

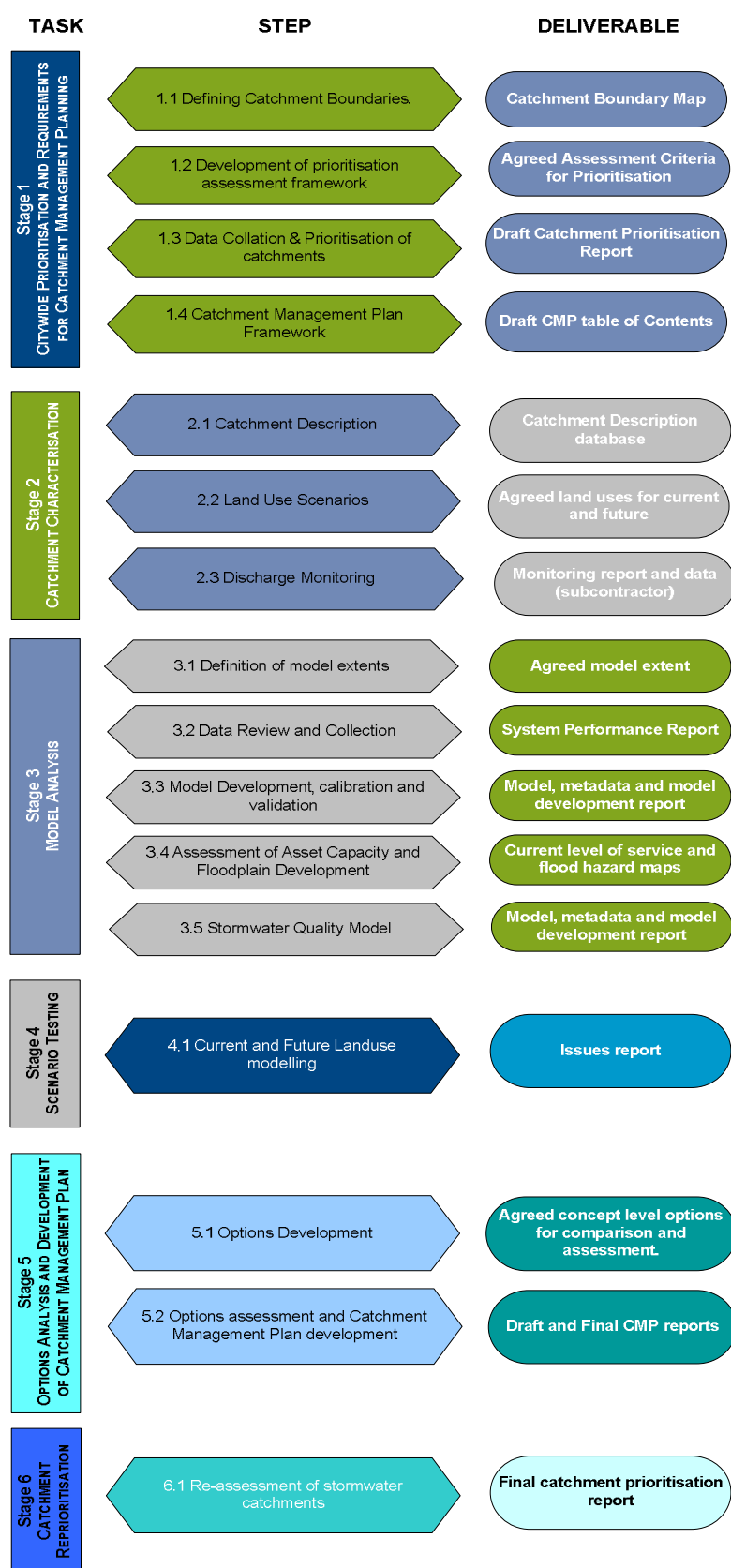


Figure 1-1: Scope of Work

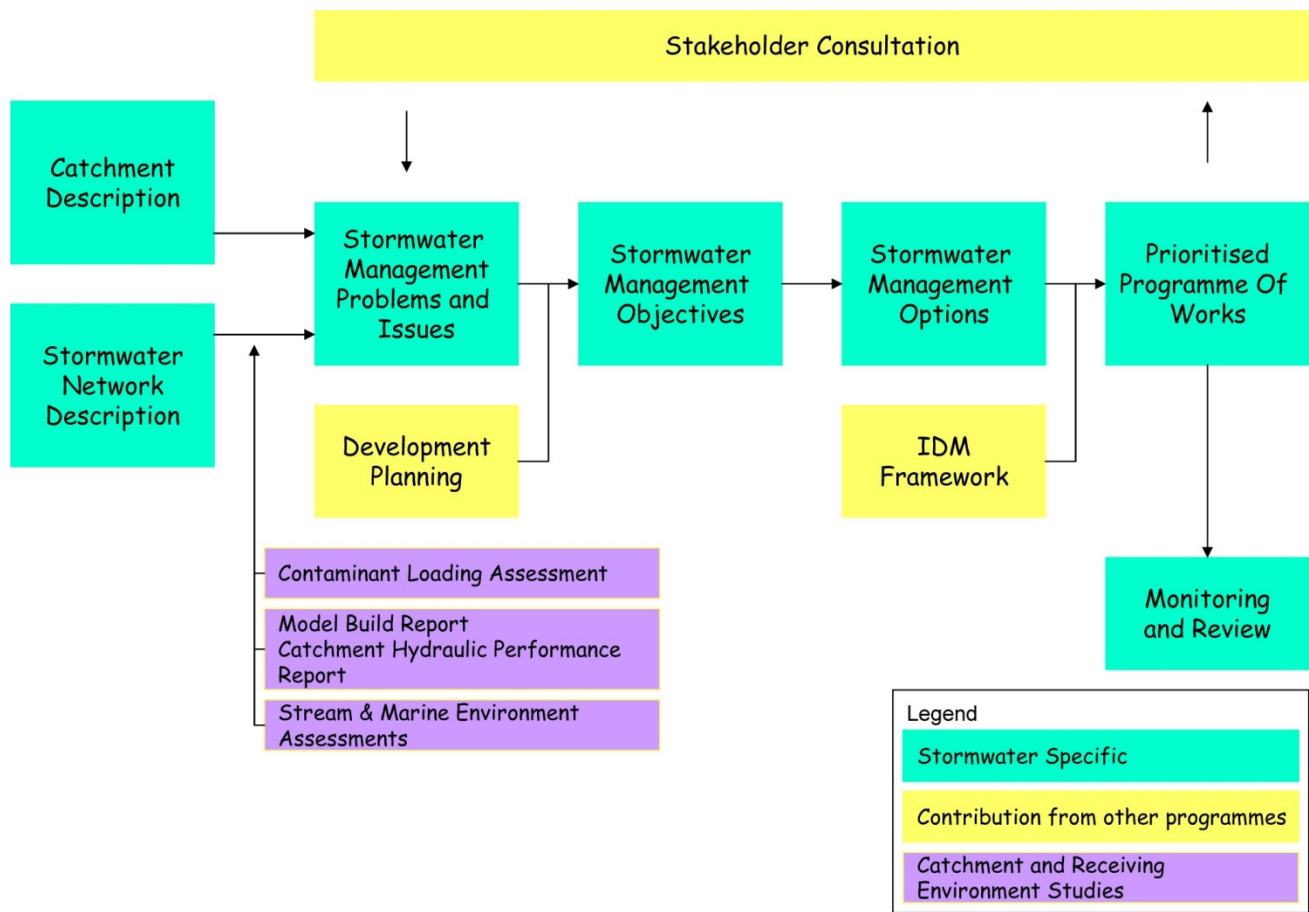


Figure 1-2: ICMP Development Process



2 Planning and Statutory Background

2.1 Planning Framework

An ICMP, and any stormwater development undertaken where the ICMP is applied, should be consistent with the objectives of national, regional and district planning documents and several key non-statutory documents. Figure 2-1 below provides the hierarchies of legislative and planning documents, both statutory and non-statutory which interact with this ICMP. As shown by the double ended arrows, there is often a two-way interaction between the ICMP and these documents.

The influence of each of the key statutory and non-statutory documents relating to stormwater management and the development of an ICMP are discussed in Sections 2.2 to 2.6. It is important to note that these documents are subject to review and change. Therefore, the ICMP must be sufficiently flexible to endure variations to these documents while remaining relevant. In some cases the ICMP may provide direction to these variations.

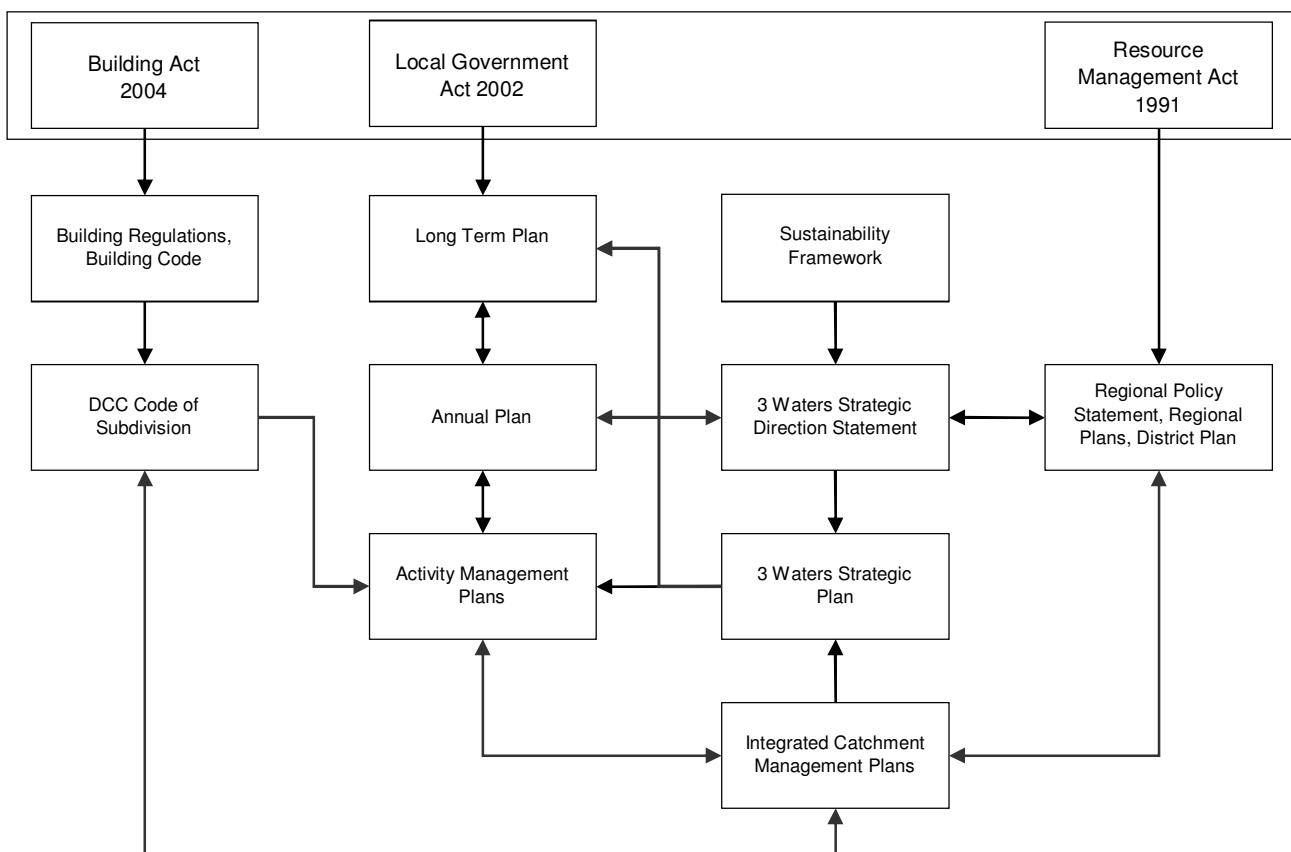


Figure 2-1: Legislative and Planning Document Hierarchies



2.2 The Local Government Act (2002)

The purpose of the Local Government Act 2002 (LGA) is to provide for democratic and effective local government that recognises the diversity of New Zealand communities and, to that end, this Act—

- (a) *States the purpose of local government; and*
- (b) *Provides a framework and powers for local authorities to decide which activities they undertake and the manner in which they will undertake them; and*
- (c) *Promotes the accountability of local authorities to their communities; and*
- (d) *Provides for local authorities to play a broad role in promoting the social, economic, environmental, and cultural wellbeing of their communities, taking a sustainable development approach.*

There are a number of responsibilities outlined within the LGA which are relevant to the ICMP. These include:

- Section 93, LTP;
- Section 95 Annual Plan; and
- Compliance with performance measures set by the Secretary of Local Government.

An ICMP needs to be consistent with the LGA. This can be achieved by promoting consultation with all parties affected by stormwater management decisions and accounting for and managing the stormwater infrastructure for Dunedin City in a manner that provides for the present and future needs of the public and the environment.

2.2.1 Long Term Plan (LTP)

Section 93 of the LGA requires a local authority to produce a LTP for the following purposes:

“to describe the activities of the local authority; to describe community outcomes; to provide integrated decision making and co-ordination of resources; to provide a long term focus for decisions and activities; and provide a basis for the accountability of the local authority to the community.”; and to provide an opportunity for participation by the public in decision making processes.”

2.2.2 Annual Plan

The Annual Plan required under Section 95 of the LGA supports the LTP by providing for the co-ordination of local authority resources, contributing to the accountability of the local authority to the community, and extending the opportunities for participation by the public in decision making relating to costs and the funding of local authority activities.

2.2.3 Performance Measures

The Secretary of Local Government is required to provide regulations that establish rules specifying performance measures for water supply; sewerage treatment / disposal; stormwater; flood protection and the provision of roads and footpaths. The performance measures relating to stormwater, wastewater and flood protection will need to be taken into account when developing solutions under the ICMP.



2.2.4 Trade Waste Bylaw

The DCC Trade Waste Bylaw 2008 regulates the discharge of Trade Waste to a Sewerage System operated by the DCC. The purpose of the Bylaw is

“to control and monitor trade waste discharges into public sewers in order to... (v) protect the stormwater system.”

Section 4A of the Bylaw states that it is an offence to discharge stormwater into the stormwater system that does not satisfy the discharge acceptance standards outlined in Schedule 1E of the Bylaw. Schedule 1E contains a number of acceptance standards, including limitations on the quality of the stormwater.

2.3 Resource Management Act (1991)

The purpose of the Resource Management Act (RMA) as defined in Section 5 of the Act is to promote the sustainable management of New Zealand’s natural and physical resources. This is to be achieved by managing the use of resources, in a manner that allows for people and communities to provide for their social, economic and cultural wellbeing, while sustaining the potential of natural and physical resource to meet the needs of future generations; safeguarding the life supporting capacity of air, water, soil and ecosystems; and avoiding, remedying or mitigating adverse effects of activities on the environment.

Section 6; Matters of National Importance, Section 7; Other Matters and Section 8; Treaty of Waitangi outline values which all persons exercising functions and powers under the RMA shall recognise and provide for, have particular regard to and take into account when achieving the purpose of the RMA.

Sections 14 and 15 of the RMA place restrictions on taking and using water, and on the discharge of contaminants into the environment.

In relation to stormwater management, the RMA therefore addresses the following:

- The need to sustainably manage our water resources to meet the needs of future generations;
- The need to preserve the natural character of our coastal environment, wetlands, lakes, rivers and their margins;
- Recognising and providing for the relationship of Māori with their ancestral lands and water;
- The control of the use of land for the purpose of the maintenance and enhancement of the quality of water in water bodies and coastal water;
- The control of discharges of contaminants and water into water;
- The control of the taking, use, damming and diversion of water, and the control of the quantity, level and flow of water in any water body, including:
 - i) The setting of any maximum or minimum levels or flows of water;
 - ii) The control of the range, or rate of change, of levels or flows of water.

It is considered that the development and implementation of an ICMP which is consistent with the purpose and principles of the RMA, will allow for the identification of in-catchment values, such as drainage patterns and sensitive receiving environments. Management recommendations are then made based on the best practicable option, to ensure that the natural and physical environment



within a stormwater catchment and its receiving environment are managed sustainably. This approach helps to ensure that the natural and physical resources within Dunedin's stormwater catchments are used in a way that provides for the community's social, economic and cultural wellbeing.

2.3.1 The New Zealand Coastal Policy Statement (2010)

The purpose of the New Zealand Coastal Policy Statement 2010 (NZCPS) is to outline policies relevant to the coastal environment to achieve the purpose of the RMA. The term "coastal environment" is broad, and although undefined in the RMA, it is generally considered an environment in which the coast is a significant element or part.

The NZCPS requires persons exercising functions and powers under the RMA to:

- Safeguard the integrity, form, functioning and resilience of the coastal environment and sustain its ecosystems, including marine and intertidal areas, estuaries, dunes and land;
- Preserve the natural character of the coastal environment and protect natural features and landscape values;
- Take account of the principles of the Treaty of Waitangi, recognise the role of tangata whenua as kaitiaki and provide for tangata whenua involvement in management of the coastal environment;
- Maintain and enhance the public open space qualities and recreation opportunities of the coastal environment, enable people and communities to provide for their social, economic, and cultural wellbeing and their health and safety, through subdivision, use, and development; and
- Ensure that management of the coastal environment recognises and provides for New Zealand's international obligations regarding the coastal environment, including the coastal marine area (CMA).

Policies within the NZCPS contain potential restrictions on the activities likely to be undertaken in relation to stormwater management and have been considered when making recommendations within this ICMP. Policy 23 (2) and (4), addressing the discharge of contaminants has particular relevance for Dunedin City.

Policy 23(2)(a) does not allow discharges of human sewage directly to water in the coastal environment without treatment unless there has been adequate consideration of alternative methods, sites and routes for undertaking the discharge that have been informed by an understanding of tangata whenua values and the effects on them. DCC does not currently have any planned direct sewage discharges. However the wastewater infrastructure network does have emergency overflow facilities to the coastal environment. These facilities are to accommodate emergency overflow discharges only. All discharges during non-emergency events are provided for through the existing wastewater network. Adequate consideration has been given to alternatives to a coastal discharge by providing an alternative for any non-emergency events therefore the current discharge scenario is consistent with this policy.

Policy 23(4) outlines steps to be taken to avoid the effects of a stormwater discharge on water in the coastal environment. These steps include:



- Avoiding where practicable and otherwise remedying cross contamination of sewage and stormwater systems;
- Reducing contaminant and sediment loadings in stormwater at source, through contaminant treatment and by controls on land use activities;
- Promoting integrated management of catchments and stormwater networks; and
- Promoting design options that reduce flows to stormwater reticulation systems at source.

The ICMP process by definition promotes the integrated management of catchments. Recommendations made within the ICMP will incorporate the other steps outlined where appropriate or required as determined by the results of stormwater quality and quantity monitoring.

The Mason Street catchment discharges into the Otago Harbour, which links with the Pacific Ocean, therefore the NZCPS must be considered when developing and implementing the ICMP. The ICMP provides a detailed assessment of the effects of current land use and development within the Mason Street catchment on the Otago Harbour. It is considered that the ICMP approach is consistent with the holistic nature of the NZCPS in particular Policy 23(4)(c), and that the stormwater management options considered by the ICMP regarding stormwater management options such as source control, treatment devices, low impact design, and community education will ensure that the adverse effects of stormwater runoff on the coastal environment will be avoided, remedied or mitigated.

2.3.2 Marine and Coastal Area Act (2011)

The Marine and Coastal Area Act repeals the Foreshore and Seabed Act 2004, and removes Crown ownership of the public foreshore and seabed.

The Act provides that any part of the common marine and coastal area owned by a local authority will form part of the common marine and coastal area, divesting local authorities of those areas. Current freehold title in existing reclamations would remain.

The Act states that resource consents in the common marine and coastal area that were in existence immediately before the commencement of the Act are not limited or affected by the Act. Existing leases, licences, and permits will run their course until expiry. Coastal permits will be available for the recognition of these interests after expiry.

The Act provides that, while there is no owner of the common marine and coastal area, existing ownership of structures and roads in the area will continue. New structures can be privately owned. Structures that have been abandoned will vest in the Crown so that it can ensure that health and safety laws are complied with.

The Marine and Coastal Area Bill was enacted on 24 March 2011. Stakeholder consultation will incorporate discussion on the Marine and Coastal Area Act.

2.3.3 National Environmental Standards

While there are currently no National Environmental Standards (NES) relevant to this ICMP it is assumed that NES will be developed in time for the type of activities covered under the ICMP. As local or regional councils must enforce standards imposed by an NES the ICMP must be flexible enough to incorporate these standards.



2.3.4 The Otago Regional Policy Statement (1998)

The Otago Regional Policy Statement (ORPS) is an operative document giving effect to the RMA. The ORPS discusses issues, objectives and policies relating to managing the use, development and protection of the natural and physical resources of the region. The ORPS identifies regional issues and provides a policy framework for managing environmental effects associated with urban and rural development.

The ICMP is influenced by the ORPS and the planning documents which sit below it (i.e. the Regional Plans). There are a number of policies contained within the ORPS which are relevant to the ICMP. Of particular relevance are Policies 6.5.5, 7.5.3, 8.5.6, 9.5.4 which seek to reduce the adverse effects on the environment of contaminant discharges through the management of land use, air discharges, coastal discharges and the built environment. The management options discussed include adopting baseline water quality standards and where possible improving the quality of water to a level above these baselines. The policies mentioned give general guidance to any stormwater management initiatives within the Region by identifying anticipated environmental outcomes. This general guidance is the main starting point for determining the direction of the ICMP.

The ORPS also addresses natural hazards in Policies 11.5.2, 11.5.3 and 11.5.4. These policies give direction to hazard management through outlining steps that should be taken to avoid or mitigate the effects of natural hazards. With flooding being an issue within the Mason Street catchment these overarching policies may play a significant role in providing direction for the ICMP if natural hazards are determined to be a priority.

The ORPS was due for full review in October 2008 however at the time this report was written the review process has not been initiated.

2.3.5 The Regional Plan: Coast for Otago

The purpose of the operative Regional Plan: Coast for Otago (Coastal Plan) is to provide a framework to promote the integrated and sustainable management of Otago's coastal environment. The Coastal Plan recognises that the coastal environment is one of the integral features of living in the Otago Region, and that it is dynamic, diverse and maintained by a complex web of physical and ecological processes. One of the principle considerations for the ICMP is the discharge of contaminants into the CMA.

Chapter 10 of the Coastal Plan addresses the discharge of contaminants to the CMA. This chapter contains a number of policies addressing issues such as; the effects of any discharge on Kāi Tahu values, avoiding effects on coastal recreation areas, areas of significant landscape or wildlife habitat value, water quality, mixing zones and discharge alternatives.

Policy 10.4.1 states that for any discharges to the CMA that are likely to have an adverse effect on cultural values Kāi Tahu will be treated as an affected party. Details relating to issues of particular significance are contained within the Kāi Tahu ki Otago Natural Resource Management Plan which is addressed below.

Objective 10.3.1 seeks *"to maintain existing water quality within Otago's coastal marine area and to seek to achieve water quality within the coastal marine area that is, at a minimum, suitable for contact recreation and the eating of shellfish within 10 years of the date of approval of this plan"*. Further, Policy 10.4.3 states that where water quality already exceeds these standards, water quality should not be degraded beyond the limits of a mixing zone associated with each discharge.



2.3.6 The Regional Plan: Water for Otago

The operative Regional Plan: Water for Otago (Water Plan) considers the use, development and protection of the fresh water resources of the Otago region, including the beds and margins of water bodies. Chapter 7 of the Water Plan outlines objectives and policies to address those issues relating to water quality and discharges.

Policies 7.7.3, 7.7.4, 7.7.5 and 7.7.7 outline matters which need to be considered when assessing resource consents for discharges including cumulative effects, the sensitivity of the receiving environment and any relevant standards. Policies 7.7.10 and 7.7.11 address stormwater systems directly, identifying required outcomes for new systems and requiring the progressive upgrade of older systems. These policies provide both general and specific guidance for any stormwater system or associated discharge within the Mason Street catchment and play a strong role in determining the suitability, consentability and priority of any management option chosen under the ICMP.

2.3.7 The Dunedin City District Plan

The operative Dunedin City District Plan identifies issues and states objectives, policies and methods to manage the effects of land use activities on the environment.

The Dunedin City District Plan applies to all users of land and the surface of water bodies within the city; it is concerned with all areas above the line of mean high water springs (MHWS). Issues pertaining to those areas below the line of MHWS, including coastal waters, are addressed in the Otago Regional Plan: Coast for Otago and the NZCPS.

Policy 21.3.1 seeks to protect the harvest potential and quality of water within catchments. Policy 21.3.8 seeks to avoid or otherwise remedy or mitigate the adverse effect of activities which discharge to water, land or air. While standards relating to water quality are the jurisdiction of ORC, the policies contained within the Dunedin City District Plan address the effects of land use on water quality for example through the consideration of matters such as stormwater runoff from subdivisions.

The Dunedin City District Plan also uses zoning as a method of regulating activities under the DCC jurisdiction. These land uses will play an integral part in determining the quantity and quality of any stormwater runoff. The Mason Street catchment consists of Port 2, Industrial 1 (In1), Residential 1 and 4 and Central Area land uses.

Careful consideration will need to be given to the In1, Port 2 and Large Scale Retail (LSR) land use zones when looking at management options under the ICMP, as these land uses are likely to produce different stormwater quantities and quality outputs to the residential zones. Activities which are permitted to occur within the In1 zone include: industrial activity, service activity, retail activity specific to and complimentary to industrial or service activity, recreational activity, service stations, vehicle and boat yards and garden centres. The Port 2 zone also permits industrial, service and related retail activities along with activities specific to a port such as the unloading and storage of cargo. It may also be that data obtained during the development of the ICMP provides input into future land use zoning within the Dunedin City District Plan.

2.4 Building Act (2004)

The Building Act 2004 includes Sections 71 to 74 which relate to limitations and restrictions on building consents and the construction of buildings on land subject to natural hazards. Flooding is the primary natural hazard of concern within the Mason Street catchment therefore the ICMP needs to ensure that any development within the catchment will not exacerbate the risk of flooding.



The Building Regulations 1992 include the Building Code, which provides guidance as to the implementation of the Building Act. Section E of the Building Code includes various performance criteria relating to stormwater systems which are relevant to the ICMP. These criteria are specific to managing natural hazards and include drainage system design and inundation probability criteria. The ICMP will need to reference the performance criteria outlined within the code when identifying management options.

2.5 Civil Defence Emergency Management Act (2002)

The Civil Defence Emergency Management Act 2002 (CDEMA) addresses the management of emergencies including flooding. Section 64(1) of the CDEMA outlines the duties of local authorities and states:

“A local authority must plan and provide for civil defence emergency management within its district.”

Producing flood maps as part of the ICMP process may be one method of providing for civil defence emergency management however this method is not specifically prescribed by the CDEMA and therefore is at the discretion of the local authority concerned.

2.6 Non Statutory Documents

2.6.1 Kāi Tahu ki Otago Natural Resource Management Plan

Kāi Tahu ki Otago Natural Resource Management Plan (Kāi Tahu Plan) provides a background to Kāi Tahu's resource management issues in the Otago Region. The Kāi Tahu Plan contains management guidelines and objectives relating to freshwater fisheries and coastal resources. Kāi Tahu are particularly concerned with the degradation of the freshwater resource as a result of piping and channelisation, the mauri and life supporting capacity of water being compromised by structures and point source discharges, and the depletion of coastal fisheries due to discharges to the CMA.

The ICMP should consider the specific concerns of Kāi Tahu where they are not addressed by the regional or district statutory planning documents, and should ensure that Kāi Tahu are considered as a potentially affected party where appropriate.

2.6.2 Code of Subdivision and Development

Chapter 18, Subdivision of the Dunedin City District Plan, contains Method 18.4.1 which makes reference to the Dunedin Code of Subdivision and Development. This code is not part of the Dunedin City District Plan but does contain guidelines, including levels of service, for any physical works (such as kerb and channel design) associated with subdivision activity, which are considered when assessing consent applications. Stormwater targets and management approaches proposed by the ICMP should ensure this code is complied with. It is also likely that the content of the ICMP may also help shape the future direction of the Code.

2.6.3 The Dunedin City Council Sustainability Framework

The DCC Sustainability Framework is a relatively new non-statutory document which has an overarching influence on all aspects of DCC's operations and decision making through the following sustainability principles:

- Affordable: reasonable cost, value for money, today / future costs.
- Environmental Care: clean energy, bio-diversity, safe.



- Enduring: forward looking, whole of life, long term, future generations.
- Supporting People: social connectivity, social equity, quality of life, safe.
- Efficient: using less, creating less waste, smarter use.

These sustainability principles will influence the content of this ICMP and any recommendations with regard to future capital works.

2.6.4 3 Waters Strategic Direction Statement and 3 Waters Strategic Plan

The purpose of the 3 Waters Strategic Direction Statement is to align the management of Dunedin's three waters activities with the city's sustainability principles. This document provides direction for the detailed 3 Waters Strategic Plan which will be largely influenced by the content of all of the ICMPs. It is through the 3 Waters Strategic Plan that the ICMPs will provide input to long term community planning objectives and ultimately, Activity Management Plans (AMP) and capital works programmes for stormwater.

2.6.5 Activity Management Plans

The DCC stormwater, wastewater and water supply AMPs contain objectives, levels of service, methods for delivering this service, asset management and levels of funding in relation to each activity. These plans are developed through the long term community planning process. The ICMP provides input to the content of the AMPs through its contribution to the 3 Waters Strategic Plan.

2.7 Resource Consents

This section outlines the classifying rules in the Dunedin City District Plan and the Water and Coastal Plans which are relevant to the activities likely to occur under the ICMP.

While there are no rules within the Dunedin City District Plan classifying the discharge of stormwater, the ICMP needs to be consistent with these provisions by incorporating further investigations of the system and environment and monitoring any discharges that are occurring.

Most consent requirements will be addressed by The Regional Plan: Water for Otago and The Regional Plan: Coast for Otago. The Dunedin City District Plan however, contains methods addressing water quality issues through investigations, monitoring, education, consultation and the creation of management plans such as this ICMP.

Rule 10.5.3 of the Regional Plan: Coast for Otago classifies the discharge of stormwater into the CMA as a permitted activity provided certain conditions are met. These conditions include restrictions on the type of discharge, the receiving environment and any effects of the discharge.

Stormwater discharge from the Mason Street catchment is unlikely to comply with the conditions of the rule due to the catchment containing industrial land uses. Any stormwater discharge would therefore be classified as controlled under Rule 10.5.3.2 and would require a resource consent with ORC exercising its control over matters such as; the location, volume rate and nature of the discharge.

It is recommended that the objectives of the ICMP should align themselves as closely as possible to the permitted activity rules to enable the objectives of the Coastal Plan to be met, where possible.



Rules 12.4 and 12.5 of the Regional Plan: Water for Otago classify the discharge of stormwater and the discharge of drainage water to water.

Rule 12.4.1 classifies the discharge of stormwater to water as a permitted activity provided that certain conditions are met. These conditions, among others include; the discharge not containing any human sewage, the discharge not causing flooding of any other person's property, erosion, land instability, sedimentation or property damage and not producing any conspicuous oil or grease films, scums or foams, or floatable or suspended materials or objectionable odours.

Should the conditions outlined in this rule not be met then the discharge of stormwater to water will be classified as a restricted discretionary activity requiring resource consent.

Rule 12.5.1 classifies the discharge of drainage water to water as a permitted activity provided the discharge does not cause flooding of any other person's property, erosion, land instability, sedimentation or property damage and does not produce any conspicuous oil or grease films, scums or foams, or floatable or suspended materials or objectionable odours.

If the conditions outlined in Rule 12.5.1 cannot be satisfied, then the discharge of stormwater to water will be classified as a restricted discretionary activity requiring resource consent.

The objectives of the ICMP should be aligned as closely as possible to the permitted activity rules to enable the objectives of the Water Plan to be met where possible.

2.8 Objectives of Stormwater Management

2.8.1 Strategic Objectives

The strategic objectives of stormwater management are outlined in Table 2-1 below and provide the overarching objectives that guide the development of this ICMP. These objectives are at the core of the relevant statutory and non-statutory documents addressing stormwater management, including the 3 Waters Strategic Direction Statement. These objectives have been developed with the aim of achieving benefits across the four wellbeings (environmental, social, economic and cultural), and have been set within the context of a 50 year timeframe.



Table 2-1: Strategic Stormwater Management Objectives

Strategic Objectives
Development: Adapt to fluctuations in population while achieving key levels of service and improving the quality of stormwater discharges. Ensure new development provides a 1 in 10 year level of service, and avoids habitable floor flooding during a 1 in 50 year event.
Levels of service: Maintaining key levels of service of the stormwater network into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.
Environmental outcomes: Improve the quality of stormwater discharges to minimise the impact on the environment and reduce reliance on non-renewable energy sources and oil based products.
Tangata whenua values: Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.
Natural hazards: Ensure there will be no increase in the numbers of properties at risk of flooding from the stormwater network.
Affordability: To meet strategic objectives while limiting cost increases to current affordability levels where practical.

2.8.2 Activity Management Plan / LTP Objectives and Targets

Table 2-2 outlines shorter term objectives, performance measures and targets derived from DCC's stormwater AMP and LTP. These objectives are to be reviewed annually but are set within the context of a 10 year timeframe. Therefore the measures and targets below may be subject to development or change based on findings from the ICMP development process. Influencing factors may include stormwater modelling results, or further research into costs surrounding changes to levels of service.

DCC also intend to begin reporting on a number of additional measures and targets relating to service provision. The ICMP development should inform this process, and help to identify the most appropriate measures and provide baseline information. It is intended that the following areas will be able to be reported on following the ICMP completion if appropriate and necessary:

- Number of written complaints;
- Number of properties with habitable floor stormwater flooding;
- Percentage of customers with stormwater provision that meets current design standards;
- Percentage of modelled network able to meet a 1 in 10 storm event; and
- Number of properties at risk of stormwater flooding in a 1 in 10 year event.



Table 2-2: Activity Management Plan Measures and Targets

Objective	Performance Measure	2010 / 2011 Target	2021 Target
Stormwater Quality	Residents' satisfaction with the stormwater collection service	≥ 60 %	≥ 70 %
	Number of blockages in the stormwater network per 100 km of mains per annum	< 15	< 10
	Number of beach closures	0	0
Service Availability	Percentage of customer emergency response times met (Stormwater)	≥ 95 %	≥ 95 %
Demand Management	Completion of stormwater catchment management plans	as plan	X (should be completed by 2013)
Environmental Consent Compliance	Percentage compliance with stormwater discharge consents	≥ 75 %	tbc
	Number of prosecutions or infringement notices for non-compliance with resource consents	0	0
	Number of recorded breaches of RMA conditions	0	0
Asset Serviceability	Number of breaks per 100 km of stormwater sewer per annum	< 1	< 1
	< x % of critical network assets in condition grade 4 or 5	To increase % of known data	tbc
Supply Cost per m ³	Drainage uniform annual charge as a percentage of median income	≤ 1 %	≤ 1 %
	Total operational cost of stormwater service per rated household	\$ 76.70	tbc

tbc: to be confirmed.



3 Consultation

During the application for coastal discharge consents in 2005, through Annual Plan consultation and through specific consultation in relation to the 3 Waters Strategy, a number of stakeholders have been identified as affected by, or interested in stormwater management in Dunedin. The following provides a summary of values identified through the consultative processes mentioned. These values have been considered when developing objectives and options for stormwater management of identified issues.

3.1 3 Waters Strategy Consultation- Stakeholder Workshops and Community Survey

For specific consultation relating to the 3 Waters Strategy, stakeholders were divided into three groups; environmental, economic / business and social / cultural. The outcomes of the specific consultation workshops were used to inform a community telephone survey to gauge the views of the wider community including catchment residents. Specific groups were also consulted directly, including: Kāi Tahu ki Otago, ORC and East Otago Taipure Management Committee. From all consultation relating to the 3 Waters Strategy there was a general recognition that stormwater requirements and standards will need to increase, in terms of both quality and volume management.

A coordinated approach to stormwater management between ORC and DCC is desired; with the responsibilities for each organisation being clarified.

Overall, increasing the sustainability and efficiency of the network is also desired.

Views Relating to Quality

- A high awareness that stormwater contains many contaminants, and thus its management is not just a matter of transportation to the coast.
- That quality involves household drains and farm runoff as well as road runoff and sewage contamination.
- Recognise that the stormwater system does include recreational places, which underlines the need for better quality stormwater
- Improving quality of disposed stormwater is a key issue – the higher the quality, the better.

Views Relating to Volume

- Recognition that climate change may result in more frequent storm events, thus putting a greater episodic demand on the system; and thus likely to require increased capacity. This may be compounded by decreases in permeable land resulting from increased property development in certain areas.
- That managing volumes (which is partially related to quality) requires a more encompassing view of the system and its management.

In summary, the consultation identified that the key points in relation to stormwater management were:

- Legislative changes, e.g. changing planning or building consents standards to further reduce the impact of new developments on stormwater;



- Passive changes, e.g. increasing the use of swales and soakholes to better manage storm events, using landscaping to reduce the visual pollution of outfalls;
- Active changes, e.g. increasing outfall pipe numbers to reduce the impact in any given area; increasing treatment standards; installing low-flow regulators;
- Doing more than simply increasing pipe capacity – i.e. review requirements for new property developments, in order to reduce runoff volumes and minimise the loss of permeable land; and
- Consideration of sustainable options e.g. stormwater captured and used by households; implementing alternative energy sources for pump stations (such as wind turbines or micro hydro-electricity generators). In rural areas, also capture stormwater in detention ponds, both to slow flows and prevent flooding but also to balance with demand for other water-use activities e.g. irrigation.

During the development of the 3 Waters Strategic Direction Statement, objective setting took the results of the community consultation into account, for example by incorporating statements relating to the use of source control for stormwater management. The ICMP approach to stormwater management also considers a range of management options for stormwater, described as 'legislative, passive and active' changes above.

3.2 Resource Consent Submissions

The resource consent process for the coastal discharge permits identified the residents within the affected catchments as interested parties. Matters raised by submitters in relation to coastal stormwater discharge permit applications are also a valuable source of stakeholder opinion. A majority of the submissions echo the views outlined above however the Kāi Tahu cultural impact assessment (CIA) outlined below goes into more detail. As part of the consent conditions for stormwater discharges, annual meetings are held with Save The Otago Peninsula Society Incorporated, and the Department of Conservation (DOC) Otago Conservancy.

3.3 Kāi Tahu Cultural Impact Assessment

In October 2005, DCC commissioned Kāi Tahu ki Otago Limited (KTKO Ltd.) to undertake a CIA (KTKO Ltd., 2005) on the discharge of stormwater into Otago Harbour and at Second Beach. This report was commissioned as part of the consent application process for the current discharge consent held for this catchment.

The report details historical use of the Otago Harbour by Kāi Tahu and their descendants, particularly for transport and as a food resource (mahika kai).

The report studies the reported levels of contaminants in the stormwater discharged to the harbour, and also in sediments within the harbour, and states that runanga are concerned about the lack of information on biological impacts, on effects further afield than the immediate area of discharge, and that they are also concerned about the possibility of wastewater discharge into the harbour. Resource consent conditions for the current stormwater discharges include sampling and monitoring of sediments within the wider harbour, and biological monitoring. At present, given the size of the receiving environment, sampling and monitoring as part of the resource consent conditions is limited, and restricted to once per year and in a small number of locations. As sampling continues, understanding of the biological impacts of the stormwater discharges should increase.



Discharge of stormwater and associated contaminants has the potential to significantly impact Kāi Tahu values and beliefs. These adverse impacts are associated with effects on the spiritual value of water, mahika kai, aquatic biota and water quality.

The traditional resource management methods of Kāi Tahu require coordinated and holistic management of the interrelated elements of a catchment, from the air to the water, the land and the coast. The CIA notes that it is accepted by Kāi Tahu that removal of all contaminants from stormwater is not possible. However, it is also considered that more could be done to reduce the level of contaminants discharged. Recommended management measures for consideration are as follows:

- Reducing the area of impervious land;
- Use of grass swales to filter stormwater;
- Covering car-parking areas and other areas where increased contaminants may be found;
- Sediment/grease traps to be installed at all industrial premises, petrol stations and car parks;
- Management plans for industrial and commercial facilities to minimise the contaminant loading into stormwater, including the management of spills;
- Ensuring industrial waste is not discharged to the stormwater system;
- Ensuring there is no discharge of human sewage to the stormwater system; and
- Ongoing awareness of best management practices and technological improvements that will reduce contaminant levels and a willingness to implement these as appropriate.

As with the wider community consultation results, it is considered that the ICMP approach to stormwater management encompasses much of what is desired by Kāi Tahu, as described above. The 3 Waters Strategic Direction statement objectives used by this ICMP support the use of source control and low impact design options for stormwater management, as suggested above by Kāi Tahu, as well as looking to reduce the incidence of wastewater discharge into the receiving environment.

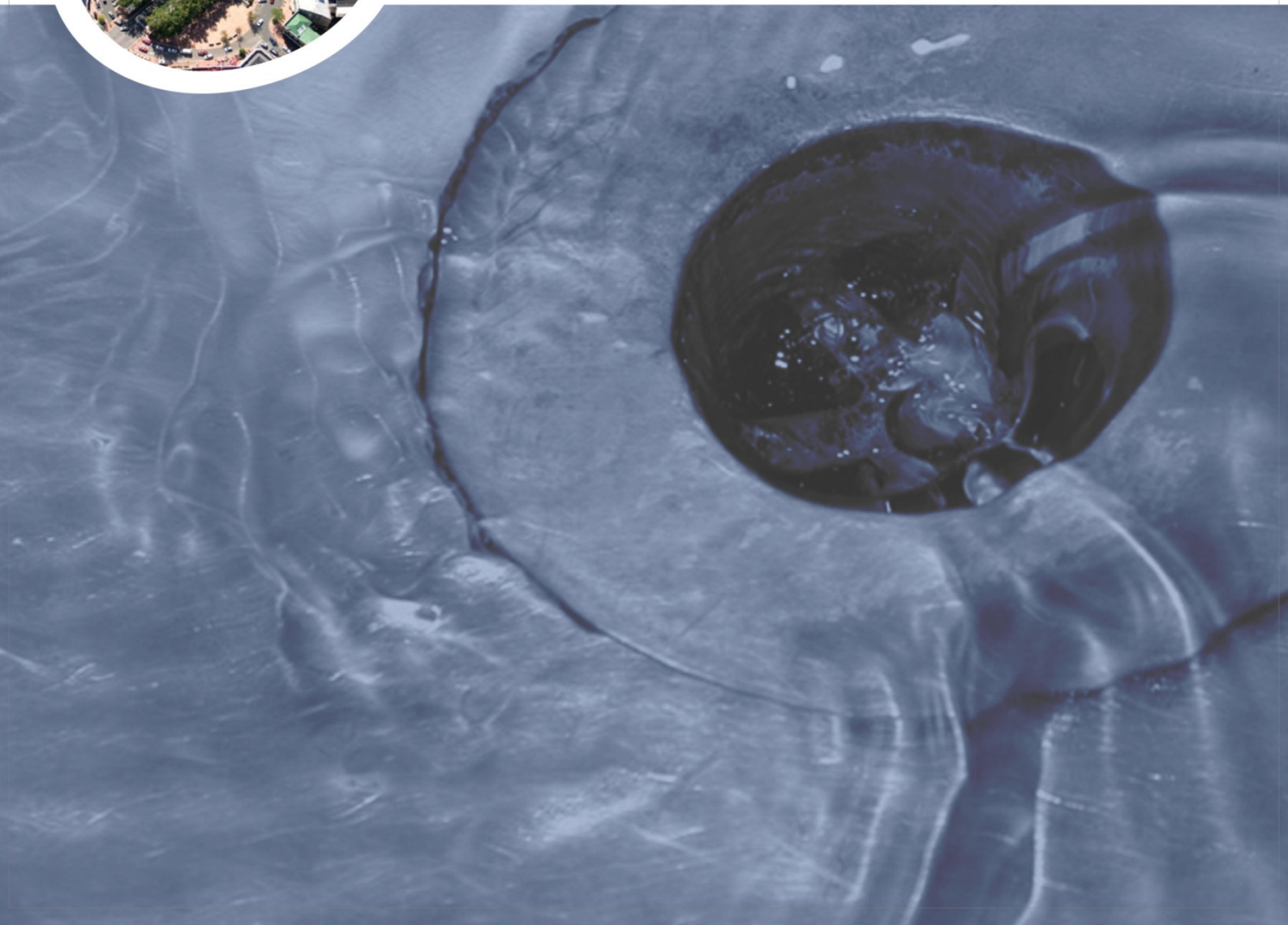
3.4 Annual Plan

A number of submissions were made with respect to stormwater issues through the 2009 Annual Plan consultation process. These submissions mainly centred on the maintenance and upgrade of the existing system so to ensure adequate treatment and filtration of the stormwater prior to it being discharged. The issue of infrastructure capacity was also raised.



Part 2

Baseline





4 Catchment Description

4.1 Catchment Location

The Mason Street catchment has a total area of approximately 210 ha and incorporates the areas of South Roslyn and Belleknowes down to Harbourside (Figure 4-1).

Land use within the catchment is varied, with commercial, industrial and urban areas located in the lower (eastern) parts of the catchment, with residential areas and open space areas occupying the steeper terrain to the west. The Dunedin Town Belt extends through the catchment to the east of Belleknowes, and includes both open grassed and forested areas.

The head of the catchment is generally located along Kenmure Street. The northern and southern extent at the head of the catchment can be defined by the location of Ross Street and Mailer Stream, respectively. The catchment narrows towards the east, with the mid reaches of the catchment defined by York Place in the north and High Street in the south. In the lower reaches the catchment becomes constrained to a single discharge point on Mason Street.

The stormwater network is predominantly piped, but also includes sections of open channel (mainly through the town belt area), all of which drain to the harbour outfall.

4.2 Topography and Geology

Figure 4-2 is a contour map of the Mason Street catchment based on 2 m contours, and Figure 4-3 provides a geological map of the catchment (Bishop and Turnbull, 1996, Revised 2004). The catchment is characterised by low lying relatively flat areas in the eastern areas which are occupied by industrial and urban land uses, with the topography increasing in steepness towards the west of the catchment. The head of the catchment has an elevation of approximately 210 m above mean sea level.

The topography of the catchment has been created by volcanic lava flows which occurred in the mid to late Tertiary period, with several volcanic episodes evident in the topographic and geologic maps (Md1e and Md2e basalt; Mdc conglomerate and Md1i phonolite). The volcanic deposits are very resilient to erosion and weathering, with the rock material typically providing variable infiltration capacity. The steep terrain at the head and sides of the catchment directs surface water predominately into two gullies which are found on the north and south of Jubilee Park, before combining to a single gully that follows the general direction of Serpentine Avenue. The upper catchment is very steep, with gradients of up to 17 %. The gradient begins to flatten out east of Broadway Avenue where the volcanic deposits give way to the more recent Quaternary deposits.

East of Crawford Street the gradient is very flat, due to the area of reclaimed seabed which is identified as geologic unit Q1an (Figure 4-3). This material consists predominately of unconsolidated and unsorted material from a variety of sources that were deposited on the shoreline to reclaim seabed. The deposits include gravels, sands, marine silts and clays, most likely combined with anthropogenic materials from industrial and domestic waste, including mine tailings from the adjacent quarry operation. Drainage capabilities of this material will be variable, depending on the specific materials used in different areas of the reclamation.



4.3 Surface Water

Ryder (2010c) contains information on characteristics of the surface water network in the Mason Street catchment. The following description is based on the information contained in that report together with the map of the stormwater network (see Figure 4-9 later in this report).

The catchment contains two streams which have been modified over time and incorporated into the stormwater network. The streams originate in two gullies towards the head of the catchment, which later combine near Serpentine Avenue. Parts of the stream networks are open channels which are largely unmodified despite flowing through urban areas in the upper catchment. The Town Belt provides a natural area where the streams are essentially natural channels.

The upper reaches of the first stream flow through natural channels behind residential properties, while the lower reaches flow from a piped section into a natural channel before entering stormwater pipes. The upper reaches of the second stream flow from stormwater pipes into a natural steep channel. The middle reaches of the stream then flow through low gradient sections before entering steeper sections in the lower reaches before entering stormwater pipes at Canongate.

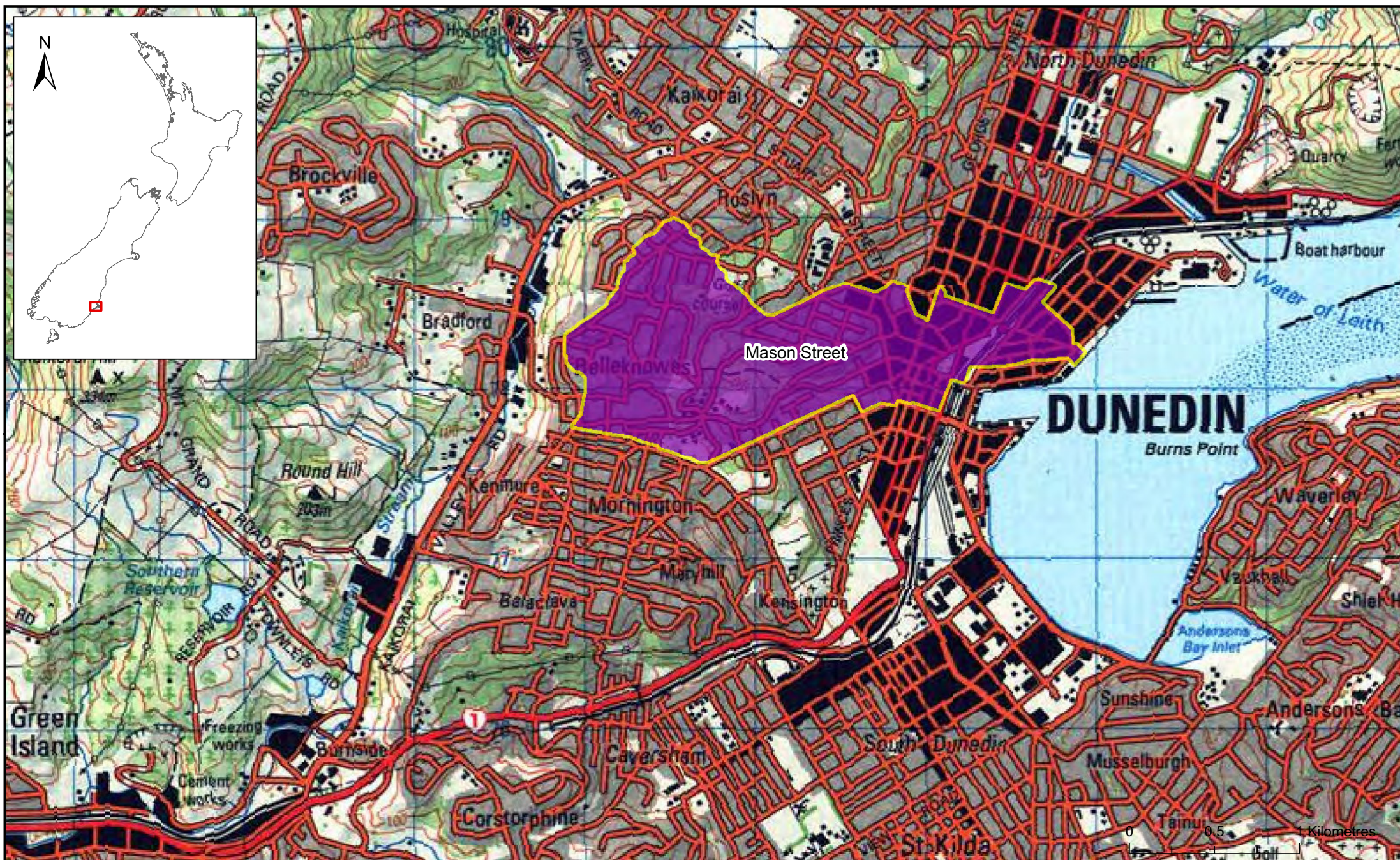
4.4 Groundwater

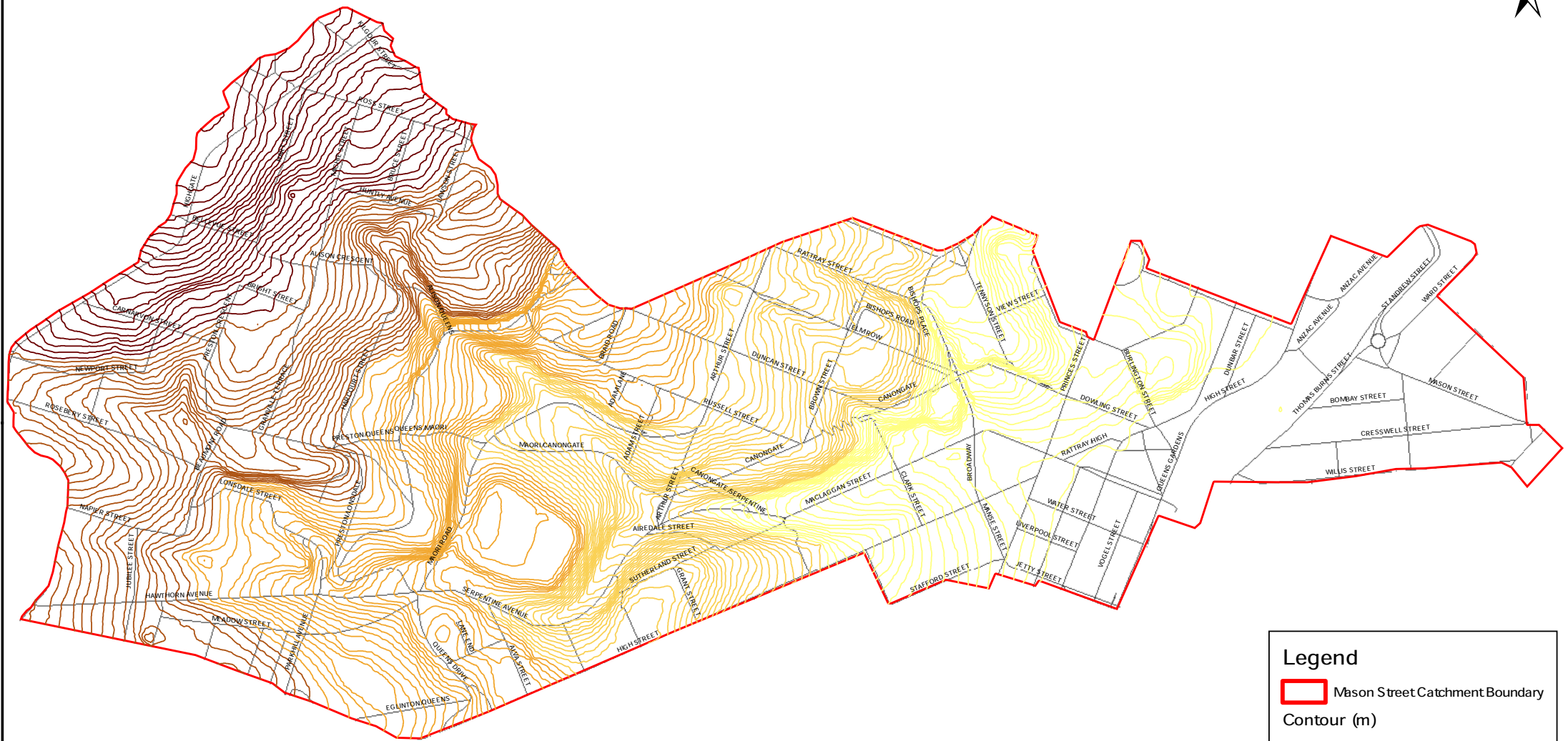
There is limited information relating to groundwater surface levels in the Mason Street catchment, and over much of the Dunedin urban area adjacent to the harbour. ORC do not currently require groundwater monitoring in the area for consent purposes. However, based on the limited information on the site geology, a conceptual understanding of the groundwater system has been developed.

Groundwater is likely to be limited to the coastal flats area. The tidal levels/range is likely to be representative of the groundwater elevation in the coastal area. However, the variability of the material associated with the reclaimed land suggests that groundwater may be perched in some areas where marine sediments have been deposited. Where gravels and sands are present in the lithology the groundwater flow is expected to be towards the coast.

The basalt rocks may contain a fractured rock groundwater system. However, as there are no wells drilled in the catchment area, it is difficult to ascertain the extent of any fractured rock groundwater. Nevertheless, water that infiltrates the basalt is expected to move vertically down through fractures in the rock. Water within the rock formation will move laterally towards the coast where it is expected to flow through the Quaternary deposits before discharging to sea. However, there is no information on groundwater in the Quaternary deposits that would indicate that a proportion of water is sourced from water passing through volcanic deposits.

There is no information currently available on the quality of the groundwater resource in this catchment, due to a lack of monitoring sites. However, given the reclaimed nature of the coastal flats which have been used extensively for industrial purposes (including extensive use of the land as a petroleum tank farm), it is possible that contamination of the groundwater system may have occurred. The extent of the potential contamination is not known.





Legend

 Mason Street Catchment Boundary

Contour (m)

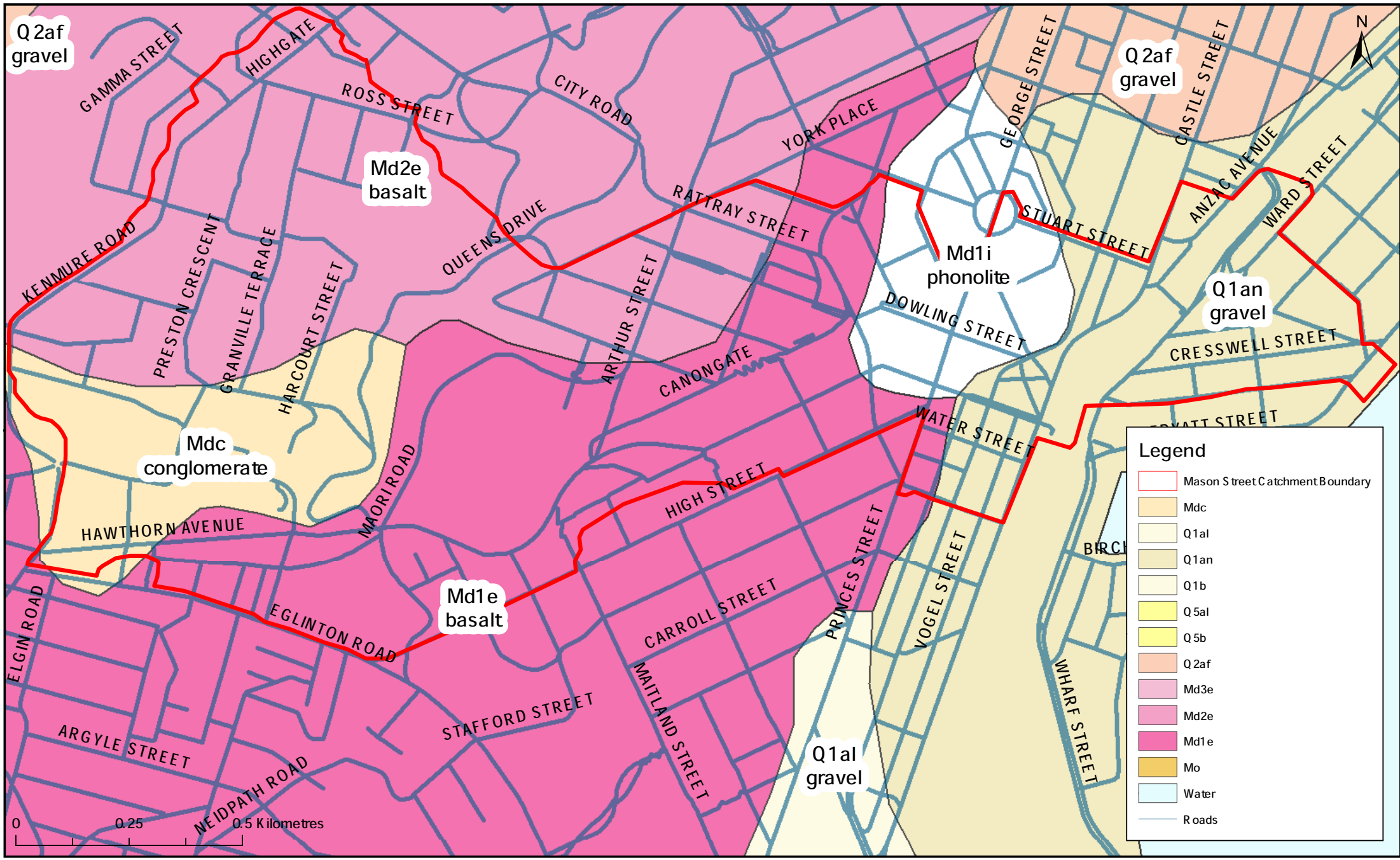
 <45

 45-90

 90-135

 135-170

 >170





4.5 Land Use

4.5.1 Historical and Current Land Use

The Mason Street catchment includes the city centre and harbour side, and parts of the suburbs of South Roslyn and Belleknowes.

Part of the Octagon lies in the Mason Street stormwater catchment; this area was created when swampland was drained. The lower part of the catchment (predominantly the flat area east of Lower High Street and Princes Streets) is reclaimed. Material removed from the cutting of Bell Hill (commenced in 1858) reclaimed much of the area along the edge of the harbour.

Lower Stuart Street is one of Dunedin's more historic precincts. This area contains several historic buildings, and is dominated by the Dunedin Railway Station, built in the early 1900s. The railway line was laid through this area as early as 1878, when Dunedin was linked to Christchurch by rail.

The lower part of this catchment has long been used for commercial activities; The Exchange, on Princes Street 400 m south of the Octagon, was the original financial heart of the city, and many of the older buildings in the city remain in this area.

Part of City Rise, the area immediately to the west of Princes Street, lies within the Mason Street stormwater catchment. This is one of Dunedin's older residential suburbs, and contains many old residences.

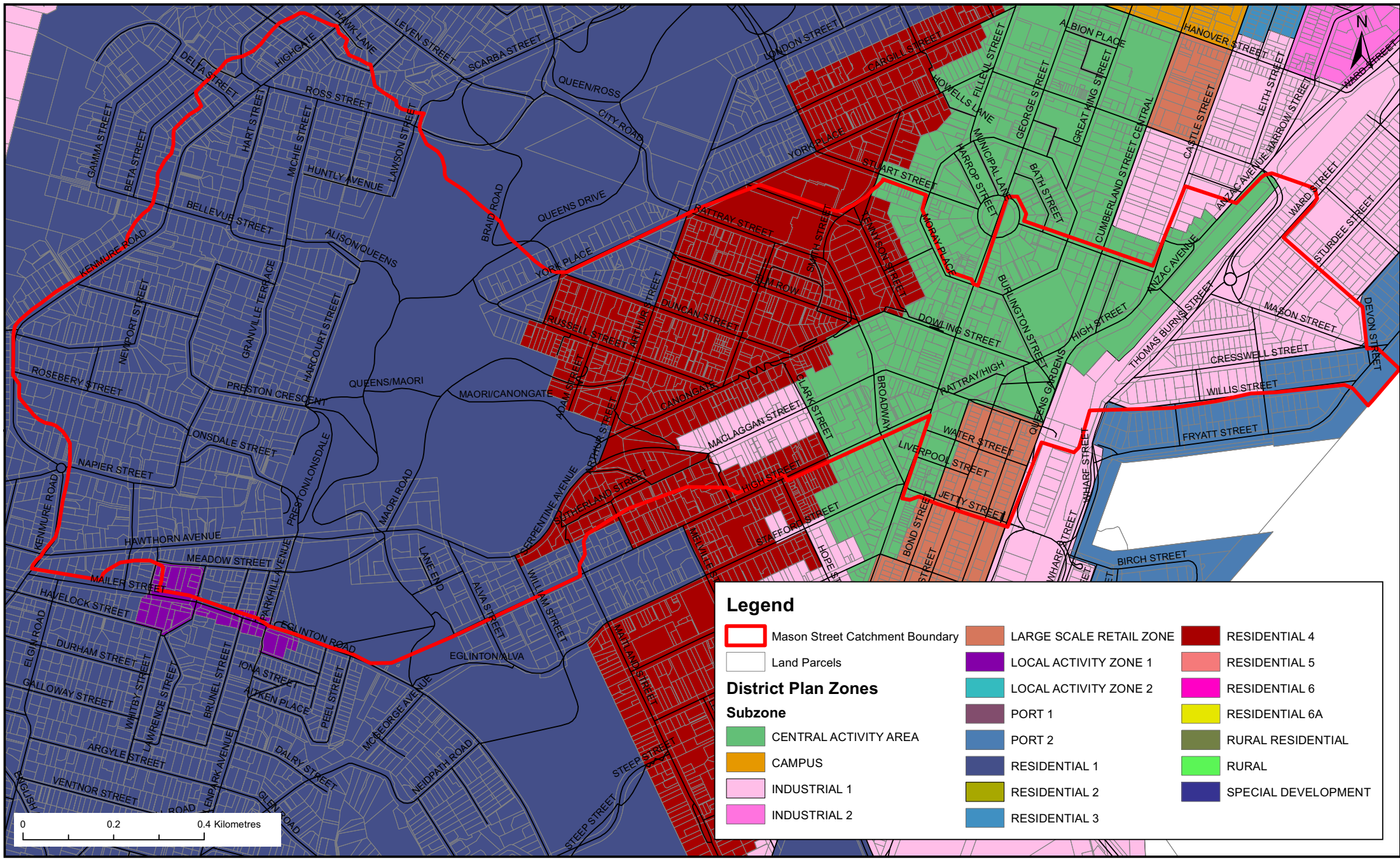
Roslyn is a large, predominantly residential suburb with some retail areas and has a notable girls' school, Columba College. The suburb is located 150 m above the city centre on a ridge which runs along the central city's western edge. The population of Roslyn in 2001 was 3,957.

Belleknowes is a smaller suburb close to the meeting points of the City Rise, Mornington and Roslyn suburbs. The features of note include Belleknowes Golf Course, the Beverly-Begg Observatory and several large parks (Jubilee and Robin Hood).

The current land use zoning is shown in Figure 4-4. The coastal flat area which is situated on reclaimed land is still used for industrial and port purposes and comprises approximately 13 % of the catchments' area. Immediately adjacent to the industrial area is the Central Activity Area, and together with the large scale retail which is located on the southern margin of the central business district (CBD) area, equates to 15 % of the catchments land use.

A smaller industrial area is also located on either side of MacLaggan Street, which is located in the lower gully of the catchment. Residential zone Residential 4 occupies the land use between the Town Belt and the CBD area and accounts for approximately 17 % of the catchment, while the town belt and the remaining residential areas are classified as Residential 1 and account for the majority of the land use in the catchment (approximately 55 %).

There is also a small local activity zone along Meadow Street.



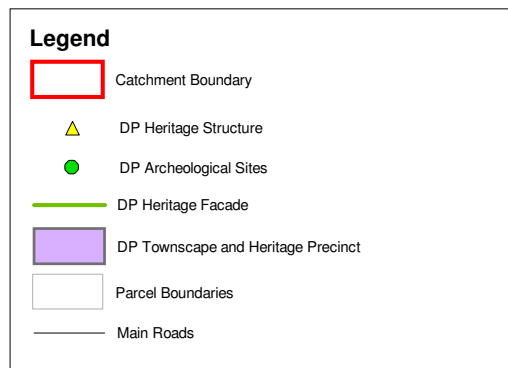
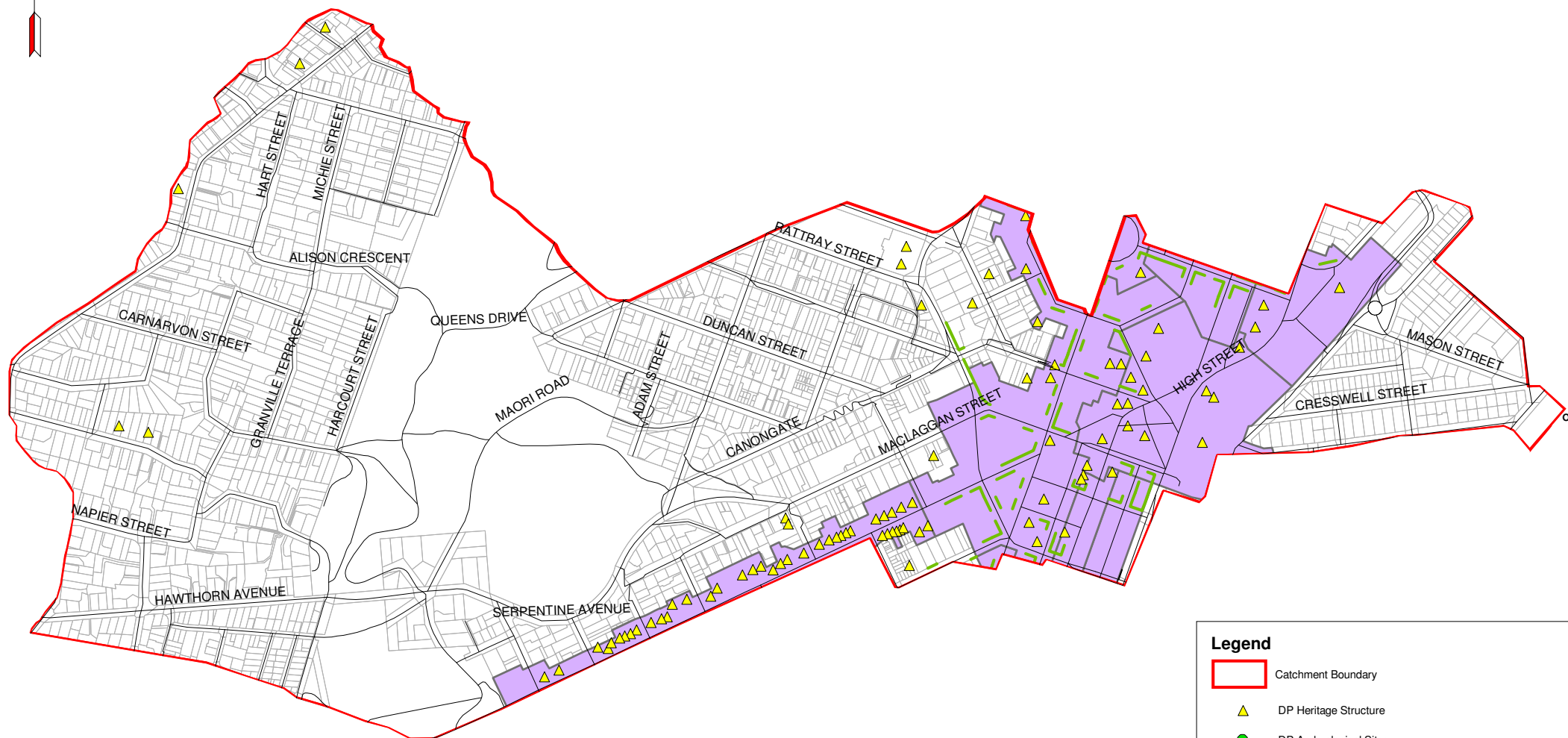


4.5.2 Cultural and Heritage Sites

According to DCC records of significant archaeological and heritage sites within Dunedin city, there are many heritage structures and heritage precincts with the Mason Street catchment (refer to Figure 4-5). The majority of heritage structures are historic houses along High Street, within the High Street Heritage Precinct. There are other historic buildings throughout the town centre, with most in the North Princes Street/Moray Place/Exchange Townscape Heritage Precinct and the Queens Garden Heritage Precinct. The most notable being Dunedin Railway Station, located on Anzac Square, built in the early 1900s. A handful of other historic buildings are scattered throughout other parts of the catchment. This includes St Joseph's Cathedral on Rattray Street, and Roslyn Presbyterian Church on Highgate Road.

There is a cenotaph in Queens Gardens to honour local servicemen and women killed in war. The Cenotaph is the focus of commemorative services each ANZAC Day.

Kāi Tahu have been identified as a key stakeholder. It should be noted that coastal and freshwater environments hold particularly high values for Kāi Tahu. Māori cultural values, along with those of other stakeholders throughout Dunedin's community, are discussed in Section 3.3.



Dunedin 3 Waters Strategy

MASON ST INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-5
Archaeological Sites and Heritage Sites

Discipline:
Stormwater

DESIGNED BY	MG	PROJECT	Final
DRAWN BY	LB	APPROVED BY	NTS
DATE	May 11	DATE NO.	3-d1040.07



4.5.3 Resource Consents and Designations within the Catchment

Information has been provided by ORC and DCC with respect to resource consents granted in Dunedin City and city-wide District Plan Designations.

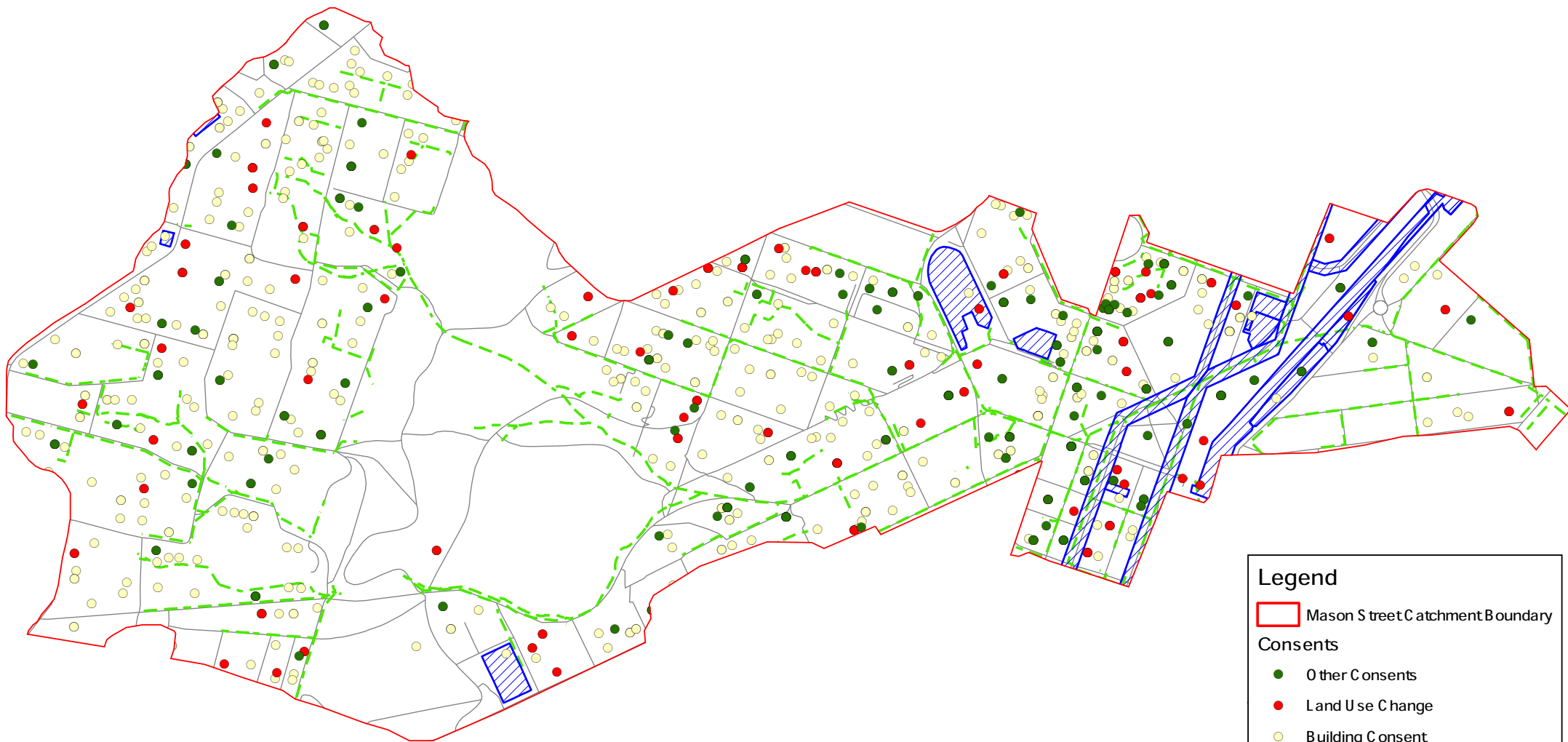
A number of consents have been granted, by ORC and DCC, within the Mason Street catchment. However, there have been no other significant resource consents granted relating to stormwater management.

DCC has granted a number of land use consents, the effects of which have been incorporated into the future catchment imperviousness calculations (Appendix B).

A number of District Plan Designations exist within this catchment. Some are for transport purposes and include the existing Main South Railway in the east of the catchment and State Highway 1 in the same area.

An area of land in the east of the catchment is designated for the construction and operation of an arterial road corridor, known as the Harbourside Arterial Link. The realignment and extension of State Highway 88 is proposed, to connect to Ravensbourne Road. The physical works include the widening and realignment of the route north of Willis Street, construction of a new corridor, new road crossings of the railway corridor, a new bridge across the Water of Leith and a new entrance into the Boat Harbour. At the time this plan was completed, this was yet to be constructed.

Figure 4-6 provides the location of the resource consents granted by DCC and District Plan Designations within the Mason Street catchment.



0 0.3 0.6 Kilometres

Legend

- Mason Street Catchment Boundary
- Consents**
 - Other Consents
 - Land Use Change
 - Building Consent
- Stormwater Network
- Main Roads
- District Plan Designation

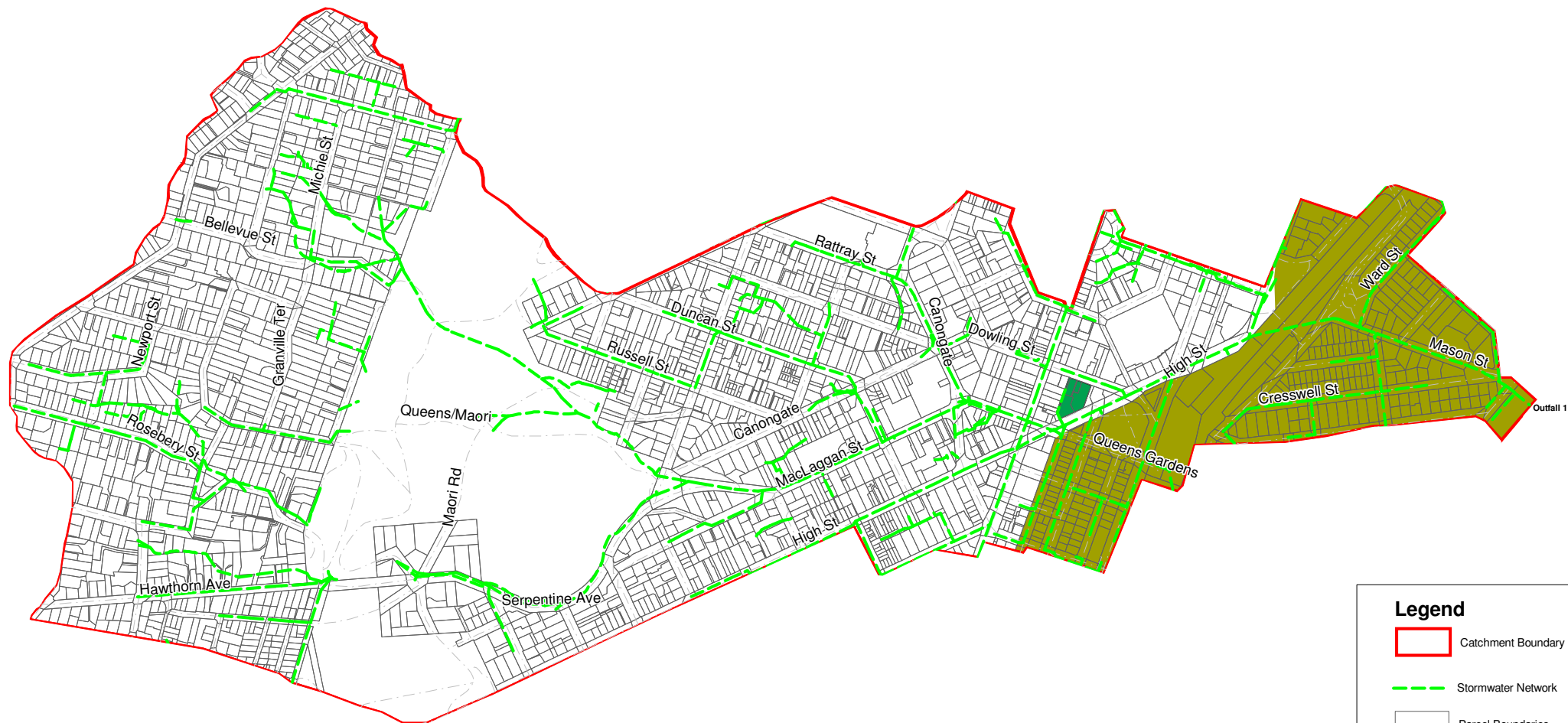


4.5.4 Contaminated Land

Data was collated from both ORC and DCC with respect to contaminated land around Dunedin City. It should be noted that the information available on contaminated land sites may be incomplete, and the extent of remediation is unknown in some instances.

Figure 4.-7 provides the location of the known contaminated land sites within the Mason Street catchment. There may be further sites around the catchment, but any information relating to these sites is not available at this time.

There is a large area of reclaimed land adjacent to the harbour. Various and unknown types of fill may have been used during land reclamation, the fill material may contain contaminants, as discussed in Section 4.2. There is also a small reclamation site on Dowling Street which is currently used as a car park.



Legend

- Catchment Boundary
- Stormwater Network
- Parcel Boundaries
- Contaminated Site
- Landfill
- Reclamation
- Reclaimed Land
- ORC Contaminated Sites

DESIGNED BY	MB	STATUS	Final
DESIGNED	MG	DATE	NTS
APPROVED	WB	DATE	April 11
DATE	April 11	3-d1040.07	



4.5.5 Future Land Use

Three future land use scenarios are being considered within the DCC 3 Waters Strategy along with the current situation. The scenarios are; 2008 (current), 2021, 2031 and 2060. For the purposes of stormwater modelling, the 2031 scenario contains the maximum allowable imperviousness for each zone, consistent with the planning horizon of the district plan (2036). The 2060 scenario also uses the maximum allowable imperviousness.

The Mason Street catchment is not expected to undergo significant changes to the existing land use practice types over the next 50 years based on the current understanding of the growth demands on the city and the existing district plan provisions.

4.6 Catchment Imperviousness

The amount of impervious surface in a catchment is one of the major influences on both the quantity of stormwater runoff generated in a catchment, and the contaminants carried within the stormwater.

Any changes to the proportion of impervious land within a catchment over time is a critical factor to consider when determining the potential future effects of urban development on stormwater issues.

4.6.1 Current Imperviousness

Figure 4-8 provides a map of current imperviousness for the Mason Street catchment. Overall, current imperviousness in the catchment is estimated to be approximately 58 %.

The land use in the lower third of the catchment which is used for industrial, large scale retail, port and central business / activity purposes is currently considered to be more than 95 % impervious.

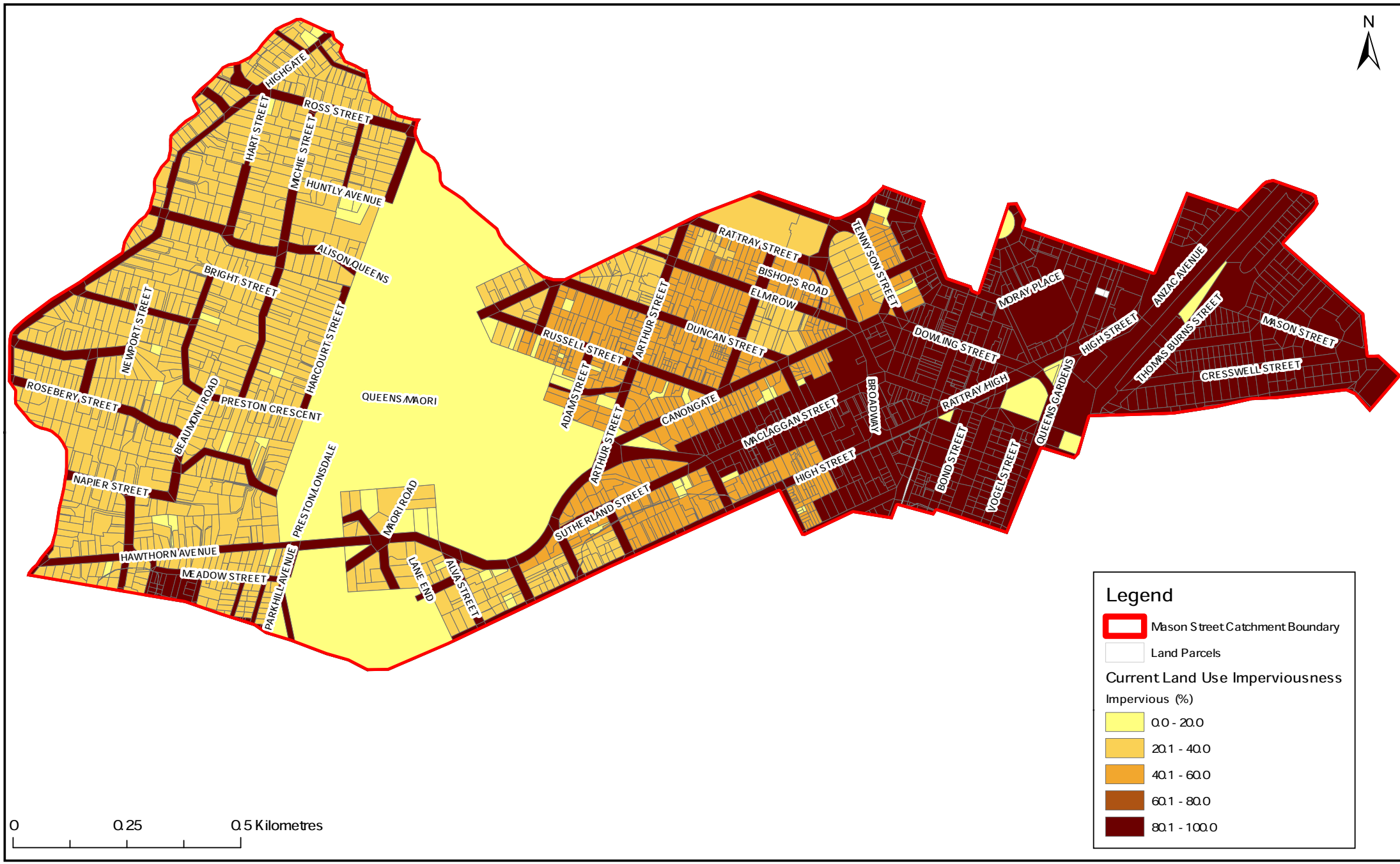
The higher density housing area (land use zone R4), which is located immediately adjacent to the CBD, includes approximately 38 ha of land of which 64 % is considered to be impervious.

The majority of the catchment has a land use zone of R1 (Residential 1). However, a significant proportion of this area is greenfields land associated with the town belt. This open space area has a low imperviousness of less than 20 %, and when combined with the residential area of R1 (which has been assigned an estimated impervious percentage of 40 %), the combined percentage of the R1 land that is impervious equates to approximately 35 %.

4.6.2 Future Imperviousness

The maximum future imperviousness has been calculated for each land parcel, and is estimated to be approximately 59 % catchment-wide. This has been based on the maximum allowable imperviousness for each land use, as per the Dunedin City District Plan rules, with exceptions for land parcels that although in a particular zone, are currently (and likely to remain) in use for other purposes such as schools, parks, and recreational reserves.

In 2060, the area zoned for industrial, large scale retail, port and central business / activity purposes is estimated to have an increase in imperviousness, with the exception of the port and central business area. The local activity zone 1 will have the largest increase in imperviousness for the whole catchment, increasing by 8.8 % to 100 %. The higher density housing area (R4), which is located immediately adjacent to the central business area of the city, will potentially increase from 64 % to 68 % imperviousness due to in-fill housing.



Legend

Mason Street Catchment Boundary

Land Parcels

Current Land Use Imperviousness

Impervious (%)

0.0 - 20.0

20.1 - 40.0

40.1 - 60.0

60.1 - 80.0

80.1 - 100.0

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Dunedin 3Waters Strategy

MASON STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-8

Mason Street Catchment Current Imperviousness

DISCIPLINE Stormwater	Drawn:	MM	Status: Final	
	Checked:	HES	Scale: 1: 7,500	Plot Date: Sep 2011
	Approved:	SDH	Job. No: 421 73227	Map No: Figure 4-8
	Date:	Sep 2011		Revision: A



4.7 Stormwater Drainage Network

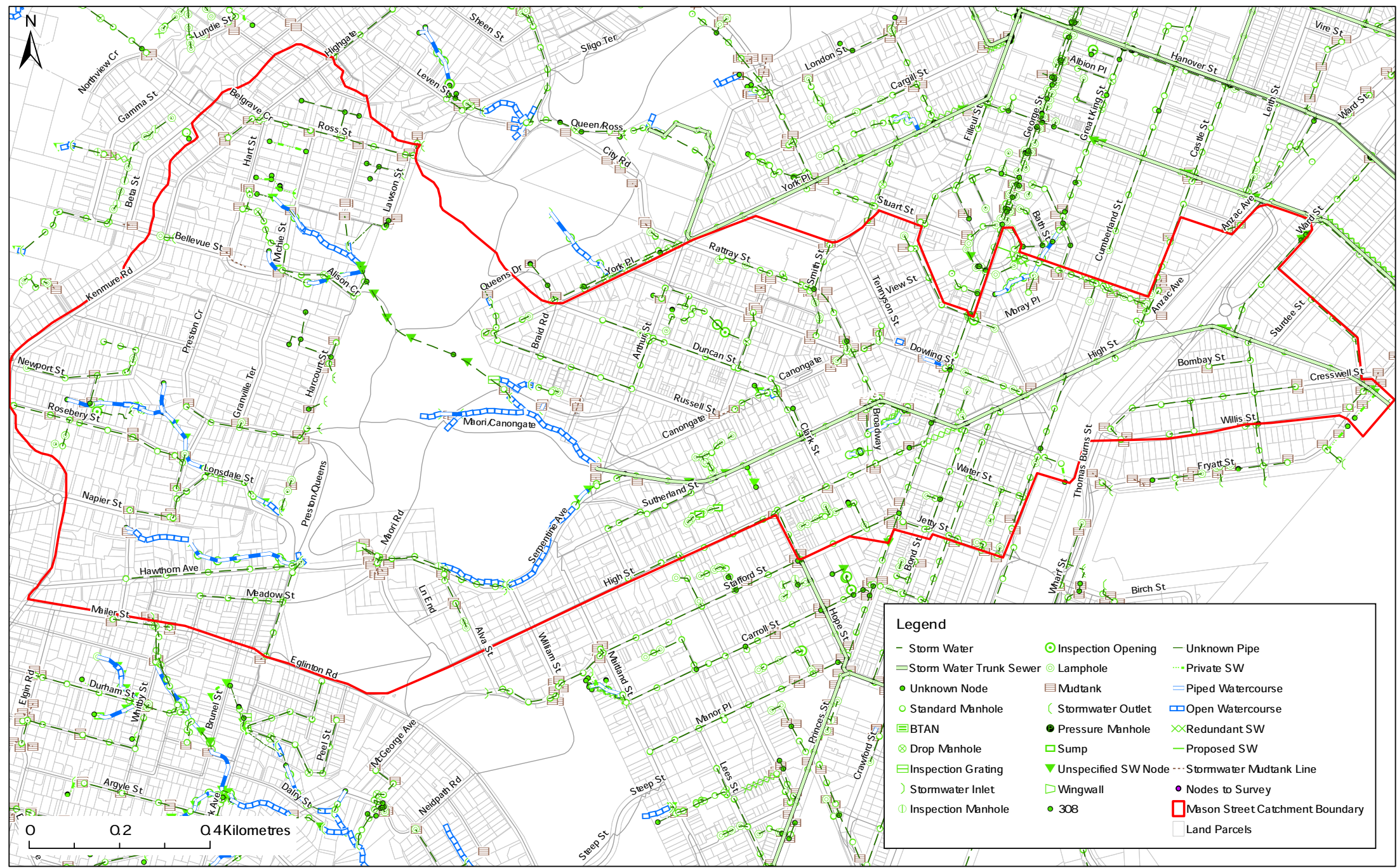
4.7.1 Network Description

Figure 4-9 provides details of the stormwater network in the Mason Street catchment, based on DCC GIS (geographic information system) data. The Mason Street catchment stormwater system consists predominantly of pipe work, but also includes several sections of open channel. The network drains to a single harbour outfall adjacent to Fryatt Street. In some of the steeper, bush covered areas of the catchment, flows are collected via natural gullies which are then intercepted by the piped stormwater network. The inlets to the piped network are key features as they determine the flow entering the system.

Figure 4-10 provides the frequency distribution of the pipe sizes in the Mason Street catchment. As can be seen, the majority of the pipes in the catchment have a diameter of between 225 mm and 1800 mm.

Key network features identified during the hydraulic model construction are as follows:

- Harbour outfall – a tidally influenced outfall on Mason Street adjacent to Fryatt Street.
- Culvert intake screen on Maori Road – the culvert intake collects a larger portion of stormwater from part of the upper catchment and conveys it under Maori Road.
- Culvert intake screen on Canongate Road – the culvert intake collects stormwater from the upper catchment and conveys it into the reticulated system.
- Culvert intake screen at the Queens Drive and Serpentine Avenue intersection – the culvert intake collects stormwater from part of the upper catchment and conveys the flows into the reticulated system.
- Bifurcation at intersection of High Street and Hope Street – the bifurcation splits flows between two lines.
- Bifurcation at intersection of Stafford Street and Hope Street (between the Mason Street and Kitchener Street catchments) – the bifurcation splits flows between two lines, one of which forms part of the Kitchener Street catchment stormwater network.



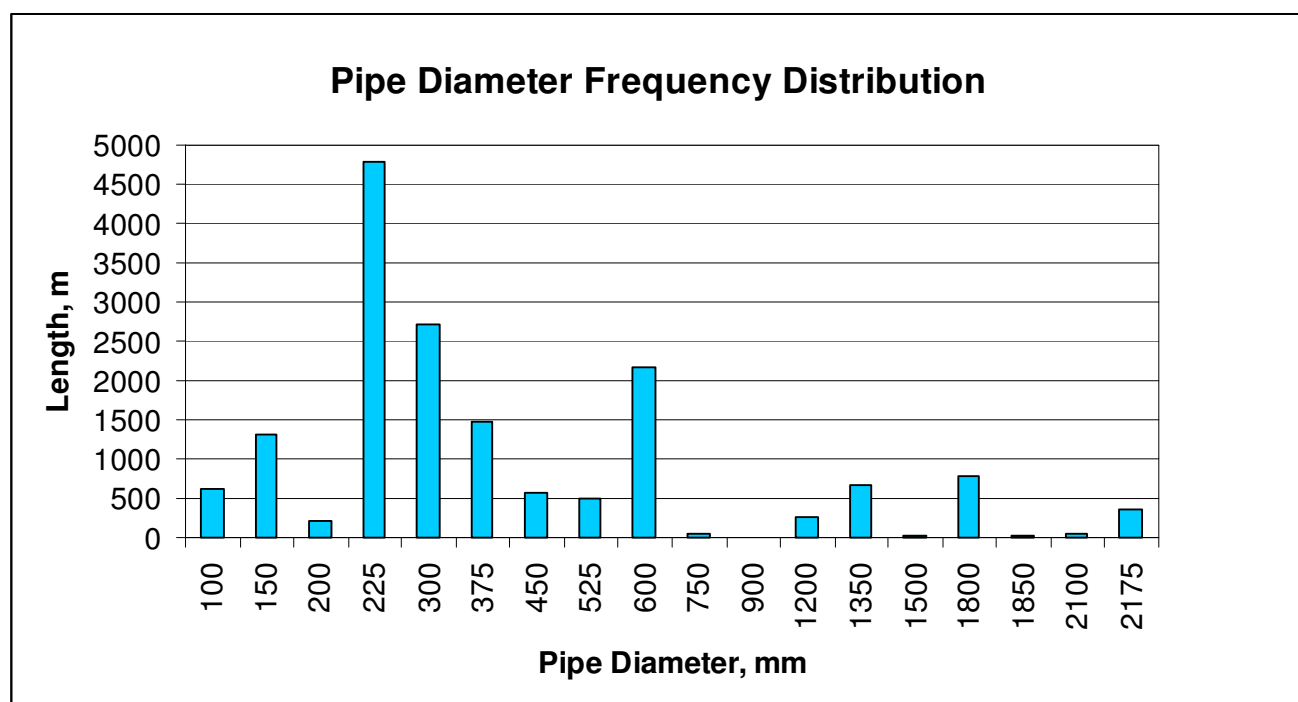


Figure 4-10: Pipe Diameter Frequency Distribution

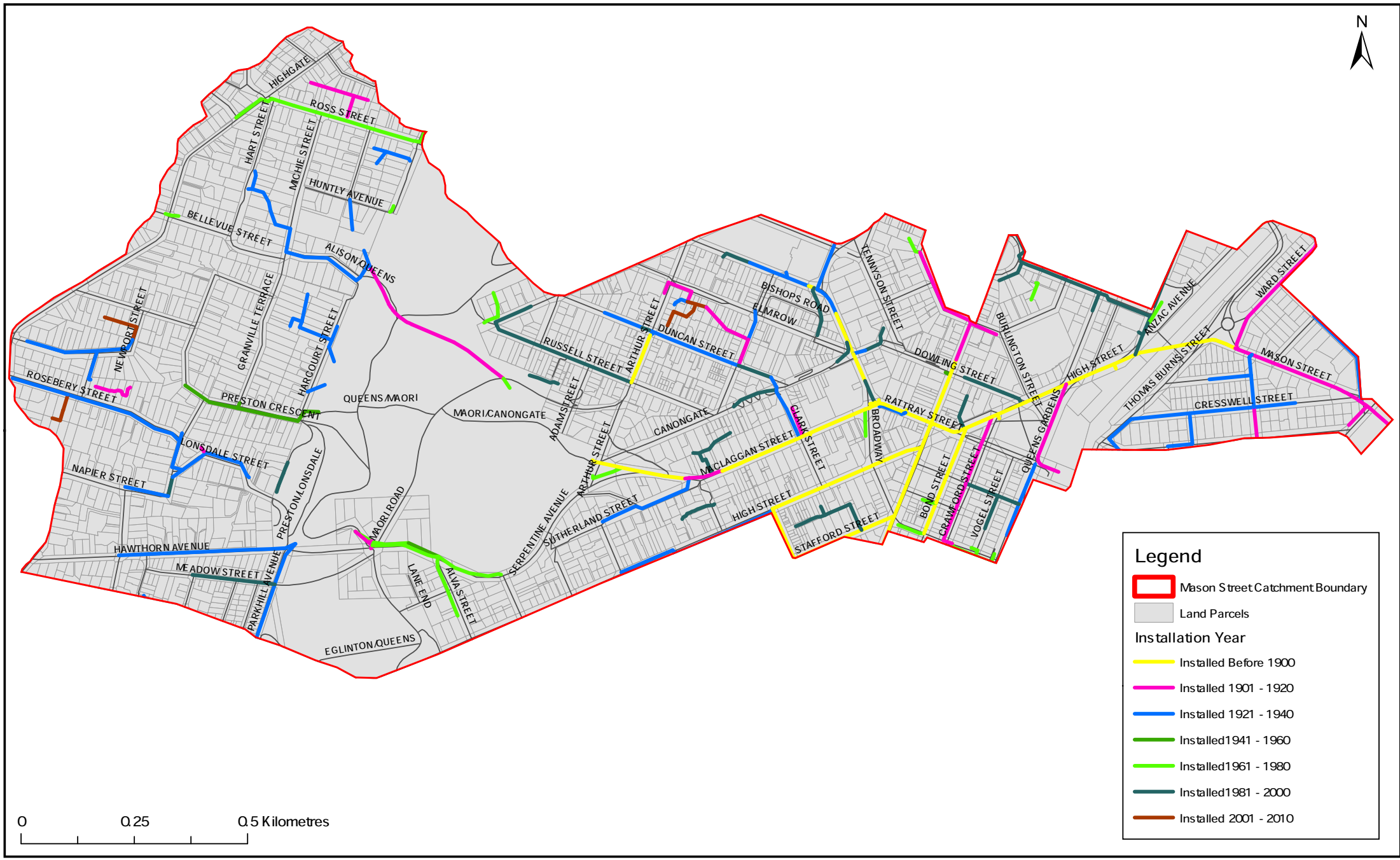
4.7.2 Network Age

Table 4-1 below provides a breakdown of pipe age in the Mason Street catchment based on pipe installation dates provided by DCC. Figure 4-11 provides a map of pipe age based on location. The outfall discharging stormwater into the harbour is over 100 years old. The oldest stormwater pipes in the network were installed in 1867.

With the expected life of most stormwater infrastructure being approximately 100 years, approximately 18 % of the network is currently overdue for renewal, with a further 18 % requiring renewal within the next ten years. 71 % of the network will be eligible for renewal within the timeframe of this ICMP (by 2060).

Table 4-1: Pipe Network Age and Length Composition

Installation Date	Approximate Age	Number of Pipelines	Length of Pipe (m)	% of Pipe Length
Installed 1900 or before	> 110 years	84	3141	18
Installed 1901 to 1920	90-110 years	73	3059	18
Installed 1921 to 1940	70-90 years	134	5641	33
Installed 1941 to 1960	50-70 years	11	428	2
Installed 1961 to 1980	30-50 years	56	1702	10
Installed 1981 to 2000	10-30 years	122	2959	17
Installed 2001 to 2009	< 10 years	14	323	2





4.7.3 Asset Condition and Criticality

A condition assessment has not been undertaken of the Mason Street stormwater network.

DCC has developed and applied a first cut criticality assessment to all water, wastewater, and stormwater network assets across the city. The criticality score has been calculated based on three weighted criteria: extent, cost, and location. For the full version of the methodology used, the DCC methodology document (available on request) should be referred to. Table 4-2 summarises the first cut version used for stormwater assets as of November 2010. Note that stormwater intakes were rated slightly differently to remaining assets, with 20 % of the weighting assigned to cost and 20 % to each of the four wellbeing, given that the consequences of failure of an intake would be largely localised in nature due to area flooding.

Figure 4-12 shows a map of the Mason Street catchment, with criticality and the four wellbeing locations identified. This map shows pipe criticality only.

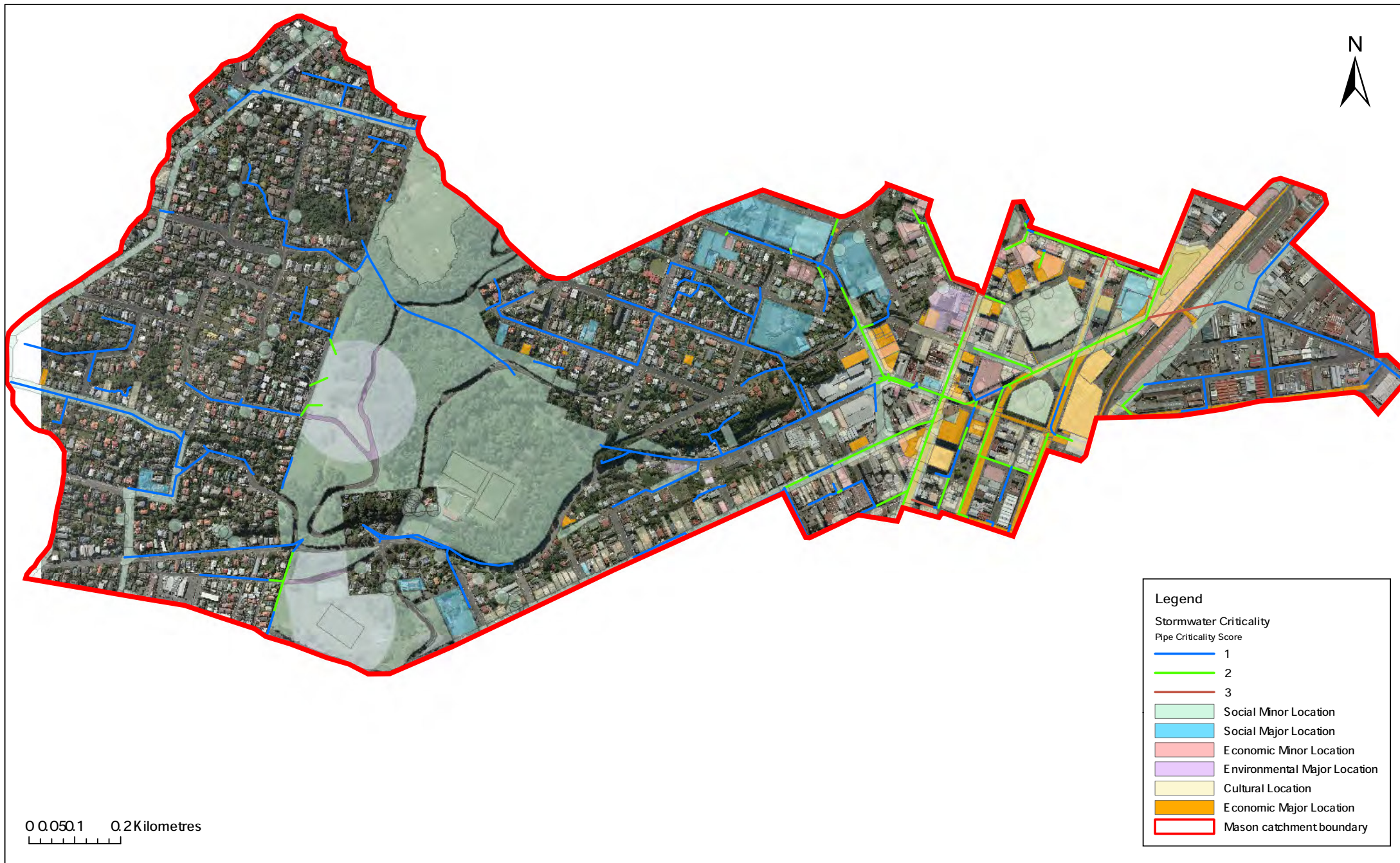


Table 4-2: Asset Criticality Score Criteria

Factor	Score	Rating Scale	Proxy Used - Pipes	Proxy Used - Manholes	Proxy Used - Outlets
Extent (20 %)	1	Insignificant function failure			Assigned same rating as upstream pipe
	2	Minor (delivery) failure – Small population	<= 600 mm diameter	Manholes on non-pressurised pipes	Assigned same rating as upstream pipe
	3	Major (delivery) failure – Large population	> 600 mm diameter	Manholes on pressurised pipes	Assigned same rating as upstream pipe
	4	Major (safety, supply, containment) failure – Small population			Assigned same rating as upstream pipe
	5	Major (safety, supply, containment) failure – Large population			Assigned same rating as upstream pipe
Cost (20 %)	1	Up to \$ 20,000	All pipes	< 3.5 m deep	< 3.5 m deep
	2	\$ 20,000 - \$ 150,000		> 3.5 m deep	> 3.5 m deep
	3	\$ 150,000 - \$ 400,000			
	4	\$ 400,000 - \$ 1,000,000			
	5	Over \$ 1 M			
Location (15 % to each of wellbeings)	1	Within 10 m of a ‘minor’ social, environmental, cultural, or economic wellbeing location			
	2	Within 5 m of a ‘minor’ social, environmental, cultural, or economic wellbeing location			
	3	Within 10 m of a ‘major’, or within 1 m of a ‘minor’ social, environmental, cultural, or economic wellbeing location			
	4	Within 5 m of a ‘major’ social, environmental, cultural, or economic wellbeing location			
	5	Within 1 m of a ‘major’ social, environmental, cultural, or economic wellbeing location			
Weighted Criticality Score	= (Extent Rating x 20 %) + (Cost Rating x 20 %) + (Social Rating x 15 %) + (Environmental Rating x 15 %) + (Cultural Rating x 15 %) + (Economic Rating x 15 %) = Criticality Rating				

Criticality 1 = Not Critical

Criticality 5 = Very Critical



Legend

Stormwater Criticality

Pipe Criticality Score

- 1
- 2
- 3

- Social Minor Location
- Social Major Location
- Economic Minor Location
- Environmental Major Location
- Cultural Location
- Economic Major Location
- Mason catchment boundary



4.7.4 Salt Water / Saline Groundwater Intrusion

The intrusion of salt water into wastewater pipelines is a major concern for DCC, due to effects on pipe condition, and more particularly, wastewater treatment plant (WWTP) processes. Wastewater pipes in the Mason Street catchment (east of the railway lines) have recently been rehabilitated to reduce saline intrusion.

In terms of the stormwater system, salt water intrusion via the outfall pipes occurs regularly, however ingress of saline groundwater along the pipelines could further reduce the capacity of the network during high tides.

An investigation by Van Valkengoed & Wright (2009) examined the regions adjacent to the Otago Harbour and highlighted the key locations where salt water is entering the wastewater system. This investigation did not, however, examine the stormwater system, therefore the extent of saline groundwater intrusion into the stormwater network is unknown. Tidal influence on the system via the harbour outfalls is discussed further in Section 8.

4.7.5 Operational Issues

Discussions were held with DCC Water and Waste Business Unit personnel during catchment walkovers in November 2009, in order to identify known operational issues or locations of historical flooding. Further discussions were held during a workshop with DCC Water and Waste Business Unit in October 2010.

Whilst no significant issues were raised, flooding in the majority of the locations predicted by the model has been witnessed in past events. Flooding and related anecdotal evidence is discussed further in Section 8.1.

System issues identified during discussions with DCC Water and Waste Business Unit were as follows:

- Overtopping of intake screens resulting in overland flow;
- Stormwater manhole overflows on Serpentine Avenue;
- Deep flooding on Rattray Street, upstream of Princes Street;
- Known flooding on Bond Street / Water Street;
- Blockage of catchpits; and
- Known nuisance flooding in the Queens Gardens area.

4.7.6 Maintenance and Cleaning

The maintenance of catchpits is perceived to be a general issue across Dunedin city according to the Water and Waste Business Unit. It was noted by the Network Management and Maintenance team that during autumn months heavy rainfall can result in blocked catchpits or inlet screens regardless of how well maintained they are. Failure to regularly maintain the inlet screens in this catchment, notably at Serpentine Avenue and Canongate Road can significantly affect the performance of the stormwater system and result in increased overland flow.



The responsibility for the cleaning and maintenance of stormwater catchpits and other structures is divided between three DCC departments, Network Management and Maintenance (Water and Waste Business Unit), Transportation Operations and Community and Recreation Services (CARS).

Network Management and Maintenance

Stormwater structures under Network Management supervision are inspected on a weekly basis, after a rainfall event and before forecast bad weather. The specification for these inspections is as follows:

- Check access to the site in respect to Health and Safety requirements.
- Check the screen intake to ensure screen is 95 % or more clear.
- Check upstream channel is clear of debris (approximately first 5 metres).
- Check for any recent signs of overflow since last visit.
- If debris blocking intake screen, remove to achieve 95 % clearance. Type of material and approximate volume and weight to be recorded on the Screen/Intake Checklist.

In addition to the weekly inspections, condition assessments are completed every six months.

Transportation Operations

DCC Transportation Operations are responsible for stormwater structures within the road reserve (except State Highway, which are the responsibility of the New Zealand Transport Agency (NZTA)).

The cleaning and maintenance of these structures is contracted to a main contractor, managed by Transportation Operations. The main contractor then subcontracts the work to a third party.

Under the Transportation Operations cleaning and maintenance contract, with the main contractor, the asset cleaning and frequency levels of service are listed as follows:

- At any time at least 95 % of mud tanks shall have available 90 % of their grate waterway area clear of debris.
- At least 95 % of mud tanks, catchpits and sumps shall have at least 150 mm below the level of the outlet invert clear of debris.
- At least 95 % of culverts shall have at least 90 % of their waterway area clear of debris throughout the entire length of the structure including 5 m upstream and downstream.
- At least 90 % of all other stormwater structures shall have 90 % of the waterway area clear of debris.

Included in the contract is an initial six month cycle to bring all stormwater structures up to specification. Once up to specification, they must be maintained to the specified level of service. Information relating to the way that compliance with the required level of service is measured was unavailable.

The cleaning and maintenance of stormwater structures in the road is currently perceived by Water and Waste Business Unit maintenance team to be inadequate. DCC have concerns that the cleaning



and maintenance contract is not specific enough and therefore the stormwater structures within the roads are not maintained to a satisfactory standard.

Community and Recreation Services

The maintenance and cleaning of stormwater structures located within parks and reserves, other than those listed under Network Management supervision, are the responsibility of CARS.

At the time of writing this plan, CARS did not have a maintenance schedule for stormwater structures within parks and reserves. They were unable to confirm the location of such stormwater structures or whether any existed within the parks and reserves.

4.8 Customer Complaints

Figure 4-13 and Figure 4-14 provide locations and dates for stormwater and wastewater flooding complaints made to DCC regarding the Mason Street catchment.

During the five year period between 2005 and 2010, approximately 94 stormwater flooding related complaints were received by the DCC call centre. Most notably, 21 complaints were logged during the 2005 storm event, 20 of which were located in the CBD area of the catchment (south of the Octagon).

Discussions were held with DCC Water and Waste Business Unit personnel during catchment walkovers in November 2009 and during a workshop in October 2010. Key areas of known stormwater flooding within the catchment were identified as follows:

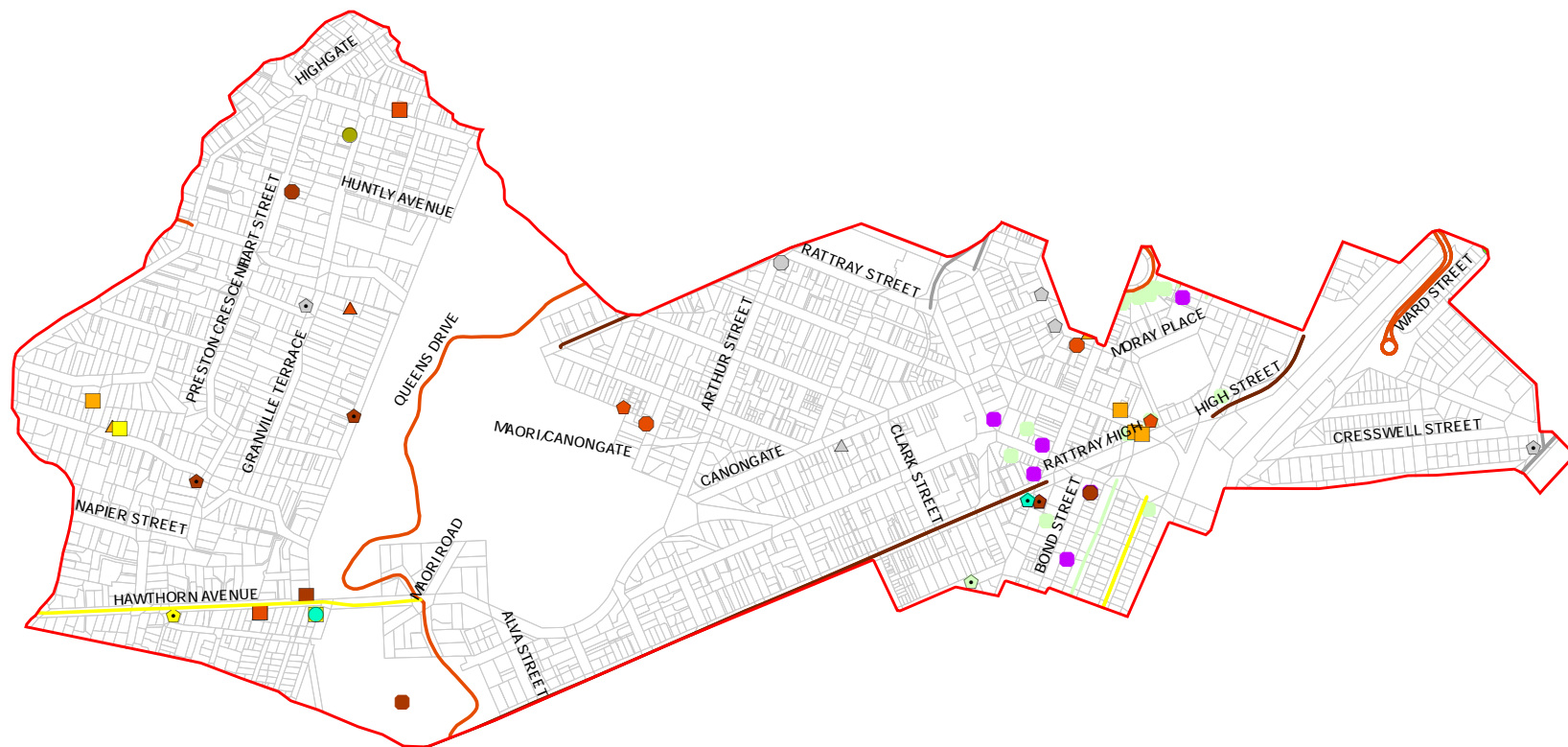
- Serpentine Avenue;
- Rattray Street;
- Bond Street/Water Street; and
- Queens Gardens / High Street / Cumberland Street.

Mapped flooding complaints are evident in all of these known flooding areas, with the exception of Serpentine avenue. Model predictions (refer Section 7) show that the flooding in this area is likely to be shallow surface flow along the road; hence this may not be an issue reported by the public.

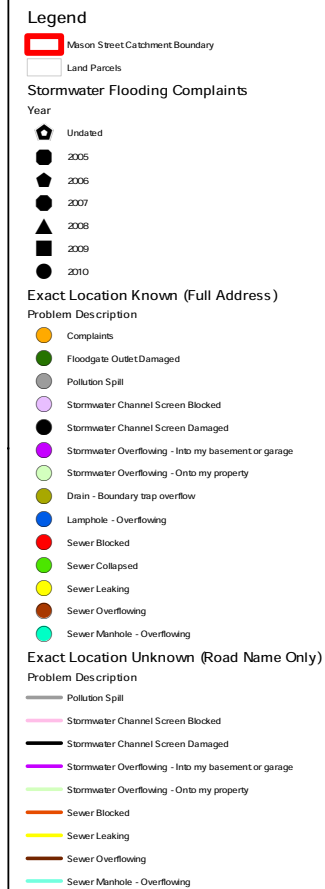
Sixty wastewater flood complaints were also received between 2006 and 2010. These appear to be fairly evenly distributed throughout the catchment.

Of note are the 2010 wastewater complaints reported on 19 April on Arthur Street and 22 April on Hawthorn Avenue. Stormwater quality sampling was undertaken taken on 23 April 2010 during a rainstorm following eight days of dry weather. While the wastewater overflows clearly occurred during dry weather, it is possible that wastewater may have entered the stormwater system at these points, to be washed out by the subsequent rain. This may have influenced stormwater result, which reported increased faecal coliform levels. This is discussed further in Sections 6 and 8.

Whilst a variety of wastewater complaints have been recorded, there are no known issues with the wastewater system within the catchment that would result in repeated flooding. It is therefore likely that these incidents recorded were isolated events or private issues.



0 0.25 0.5 Kilometres



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Dunedin 3Waters Strategy

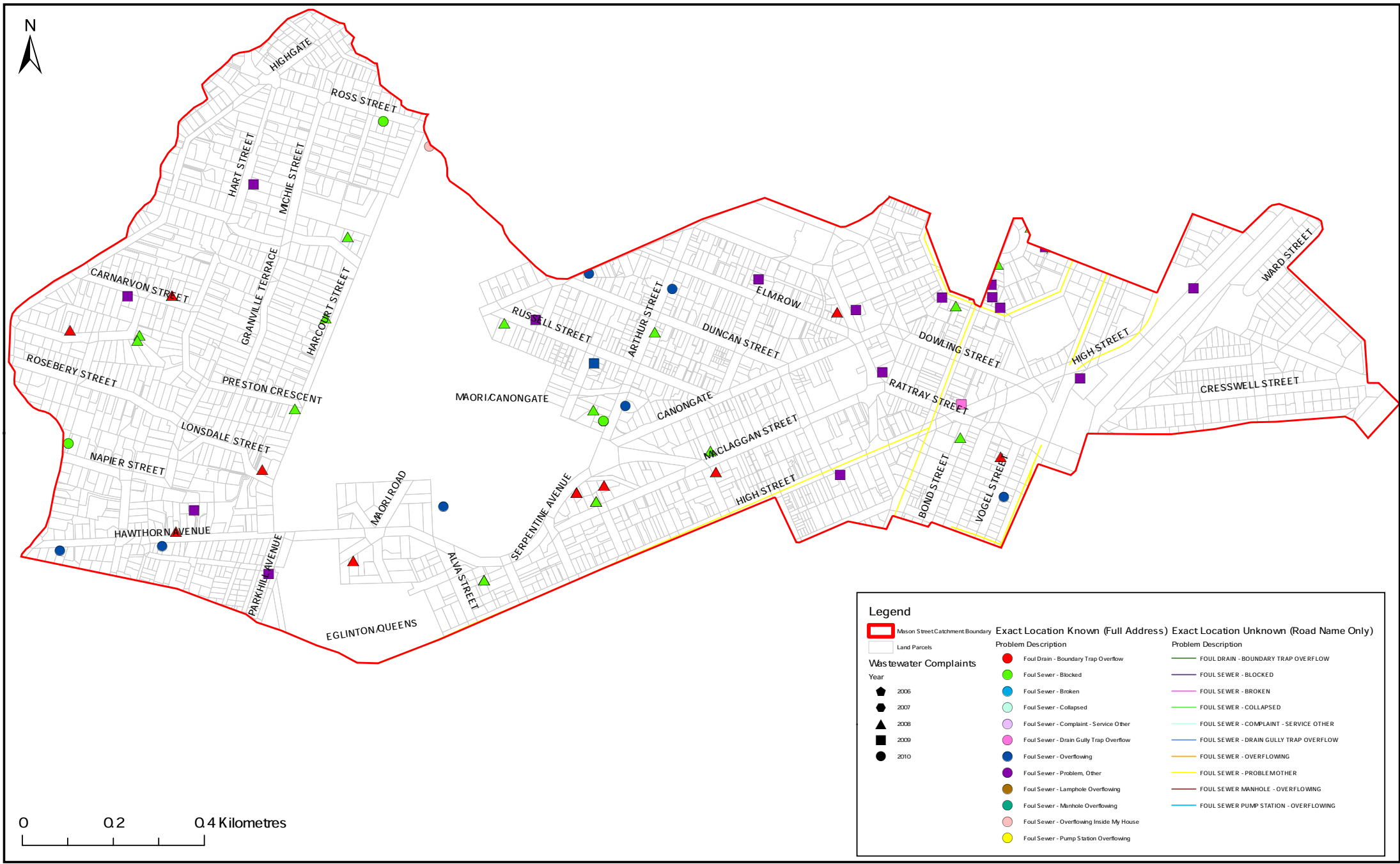
MASON STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-13

Mason Street Catchment Reported Stormwater Flooding

DISCIPLINE
Stormwater

Drawn:	MM	Status:	Final	
Checked:	HES	Scale:	1:10,000	Plot Date: Sep 2011
Approved:	SDH	Job. No:	421 73227	Revision: A
Date:	Sep 2011	Map No:	Figure 4-13	





4.9 Water and Wastewater Systems

Figure 4-15 provides a layout of the three waters networks in the Mason Street catchment.

Both the wastewater and water networks have been studied at a macro scale as part of the 3 Waters Strategy Phase 1, and in more detail during Phase 2. Section 12 further discusses modelling work undertaken on the water and wastewater systems throughout the city. Issues discovered in the Mason Street catchment during Phase 1 and 2 are highlighted below.

4.9.1 Water Supply System

The Dunedin water supply network was investigated for Phase 1 at a distribution mains level only, with further investigations focussing on key areas during Phase 2. A raw water study investigated the sources and reliability of water supply to the city.

The results indicated that the Dunedin water supply distribution (trunk mains) network provides sufficient treated water capacity and raw water storage, on a daily and weekly basis, to meet peak summer demands. It is recognised that there is a lack of strategic raw water storage during severe drought conditions.

The Dunedin water supply network receives treated water from the Mount Grand WTP to the north east of the city and the Southern WTP to the south east of the city. A number of sources supply raw water to the WTPs. Treated water from the WTPs is supplied to the city primarily by gravity, with the distribution mains, reservoirs and pressure reducing valves controlling the pressure and flow to most of the water supply zones in the city. A number of pump stations are also required to boost water pressure to reservoirs at high points or at the extremities of the system.

The water for the Mason Street catchment is supplied from three reservoirs North End, Maori Hill and Beta Street. The North End reservoir supplies the main part of the catchment via the George Street pressure reducing valve. Maori Hill supplies the west part of the catchment between Beaumont Road and Rattray Street. Beta Street supplies the far west area to the west of Beaumont Road. There are approximately 41 km of water supply pipes within the Mason Street catchment, ranging from 15 mm to 450 mm in diameter, most of which are less than 200 mm in diameter. The majority of the supply pipes in this catchment are constructed from cast iron.

The Mason St catchment covers multiple water supply zones, with the majority of the catchment's water supplied from the Central City and the Intermediate zones. Leakage is higher in the CBD than in the Intermediate zone, which is close to the Dunedin average.

The DCC capital works programme (2010-2020) identifies a supply pipe renewal in Moray Place for 2010/11.

4.9.2 Wastewater System

The main areas of investigation into the Dunedin City wastewater system for Phase 1 were system capacity, hydraulic performance, wastewater overflows and pumping stations. Current and future anticipated issues within the system at a macro level were identified.

Flow survey and modelling from Phase 1 revealed a strong wet weather influence on the wastewater system city-wide, caused by both direct and indirect entry of stormwater via storm induced inflow and infiltration (I&I). A number of manhole overflows were also predicted by the modelling whereby wastewater may then enter the stormwater system via kerb and channel and stormwater sumps and contribute to stormwater flows. Investigations also revealed that a number of cross connections



between the wastewater and stormwater, and wastewater overflows directly to the receiving environment have been found to operate following rainfall events within Dunedin City.

The Dunedin City wastewater system collects wastewater from commercial, industrial and residential customers in Dunedin City. It is split into three distinct schemes, the Dunedin Metropolitan Scheme, the Mosgiel Scheme and the Green island Scheme.

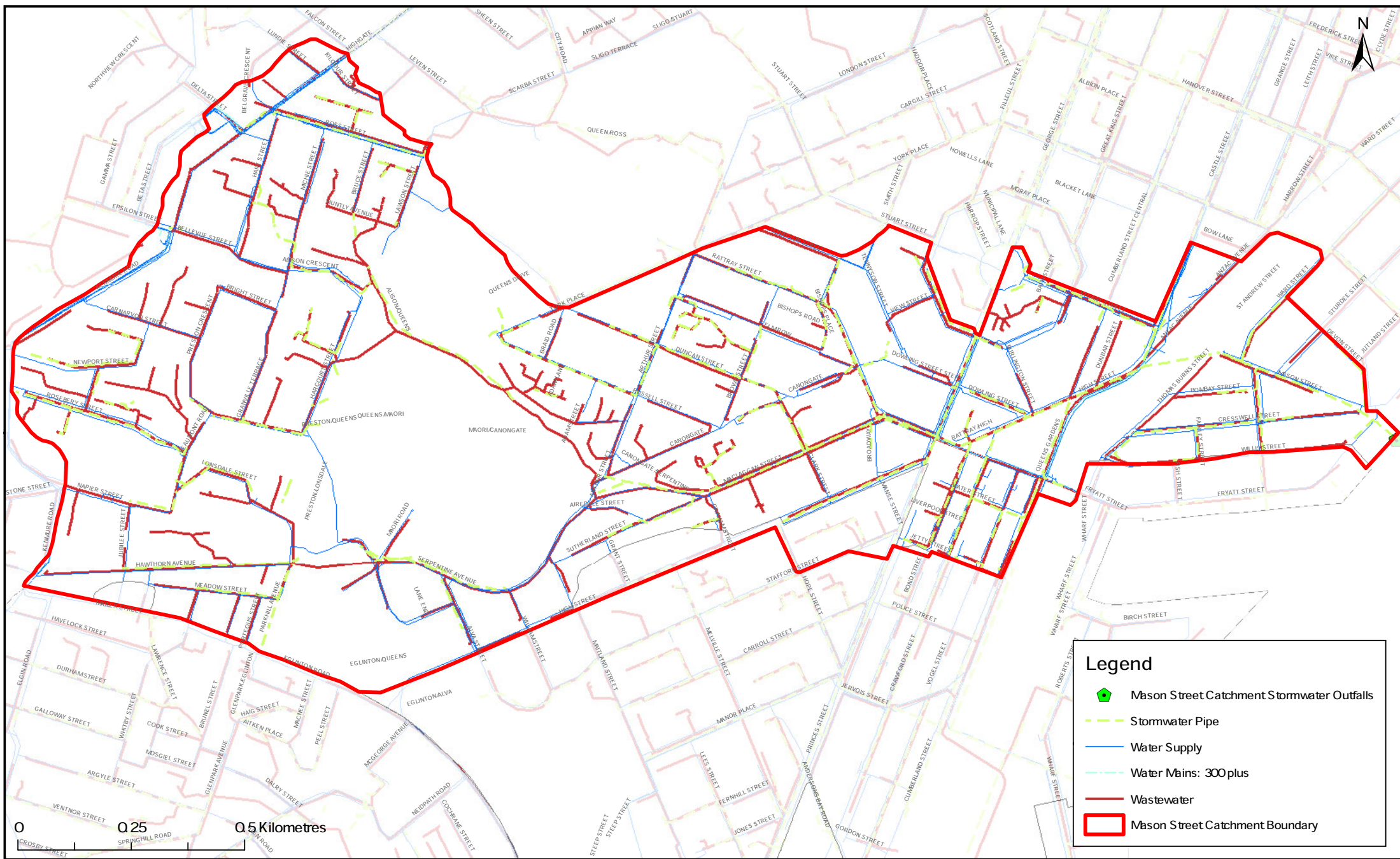
The wastewater system within the Mason Street catchment is part of the Dunedin Metropolitan Scheme. The Metropolitan Scheme provides wastewater services to the urban area of Dunedin, West Harbour communities, Ocean Grove and the Peninsula down to Portobello. The main interceptor sewer (MIS) is the main sewer line that collects wastewater flows from the Metropolitan Scheme. It conveys flows to the Musselburgh pump station where they are then pumped to the Tahuna WWTP. The MIS extends from the Harrow Street / Frederick Street intersection in the city centre to the Musselburgh pump station.

The wastewater system within the Mason Street catchment comprises approximately 32 km of wastewater pipeline, approximately 83 % of which are between 150 mm-300 mm in diameter.

The MIS runs through the Mason Street catchment along Anzac Avenue and Cumberland Street. Flows from Belleknowes, central Dunedin and harbourside are conveyed to the MIS which in turn conveys the flows to the Musselburgh pumping station and ultimately the Tahuna WWTP.

As discussed in Section 4.7.4, a number of wastewater pipes in the lower catchment were rehabilitated during 2011, to reduce sea water infiltration into the network.

The 3 Waters Strategy Project wastewater study did not identify any significant issues with the wastewater system within the Mason Street catchment.



 DUNEDIN CITY COUNCIL Kaitiaki Take Kōwhiri o Te ōpaki  URS New Zealand Limited Level 10, 100 The Quadrant Auckland, New Zealand Phone: 011 374 0000 Fax: 011 374 0001 	Dunedin 3Waters Strategy	MASON STREET INTEGRATED CATCHMENT MANAGEMENT PLAN	DISCIPLINE Stormwater	Drawn: MM	Status: Final		
		Checked: HES		Scale: 1: 7,500	Plot Date: Sep 2011		
		Approved: SDH		Job. No: 42173227	Map No: Figure 4-15	Revision: A	
		Date: Sep 2011					
		Figure 4-15 Mason Street Catchment Three Waters Networks					



5 Receiving Environment

This section identifies and describes the stormwater receiving environment for the Mason Street catchment. An overview of the quality and value of the receiving environment is provided. It is acknowledged that both historical and current stormwater management, as well as many of other activities not related to stormwater management within the catchment, have contributed to the state of this environment.

Part 3 of this report identifies and analyses the effects that specific stormwater management practices, may be having on the receiving environment of the catchment. Where the effects are considered to be unacceptable, options for avoiding, remedying or mitigating the effects are discussed in Part 5 of this report.

The stormwater network in the Mason Street catchment discharges directly to the marine environment at the north-eastern shore of the Otago harbour basin via one large outfall located adjacent to Fryatt Street, at the end of Mason Street. The location of the outfall, relative to other DCC stormwater outfalls and the Otago Harbour receiving environment, is shown in Figure 5-1.

This catchment contains two streams with natural channels, the locations of which are indicated in Figure 5-3. The streams receive discharges directly from, and form part of, the stormwater network.

5.1 Marine Receiving Environment

Monitoring of the harbour environment is undertaken on an annual basis in accordance with the conditions of resource consent for DCC's stormwater discharges. To date, four rounds of monitoring have been undertaken (2007, 2008, 2009, 2010). The annual monitoring involves the following, and while intended to identify the effects of stormwater discharges, as noted above, may be measuring the effects of historical contamination (particularly in the case of sediment monitoring where annual deposition rates are thought to be low), as well as the effects of other contaminant sources other than stormwater:

- Biological monitoring: Macroalgae, epifauna and infauna are surveyed at low tide from four sites; two within 20 m and two a minimum of 50 m from each outfall monitored. Shellfish and octopus are collected from within 20 m of the confluence of the stormwater outfall and water's edge at low tide; and fish (variable triplefins) are collected within 50 m of the stormwater outfalls. The flesh of the animals is then analysed for heavy metals and polycyclic aromatic hydrocarbons (PAHs).
- Sediment monitoring: Replicate samples are collected from the top 20 mm of sediment within 20 m of each outfall monitored. The sediment is analysed for a suite of contaminants including heavy metals, bacteria and PAHs. In addition to the annual sampling, sediment is also analysed from four transects across the centre of the upper harbour, every 5 years.
- Stormwater monitoring: Stormwater grab samples are taken from a number of outfalls, within one hour of the commencement of a rain event greater than 0.5 mm, in an attempt to capture the first flush stormwater. The stormwater is then analysed for a suite of contaminants. Stormwater quality is discussed further in Section 6.

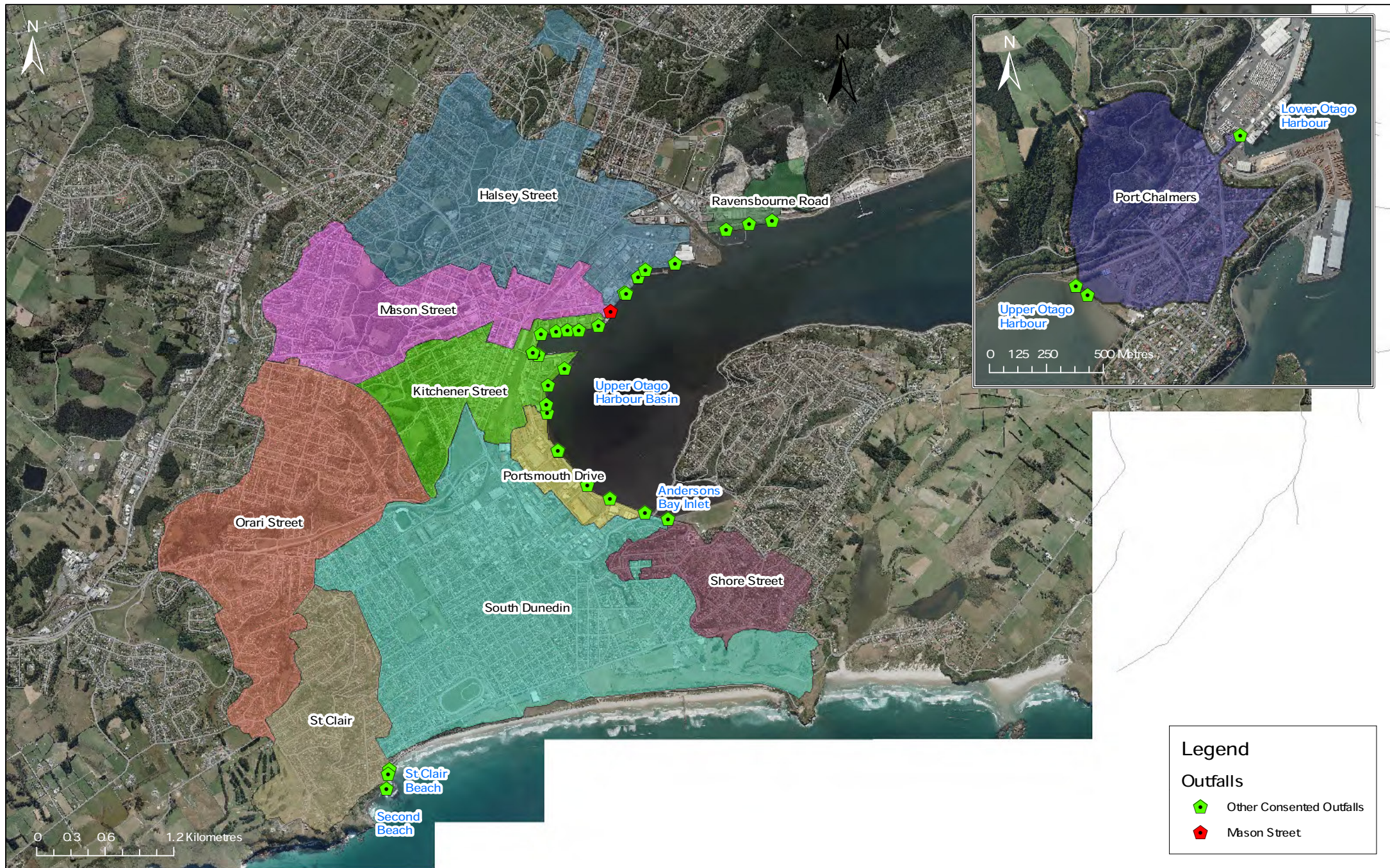
There have been a number of studies carried out to establish the condition of the Otago Harbour receiving environment. A study of Dunedin's marine stormwater outfalls was completed in 2010 by Ryder Consulting Ltd (Ryder, 2010a), for the purpose of assessing the current quality of the receiving environments and the potential effects of stormwater on the environments. This study comprises an assessment of the stormwater, sediments, and ecology in the vicinity of the major outfalls within the



harbour using sites and methods generally in accordance with those carried out for the annual monitoring. The results of this study were compared with past surveys and historical data in order to determine the condition of the harbour receiving environment.

The following reports are provided for reference in Appendix C:

- Ryder (2010a) Ecological Assessment of Dunedin's Marine Stormwater Outfalls.
- Ryder (2010b). Compliance Monitoring 2010. Stormwater Discharges from Dunedin City.
- Ryder (2010c). Dunedin Three Waters Strategy Stream Assessments.
- Ryder (2009). Compliance Monitoring 2009. Stormwater Discharges from Dunedin City.
- Ryder (2008). Compliance Monitoring 2008. Stormwater Discharges from Dunedin City.
- Ryder (2007). Compliance Monitoring 2007. Stormwater Discharges from Dunedin City.
- Ryder (2006). Remediation of Contaminated Sediments off the South Dunedin Stormwater Outfall: A proposed course of action.
- Ryder (2005a). Characterisation of Dunedin's Urban Stormwater Discharges & Their Effect on The Upper Harbour Basin Coastal Environment.
- Ryder (2005b). Spatial Distribution of Contaminants in Sediments off the South Dunedin Stormwater Outfall.



	MASON STREET INTEGRATED CATCHMENT MANAGEMENT PLAN				DISCIPLINE Stormwater		Drawn: MM Checked: HES Approved: HES Date: Sep 2011	Status: Final Scale: 1:30,000 Job No: 42173227	Plot Date: Sep 2011 Map No: Figure 5-1 Revision: -
	Figure 5-1								
	Mason Street Catchment Marine Receiving Environment								
	Dunedin 3 Waters Strategy								



5.1.1 Upper Harbour Basin

The upper harbour basin is a highly modified environment as a result of reclamation, road works and dredging activities (Smith, 2007). Stormwater is received from the greater Dunedin urban area and surrounding rural catchments and discharged via outfalls into the Otago harbour at a number of locations, shown in Figure 5-1.

The tidal range in the Otago Harbour is approximately 2.2 m. Tidal current water velocities range from zero to 0.25 m/s (Ryder 2005), and estimates for harbour flushing times range from 4 to 15 days (Grove and Probert, 1999).

A study by Smith and Croot (1993), describes the circulation of water in the Otago Harbour as being dominated by the tide and inputs of heavy rainfall (refer Figure 5-2). Smith and Croot (1993) report that flushing times in the harbour are hard to establish as heavy rainfall has a dramatic effect on dilution displacement of the water in the upper harbour. Harbour flushing times, therefore, may vary and be greatly reduced during rainfall events.

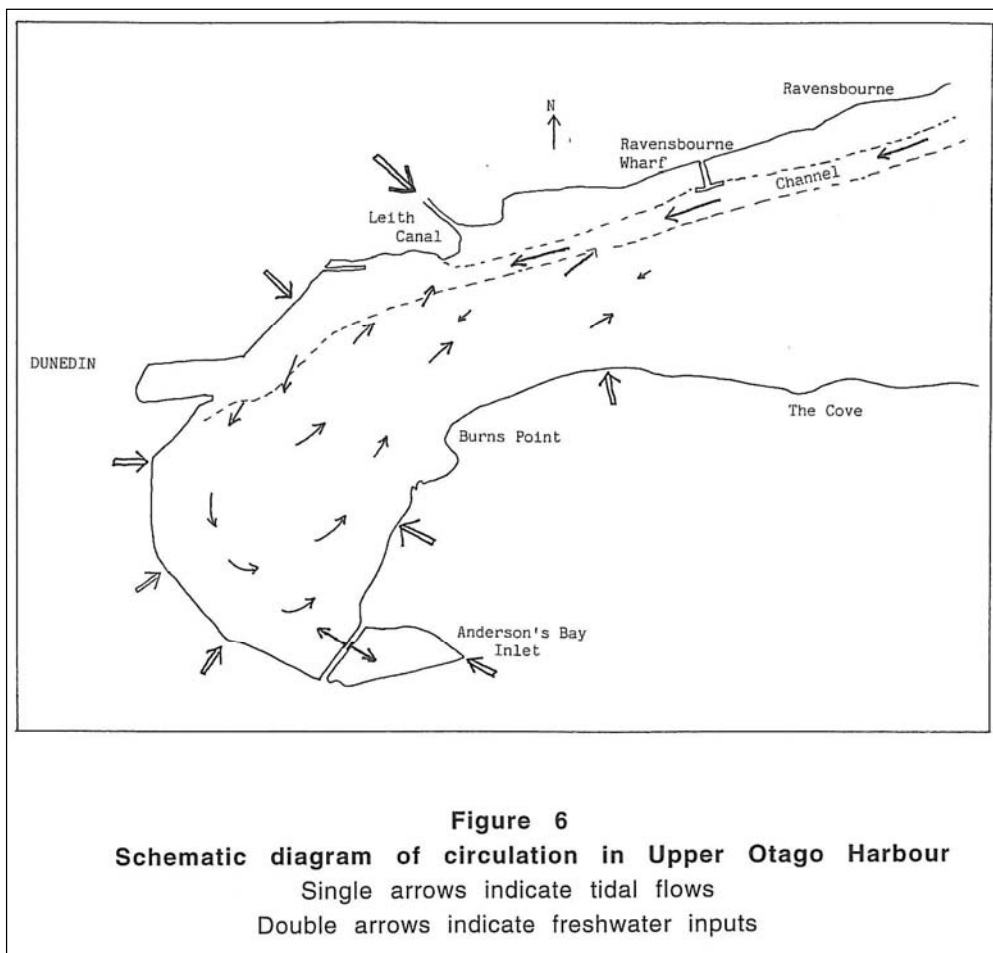


Figure 5-2: Circulation of Water in the Upper Otago Harbour (from Smith and Croot, 1993)



5.1.2 Recreational and Cultural Significance

The harbour is considered an important area for recreation. It is frequently used by wind surfers, fishers and hobby sailors. There are a number of boat clubs and tourism operators in the area that make use of the harbour.

The CIA undertaken by KTKO Ltd. (2005), relating to the initial applications for consent by DCC, to discharge stormwater into the marine environment, describes the strong relationship that Kāi Tahu ki Otago have with the coastal environment. Evidence of Māori use of the harbour extends back to Māori earliest tribal history when the harbour was a valued food resource and used for transport. The report states that the increasing degradation of the harbour environment has affected Māori in many ways and its place as a mahika kai has been dramatically altered. Further consultation with Kāi Tahu is discussed in Section 3 of this report.

5.1.3 Harbour Ecology

The resource consent associated with the outfall of the Mason Street catchment has conditions requiring biological monitoring. The outfall from the Mason Street catchment is adjacent to other large outfalls from other urban catchments. Hence results of ecological studies would make it difficult to distinguish between any potential effects of each catchment. Additionally, the number of stormwater outfalls and other sources discharging into the harbour are numerous, and harbour ecology is affected by all inputs.

The outfall of the Mason Street catchment discharges into deep water therefore biological assessment of the benthic communities of the intertidal zone is not possible.

The discharge consent for this catchment requires that sampling of fish (spotties or triplefins) occurs within 50 m of the confluence of the outfall and the waters' edge at low tide. The weight and length of each fish is recorded and the flesh is analysed for a number of contaminants.

The additional data collected for the 2010 study comprised recording the epifaunal (sediment surface dwelling) species presence on visiting the outfall locations.

The biological investigations undertaken to date look at the effects of the presence / absence of particular stormwater associated contaminants on the ecological communities of the harbour. Where assessment of benthic communities was not possible due to the depth of the water at the outfall (as in this catchment), analysis of contaminant levels in the flesh of marine species was undertaken. However, significant amounts of data are required to link any contamination within the flesh of organisms with stormwater discharge contamination. Table 5-1 below provides typical sources of urban stormwater contaminants.


Table 5-1: Sources of stormwater contaminants

Contaminant	Potential Sources
Total Suspended Solids (TSS)	Erosion, including stream-bank erosion. Can be intensified by vegetation stripping and construction activities.
Arsenic (As)	Naturally occurring in soils/rocks of New Zealand; combustion of fossil fuels; industrial activities, including primary production of iron, steel, copper, nickel, and zinc.
Cadmium (Cd)	Zinc products (Cd occurs as a contaminant), soldering for aluminium, ink, batteries, paints, oils spills, industrial activities.
Chromium (Cr)	Pigments for paints & dyes; vehicle brake lining wear; corrosion of welded metal plating; wear of moving parts in engines; pesticides; fertilisers; industrial activities.
Copper (Cu)	Vehicle brake linings; plumbing (including gutters and downpipes); pesticides and fungicides; industrial activities.
Nickel (Ni)	Corrosion of welded metal plating; wear of moving parts in engines; electroplating and alloy manufacture.
Lead (Pb)	Residues from historic paint and petrol (exhaust emissions), pipes, guttering & roof flashing; industrial activities.
Zinc (Zn)	Vehicle tyre wear and exhausts, galvanised building materials (e.g. roofs), paints, industrial activities.
PAHs	Vehicle / engine oil; vehicle exhaust emissions; erosion of road surfaces; pesticides.
Faecal coliforms / E.coli	Animals (birds, rodents, domestic pets, livestock), sewage.
Fluorescent Whitening Agents (FWAs)	Constituent of domestic cleaning products, indicator of human sewage contamination.
References: ARC (2005); ROU (2002); Williamson (1993).	

The results of the biological monitoring for consent requirements 2007 to 2010, and the 2010 study can be summarized as follows:

- Fish: The monitoring results indicate that the mean weight and length of fish sampled increased between 2007 and 2010. The results for the contaminant concentrations in the flesh samples are variable between years and show no clear trend. The results for 2009, however, generally indicate higher contaminant levels than other monitoring years. The results are shown in Table 5-2.
- The Australia New Zealand Food Standards Code 2004 (the Code), sets out maximum levels (MLs) of specified contaminants in nominated foods. The lead and arsenic concentrations measured in the fish flesh samples (2007 to 2010) were all below the MLs, outlined in the Code for specified contaminants in fish. This may indicate that the fish community in this location is not being exposed to significantly high levels of these contaminants.
- Epifauna: Around the outfalls epifauna was found to comprise mainly of small barnacles and encrusting ascidians. Abundance was high at all sites with no perceptible change in



abundance along the wharf with distance from the outfall. The 2010 monitoring report notes that in general, whilst not pristine, the upper harbour and the ecological communities associated with the intertidal areas adjacent to the major stormwater outfalls appear not to be undergoing any significant degradation as a result of the stormwater inputs during the monitoring period (2007-2010).

Table 5-2: Contaminant Levels Measured in Fish Flesh Adjacent to the Mason Street Outfall

Contaminant	Level in Fish Flesh mg/kg				ANZ Food Standards Code ML
	2007	2008	2009	2010	mg/kg
Arsenic (As)	1.9	1.6	1.9	1.6	2.0
Cadmium (Cd)	0.0047	0.0047	0.0110	0.0091	-
Chromium (Cr)	0.05	BDL	0.14	BDL	-
Copper (Cu)	0.54	0.52	1.20	0.38	-
Nickel (Ni)	BDL	BDL	< 0.095	BDL	-
Lead (Pb)	0.140	0.120	0.430	0.140	0.500
Zinc (Zn)	21	20	21	18	-
PAHs	0.0056	0.0023	0.0060	0.0150	-

BDL – Below Detectable Limits.

5.1.4 Harbour Sediments

The upper harbour bed has been classified, in general, as muddy sands / sandy muds, with varying proportions of fine gravels (Ryder, 2005b). The Mason Street catchment outfalls discharge into deep water.

The stormwater catchments and associated outfalls into the Otago harbour are located close together, and a certain amount of dispersion and mixing occurs in the harbour environment. It is difficult to associate any sediment contamination with any one outfall, and as noted above, the influence of other urban stormwater discharges, and discharges from a variety of other activities, both current and historical, are also expected to be evident in harbour sediments.

The resource consents associated with the outfalls in the Mason Street catchment have no sediment monitoring requirements, therefore the sediment results from outfalls in the catchments adjacent to the Mason Street catchment are discussed to give an indication of sediment quality in the vicinity of the Mason Street catchment. A range of historic data is available regarding contaminant levels within the harbour sediments. However, historic values should be viewed with caution as sampling in previous years may have used different protocols and sediments may have been collected from different substrate depths and by different methods

Sediment monitoring has been carried out adjacent to Mason Street catchment in the Kitchener Street and Halsey Street catchments. However, the Kitchener Street catchment (White Street outfall), is 640 m to the south of the Mason Street catchment and the Halsey Street catchment (Wickliffe



Street outfall) lies 390 m to the north. This distance is considered significant and the results from these locations will not necessarily reflect the sediment quality in the vicinity of the Mason Street catchment outfall. Furthermore, these catchments have high proportion of industrial (historic and current) land use which is not the case in Mason Street catchment and the sediment results from these catchments may reflect the high proportion of industrial land use.

Ryder (2010b) details the full results of marine sediment monitoring, harbour-wide, for DCC stormwater discharge consents.

Within the 20 mm samples collected and analysed for monitoring purposes, there may be a number of years' worth of sediment deposition and a chance that any contamination measured in the samples may be historic. Each sample should not therefore be considered as indicative of the contamination deposited in any given year.

The 2010 study concludes that in general, there is high variability in contaminant levels in the harbour sediments and trends through time remain relatively unclear. Harbour-wide trends may become clear with further data from future monitoring rounds, however the effects of other activities and other catchments discharging to the harbour on the sediment quality at this location is currently unknown.

Sections 6 and 8 of this report discuss stormwater quality and assess the effects on the environment in further detail.

5.2 Freshwater Receiving Environment

An assessment of the streams located within selected Dunedin stormwater catchments was completed in 2010 by Ryder Consulting Ltd (Ryder, 2010c) (refer Appendix C). This assessment was carried out for the purpose of identifying the current state of the streams within each catchment and identifying the potential effects of stormwater on stream health. This study comprised an assessment of the physical quality, water quality and ecology of the streams. The results of this study were also compared with past surveys and historical data, where available, in order to determine the condition of the freshwater receiving environment.

The assessment of stream health indicates, in part, the effect of ongoing stormwater discharges into the watercourses. Streams in the Mason Street catchment have been receiving stormwater from urban development (both diffuse and concentrated) since the late 1800s; as a result, DCC's stormwater collection network has evolved around these natural flow corridors; and due to reclamation efforts adjacent to the harbour, the natural stream discharge point has been extended out to the harbour via the piped network.

The effects of stormwater discharge on streams can take a number of forms; physical effects (e.g. erosion, substrate changes) are often the result of land use changes (increased imperviousness) changing the natural hydrological flow regime of the catchment; whereas chemical changes result from the quality of the stormwater being discharged. Each of these changes has an effect on the habitat, and hence the stream ecology. Modification of the stream environment through physical works also results in changes to the flow dynamics, and incorporation of fish barriers, in some instances.

DCC have published a watercourse information sheet (May 2010), for property owners with a watercourse. It includes the following information:



“In Dunedin, a watercourse is defined as any natural, modified or artificial channel through which water flows or collects, either continually or intermittently, or has the potential to do so, and includes rivers, streams, gullies, natural depressions, ditches and drainage channels. This also includes any culvert or stormwater pipe that replaces a natural channel. A watercourse is owned by the property owner through which the watercourse passes through from the point of entry to the exit point of the property boundary.”

“Property owners are responsible for the following:

- *Ensuring that there are no obstructions or impediments in the watercourse which may inhibit the flow of water; and*
- *Ensuring that any grates or outlets within your property are kept clear of debris at all times.”*

In general, alterations to watercourses require consent from both DCC and ORC.

Three streams with natural channels were identified as suitable for assessment in the Mason Street catchment. A total of four sites were assessed in June 2010. The locations of the streams and assessment sites are shown in Figure 5-3.

Two assessment sites were established at the upstream and downstream ends of a stream to the west of the Town Belt (Mason Street 1 upstream and Mason Street 1 downstream).

The other stream identified in this catchment is located within the Town Belt. This stream has two tributaries, one of which comprises entirely of natural channel, whereas the other contains extensive areas of concrete open channel. Two assessment sites were established along this stream, one located at the upstream end of the tributary with a natural channel, (Mason Street 2 upstream) and the other at the downstream end below the confluence of the two tributaries (Mason Street 2 downstream).

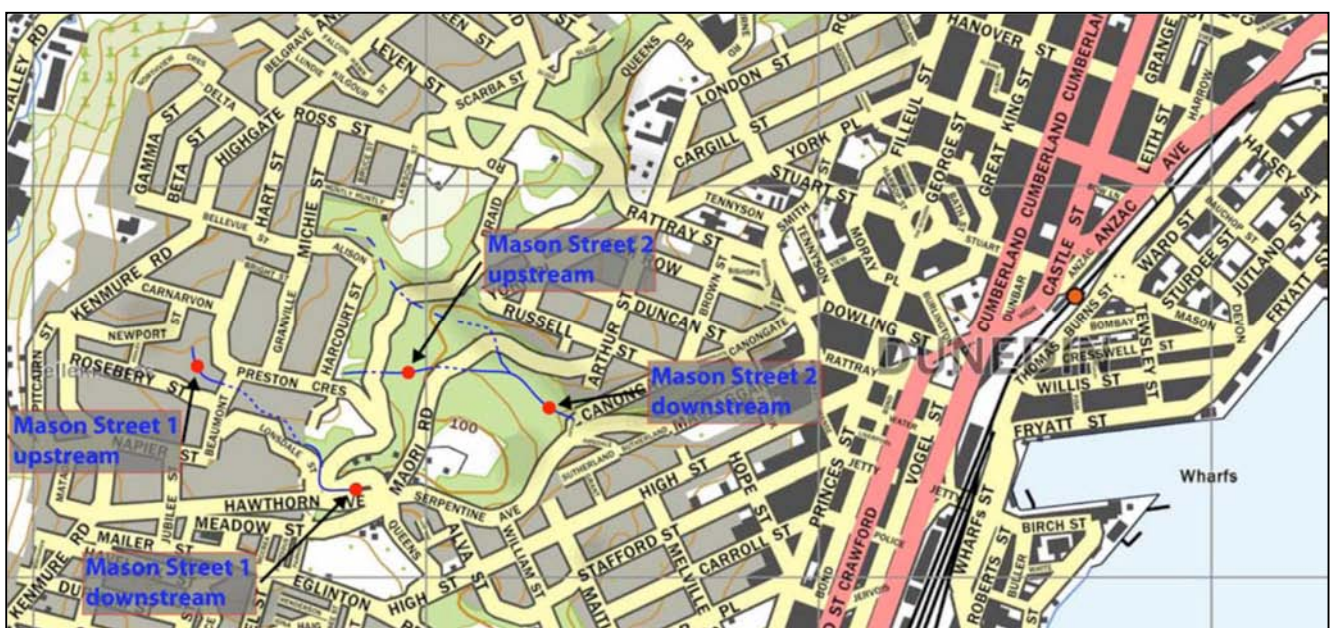


Figure 5-3: Freshwater Receiving Environment



5.2.1 Habitat characteristics

The habitat characteristics of the streams at the four sites assessed are summarised in Table 5-3 and the following text.

Table 5-3: Assessment site characteristics

Characteristic	Mason Street 1 - Upstream	Mason Street 1 - Downstream	Mason Street 2 - Upstream	Mason Street 2 - Downstream
Length	15 m	50 m	100 m	150 m
Channel width	0.5 m	2-3 m	1.0-2.0 m	0.5-2.0 m
Channel depth	2-40 cm	3-50 cm	2-30 cm	3-100 cm
Bank height	0.3 m	0.5-1.0 m	1.0-2.0 m	0.2-1.0 m
Bank stability	High	High	Generally high with some slumping	Generally high with some undercutting
Wetted width	0.5 m	1.0 m	0.5-1.0 m	0.5-1.0 m
Dominant riparian vegetation	Lawns, large trees, herbs and ferns	Dense native forest canopy. Ivy and weeds groundcover	Dense native forest canopy. Ivy and weeds groundcover	Dense forest, ivy, blackberry
In-stream characteristics	Runs, with shallow riffles and some pools	Shallow riffles, with runs and small pools	Shallow riffles, with runs and small pools	Shallow riffles and deeper pools, with runs
Bed substrate	Fine sediments and gravels	Gravels and cobbles, with small boulders and some clay-like substrate.	Clay-like substrate, cobbles and boulders, with some gravel and bedrock.	Gravels and extensive bedrock
Other in-stream	Woody debris and leaves - occasional	Woody debris and moss - common	Some woody debris and moss. Leaves – common	Woody debris, moss and leaves were common

Mason Street 1 upstream

The upper reaches of this stream flow through natural channels behind residential properties. Land use within the stream catchment and adjacent to the assessment site is mainly urban (Figure 5-4).

The stream is contained within a gully behind private residential properties so no amenity values were identified.

Mason Street 1 downstream

The lower reaches of this stream flow from a piped section that runs beside Lonsdale Street into a natural channel. This channel runs parallel with Hawthorn Avenue before re-entering stormwater pipes upstream of the junction of Hawthorn Drive and Maori Road. Land use within the lower stream catchment and adjacent to the assessment site is mainly urban with the Town Belt on the left bank of the channel. (Figure 5-5).



The stream is contained within a gully next to Hawthorn Avenue but the dense forest cover prevents views of the stream from the public road. However, there is a footbridge over the channel at the upstream end of the assessment site and further upstream sections of the channel are visible from Lonsdale Street. Aside from these limited views, no other amenity values were identified.



Figure 5-4: Mason Street 1 Upstream - Assessment Site



Figure 5-5: Mason Street 1 Downstream - Left: Assessment Site; Right: Location of Entry to Stormwater Pipes



Mason Street 2 upstream

The upper reaches of this stream flow through stormwater pipes near Harcourt Street into a steep channel that is piped beneath Queens Drive. The natural channel between Queens Drive and Maori Road contains steep sections in its upper reaches, with reaches of shallower gradient downstream (Figure 5-6).

Land use within the upper stream catchment and adjacent to the assessment site is mainly urban with the Town Belt surrounding the channel below Harcourt Street.

The stream is contained within a gully next to a public walkway between Queens Drive and Maori Road. However, only short sections are visible from the footpath. Downstream of Maori Road several walking and mountain biking tracks cross the stream. Aside from these stream crossings, no other amenity values were identified.

Mason Street 2 downstream

The middle reaches of this stream, downstream of the confluence of the two tributaries, flow through shallow gradient sections before entering higher gradient sections in the lower reaches. The stream enters stormwater pipes at Canongate. Land use within the lower stream catchment is dominated by the Town Belt with urban land behind the reserve on the left bank of the stream (Figure 5-7).

The stream is contained within a gully next to a public walkway between Maori Road and Canongate. Walking tracks are present between the public walkway and the stream, however, these tracks are small and appear to be used infrequently. The stream channel is visible from Canongate at the inlet to the stormwater pipes. Apart from these limited views, no other amenity values were identified.



Figure 5-6: Mason Street 2 Upstream - Assessment Site Upper Reaches



Figure 5-7: Mason Street 2 Downstream - Left: Assessment Site Lower Reaches; Right: Location of Entry to Stormwater Pipes

5.2.2 Water Quality

The pH level in the streams at all four assessment sites was within the range 6.5 to 9.0. This is typically cited as being the appropriate range for freshwater bodies in New Zealand (ANZECC,1992). Water temperature was low reflecting the time of year of sampling.

Conductivity levels were low at Mason Street 2 upstream but slightly higher at all other sites. A higher conductivity indicates higher levels of nutrient enrichment.

The Third Schedule of the RMA (1991) states that a dissolved oxygen (DO) level of 80 % is an acceptable minimum standard for lowland river environments in New Zealand. The DO levels were lowest at the two Mason Street 1 sites and below the acceptable minimum standard at the upstream site.

5.2.3 Stream Ecology

The ecological assessment of the streams involved the survey of aquatic plants, benthic macroinvertebrates and fish.

Benthic algal cover and aquatic plants were recorded and the relative abundance and diversity of species assessed.

Macroinvertebrates were sampled from a representative area of the stream bed substrate using a kicknet. The abundance and diversity of taxa was assessed and macroinvertebrate community health index score was calculated to give an indication of habitat quality. The health index score generally increases as water quality and habitat diversity increases. A semi-quantitative macroinvertebrate community Index (SQMCI) score was also calculated. This can be used to determine the level of organic enrichment in a stream.

In order to sample fish species and determine the fish community within the stream, electric fishing was carried out at locations representative of the different habitats within the stream. Where electric



fishing was not able to be carried out efficiently, spotlighting was carried out to visually identify the fish.

The results of the stream ecological assessment are summarised below. A number of different benchmarks were used to assess the significance of the findings; the number of taxa observed at each site was assessed against the national average as determined in a nation-wide survey by Quinn and Hickey (1990) and the macroinvertebrate community health index scores were used to assess habitat quality using narrative terminology of Stark and Maxted 2004. In addition, any notable species identified within the streams are discussed, where relevant, in terms of the DOC 'threat of extinction' classification (Molloy et al, 2002). Since 1992 DOC has used a classification system that has been developed in New Zealand to categorise species according to their threat of extinction. The system scores taxa against criteria that assess population status, impact of threats, recovery potential, taxonomic distinctiveness, and their value to humans; and categorises species according to their priority for conservation action.

- **Aquatic Plants:** Benthic algae was not observed at either upstream site, likely due to the unsuitable habitat quality (gravel and fine sediment) for algal growth. Algal growth was restricted at both downstream sites to thin brown films comprising diatom taxa.
- **Macroinvertebrates:** A total of 19 different taxa were observed within the Mason Street catchment streams. The average number of taxa per sample was below the national average of 14 (as determined in a nation-wide survey by Quinn and Hickey, 1990). Only one sample from Mason Street 2 downstream had a taxonomic diversity comparable with the national average.
- **Macroinvertebrate communities** were dominated by oligochaete worms with a high abundance of snails at Mason Street 2 downstream. Other taxa observed were found in low abundance.
- **Macroinvertebrate community health index scores** were very low throughout the catchment, except at the Mason Street 2 downstream site, and indicative of a 'poor' quality habitat (using narrative terminology of Stark and Maxted 2004). The score at the Mason Street 2 downstream site was slightly lower than the health index score and was indicative of 'fair' quality habitat.
- **Isopods** (*Austrodotea benhami*) were found at the Mason Street 2 downstream site. Isopods are scarce within New Zealand freshwater fauna and *A. benhami* is thought to be the most vulnerable due to its limited geographical range and land use developments within the catchments in which it is found (Chadderton et al, 2003). DOC, using the 'threat of extinction' classification has listed this isopod species as 'range restricted' (Hitchmough et al, 2007).
- **Nine crayfish**, juveniles and adults, were observed at Mason Street 2 downstream. DOC, using the 'threat of extinction' classification (Molloy et al, 2002), has listed freshwater crayfish as 'in gradual decline' (Hitchmough et al, 2007).
- **Fish:** No fish were caught or observed in the Mason Street 1 streams. However, a healthy population of banded kokopu, comprising large individuals and juveniles, were observed at both Mason Street 2 sites. Using the 'threat of extinction' classification (Molloy et al, 2002), DOC has classified banded kokopu as 'not threatened'. However, confidence in this classification is low based on poor data available for assessment (DOC, 2005).



5.2.4 Summary

The following summarises the freshwater receiving environment within the Mason Street catchment. Further to the use of national classification systems, the different habitat and ecosystem features of the streams surveyed in the Dunedin stormwater catchments as part of this study, have been interpreted relative to each other to summarise the receiving environment within the catchment. The features have been given an overall value of between 'poor' and 'excellent', based on the findings of the site assessments. This is shown in Table 5-4 below.

The aquatic ecosystems within the catchment were found to be of varying quality. The Mason Street 1 upstream site was found to have poor water quality and poor ecology, however some in-stream features, such as bank stability and flow variability were found to be good/excellent. Habitat quality was higher at the Mason Street 1 downstream site but invertebrate communities were poor and no fish were observed.

A higher quality of habitat and aquatic communities was observed at the Mason Street 2 sites. Whilst a poor invertebrate community was found at the upstream site, the streams contained several features of interest: an abundant freshwater crayfish population, threatened isopod species and abundant banded kokopu population. In addition, all habitat features were found to be good or excellent.

Whilst the stream quality is not good compared to a pristine, wilderness environment, the quality of Mason Street 1 is as to be expected for a modified urban stream and the presence of features of interest in the Mason Street 2 stream indicates a good quality for a modified urban stream.

Table 5-4: Summary of Habitat and Ecosystem Quality in the Mason Street Catchment
(Values are 'poor', 'good', and 'excellent')

Feature	Mason Street 1		Mason Street 2	
	Upstream	Downstream	Upstream	Downstream
Riparian vegetation	Poor	Good	Good	Good
In-stream cover	Poor	Excellent	Good	Good
Bank stability	Excellent	Excellent	Good	Good
Bed substrate	Good	Excellent	Good	Good
Flow variability	Good	Excellent	Good	Good
Water quality	Poor	Good	Excellent	Excellent
Invertebrates	Poor	Poor	Poor	Good
Fish	Poor	Poor	Excellent	Excellent



6 Stormwater Quality

This section of the report provides a description of stormwater quality monitoring undertaken to date in and around the catchment, and provides a characterisation of the stormwater quality being discharged from the Mason Street catchment based on the information available.

6.1 Stormwater Quality Monitoring

Annual water quality sampling of the stormwater discharges in this catchment is required as a condition of the discharge consents. The single outfall in the Mason Street catchment has been included in this sampling regime.

The resource consents for stormwater discharge in this catchment require that the water quality sampling shall be undertaken; following one storm event annually, during storms with an intensity of at least 2.5 mm of rainfall in a 24 hour period and the storms must be preceded by at least 72 hours of no measureable rainfall.

Monitoring of the stormwater quality at the outfall has been carried out by Ryder Consulting Ltd. Several rounds of monitoring have been completed to date; 2007, 2008, 2009 and 2010. A single grab sample was taken from the stormwater outfall within 1 hour of the commencement of a rainfall event in attempt to capture the first flush, and therefore worst case scenario.

Three time-proportional stormwater quality samples have also been taken across Dunedin as part of the 3 Waters Strategy; one at South Dunedin (2009), one at Bauchop Street (2009), and one at Port Chalmers (2010). These three sites provide stormwater quality representing industrial / residential, commercial / residential, and residential land uses respectively.

6.2 Stormwater Quality Results

Urban stormwater can contain a wide range of contaminants, ranging from suspended sediments and micro-organisms to metals and petroleum compounds, amongst others. The sources of the contaminants are also wide ranging in urban environments with anthropogenic activities significantly contributing to runoff quality.

Table 6-1 presents the results of the annual monitoring at the Mason Street outfall, which is undertaken via a grab-sampling technique, providing a 'snapshot' of stormwater quality during a storm event.

Table 6-2 shows the results of the time proportional sampling in Dunedin. These results provide an indication of the variations in contaminant concentrations throughout the duration of a rainfall event for catchments with differing urban land uses.

There are no specific guidelines for stormwater discharge quality, either nationally or internationally, however Table 6-3 presents stormwater quality data from a variety of sources. This information provides an indication of 'typical' stormwater contaminant concentrations that might be expected from urban catchments.

The annual monitoring results indicate that the level of contaminants in the stormwater is variable between the years monitored for the Mason Street outfall, with many contaminants below detectable levels in certain years. Considerable variability can be expected in stormwater sampling due to antecedent conditions (the number of days prior to rainfall) and event characteristics (intensity and duration of rainfall), affecting the amount of sediment (and hence contaminants) present in the



stormwater. Additionally, the grab-sampling technique employed may have taken a sample at any point in the event.

The 2010 stormwater samples were collected 23rd April, during a 2.6 mm rainfall event following eight days of dry weather.

The results of the 2010 monitoring indicate, in general, an increase in contaminant levels than the previous year for zinc, E.coli, faecal coliforms and suspended solids. However, across the four sampling years the results do not show any clear trends and therefore it is difficult to determine any deterioration or improvement in the quality of stormwater being discharged from this catchment. In addition, the majority of contaminants were measured at levels within or below the range typically observed for stormwater from similar land uses.

Suspended solid concentrations have shown an increasing trend from 2008 to 2010, however they are still within the typical range for urban stormwater when compared both with the stormwater data from other sources and time proportional (see Tables 6-2 and 6-3).

Microbial contamination of the stormwater from this catchment is generally quite high compared with the typical range for stormwater (1,000 – 21,000 MPN/100 ml) (Metcalf & Eddy, 1991), with the 2010 results being particularly high. The 2010 results may signify that wastewater has entered the stormwater at some point. During the dry period preceding sampling in 2010, two wastewater flooding incidents were reported (19th April and 21st April), and it is possible that these events contributed to the microbial contamination levels observed during the rainfall event sampled on 23rd April.

However, there are no known wastewater network related issues in this catchment, and these incidents (19th and 21st April) appear to be isolated private issues; which may not signify ongoing microbial contamination in the catchment. This is discussed further in Section 8 of this report.



Table 6-1: Stormwater Quality Consent Monitoring Results –, Mason Street Catchment Outfall

Year	Contaminant												
	pH	As	Cd	Cr	Cu	Ni	Pb	Zn	TSS	Oil and Grease	FWA	E.Coli	Faecal Coliforms
		g/m ³									µg/l	MPN/100ml	cfu/100ml
2007	7.1	0.006	BDL	BDL	0.022	0.004	0.0258	0.25	62	5	0.007	22000	22000
2008	7.0	BDL	BDL	BDL	0.012	BDL	0.0089	0.16	37	7.9	0.07	26000	26000
2009	7.4	0.0077	0.0077	BDL	0.021	0.0055	0.014	0.35	37	BDL	0.051	50000	50000
2010	7.0	BDL	0.00051	BDL	0.0157	BDL	0.00102	0.43	138	BDL	0.156	350000	350000

BDL = Below detection limits

Table 6-2: Dunedin Time Proportional Stormwater Monitoring Results, Contaminant Ranges

Location, Date (Land Use)	Contaminant											
	pH	As	Cd	Cr	Cu	Ni	Pb	Zn	TSS	Oil and Grease	E.Coli	Faecal Coliforms
		g/m ³									MPN/ 100ml	cfu/ 100ml
South Dunedin, 2009 (Industrial / Residential)	7.0 - 7.7	0.0012 - 0.0052	BDL - 0.00041	0.0011 - 0.0074	BDL - 0.064	0.0067 - 0.0730	0.0008 - 0.0044	0.230 - 0.840	17 - 160	26 - 42	3900 - 14000	5400 - 20000
Bauchop Street, 2009 (Commercial / Residential)	6.7 - 7.9	BDL - 0.0038	BDL - 0.00054	BDL - 0.0500	0.040 - 0.230	BDL - 0.0870	BDL - 0.0870	0.05 - 2.50	26 - 330	7 - 53	n/a	n/a
Port Chalmers, 2010 (Residential)	7.6 - 7.9	BDL	BDL	BDL	BDL	BDL - 0.1080	0.0024 - 0.0077	0.108 - 0.260	8 - 47	6 - 18	n/a	320 - 1000

BDL = below detection limit



Table 6-3: Comparison of Mason Street Catchment Stormwater Quality with Other Stormwater Quality Data

Contaminant (g/m ³)	Time Proportional Dunedin	Christchurch Recommended Provisional Mean Values ¹	Pacific Steel, Auckland ²	Brookhaven Subdivision ³	Australian Stormwater Mean ⁴	Urban Highway, USA ⁵	New Zealand Data Range ²	Mason Street 2010
	Residential / Industrial	Christchurch	Industrial	Residential	Australian sites	Highway	Urban	Mixed Use
TSS	8 - 330	33 - 200	124	5 - 49	164	142	-	138
Zinc	0.05 - 2.50	0.40	2.80	0.003 - 0.260	0.910	0.329	0.09 - 0.80	0.43
Copper	BDL - 0.23	0.05	0.08	0.002 - 0.031	0.08	0.054	0.015 - 0.110	0.0157
Lead	BDL - 0.087	0.075	0.23	0.003 - 0.007	0.25	0.4	0.06 - 0.19	0.001

BDL = below detection limit

¹ Christchurch City Council (2003). ² Williamson (1993). ³ Zollhoefer (2008). ⁴ Wendelborn et al. (2005). ⁵ U.S. Department of Transportation Federal Highway Administration (1990).



7 Stormwater Quantity

7.1 Introduction

A linked 1 and 2-dimensional hydrological and hydraulic model of the Mason Street catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different scenarios. Two modelling reports were produced for DCC; the '*Mason Street Model Build Report*' (Opus, 2010a), and the '*Mason Street Catchment Hydraulic Performance Report*' (Opus, 2010b), and the information presented in this section is sourced from these reports. Figure 7-1 provides a diagram of the model extent.

The modelling analysed a number of influences on the system, as follows:

- Two alternative catchment imperviousness figures; one for the current land use, and one for the future, representing the likely maximum imperviousness.
- Seven different high tide situations; current MHWS; MHWS with 2030 and 2060 medium and extreme climate change scenarios; and MHWS with two storm surges (1 in 2 yr Average Recurrence Interval (ARI) applied to current, and 1 in 20 yr ARI applied to 2060 extreme climate change).
- Five design rainfall events; 1 in 2 yr, 1 in 5 yr, 1 in 10 yr, 1 in 50 yr and 1 in 100 yr ARI events (refer Rainfall Analysis, Appendix D).
- Three climate change scenarios; no climate change, mean climate change, and extreme climate change (for 2031 and 2060 design horizons).

The model was constructed in the hydraulic and hydrologic software package, InfoWorks CS v10.5, using asset data based on DCC's Hansen and GIS stormwater databases. Missing information or more detailed information was then obtained from as-built drawings, LiDAR (light detecting and ranging) data, site visits and operational knowledge. Flow monitoring was undertaken for this catchment and the model calibrated to replicate the observed flow, depth and velocity data as well as was possible. A historical rainfall event (February 2005) was also run through the model and compared with reported flooding information for the same event, in order to gauge model confidence. As the historical records of flooding matched well with the model's predicted flooding, and the historical event is considered to be greater than a 1 in 10 yr ARI event, confidence in the model is considered to be moderate to high.

7.2 Model Results

Fourteen scenarios representing different land use, rainfall, climate change and tide combinations have been modelled. Tables 7-1 and 7-2 below provide the results of the modelling, in relation to information required to assess the performance of the system and enable the environmental effects to be determined.

Section 8 analyses the modelling results in order to identify key effects relating to system capacity and flooding. In general, DCC are particularly concerned with the point at which a manhole is predicted to overflow and cause flooding (particularly to potential habitable floor level); however the pipe surcharge state, and manholes that are 'almost' overflowing are also of relevance when considering available capacity in the system. Section 8 analyses the modelling results in order to identify key issues relating to system capacity and flooding.



With respect to flooding of private property, model results are presented as a 'number of land parcels with flood depth potentially ≥ 300 mm', and are based on a GIS assessment of DCC cadastral maps, overlaid with modelled flood extents. When targets for protection of private property are set (Section 11) these are set to limit the flood risk to private property and habitable floors. As discussed further in Section 8, the modelled deep flooding of part of a parcel does not necessarily mean that the entire property is inundated; further detail (including survey) is generally required to confirm the risk to habitable floors.

Table 7-1: Mason Street Catchment Model Results - Current Land Use

Hydraulic Performance Measure	ARI	Current Land Use
Percentage of manholes predicted to overflow	1 in 2 ¹ yr	4
	1 in 5 yr	8
	1 in 10 yr	18
Number of land parcels with flood depth potentially ≥ 300 mm ²	1 in 2 ¹ yr	2
	1 in 5 yr	6
	1 in 10 yr	7
	1 in 50 yr	24
	1 in 100 yr	29
Estimated flood extent (% of catchment area with flood depth ≥ 50 mm)	1 in 2 ¹ yr	0.02
	1 in 5 yr	0.13
	1 in 10 yr	1.01
	1 in 50 yr	2.52
	1 in 100 yr	3.75
Modelled percentage (by number) of pipes surcharging	1 in 2 ¹ yr	29
	1 in 5 yr	56
	1 in 10 yr	65
Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover)	1 in 2 ¹ yr	6
	1 in 5 yr	18
	1 in 10 yr	25

¹ 1 in 2.33 year event (mean annual flood)

² On all or part of a land parcel, or against a building void in the 2-D surface



Table 7-2: Mason Street Catchment Model Results - Future Land Use / Climate Change

Hydraulic Performance Measure	ARI	Planning Scenario				
		2031			2060	
		Growth Only	Mean Climate Change	Extreme Climate Change	Mean Climate Change	Extreme Climate Change
Percentage of manholes predicted to overflow	1 in 10 yr	19	24	25	25	28
Number of land parcels with flood depth potentially ≥ 300 mm ¹	1 in 10 yr	8	15	16	18	19
	1 in 50 yr		40		41	
	1 in 100 yr					77 ²
Estimated Flood Extent (% of catchment area with flood depth ≥ 50 mm) ²	1 in 10 yr	1.02	1.18	1.41	1.86	2.12
	1 in 50 yr		3.13		3.49	
	1 in 100 yr					8.62 ²
Modelled percentage (by number) of pipes surcharging	1 in 10 yr	65	71	72	70	71
Percentage of manholes with free water level within 300 mm of cover	1 in 10 yr	27	32	31	32	41

¹ On all or part of a land parcel, or against a building void in the 2-D surface

² Includes areas flooded outside the catchment boundary



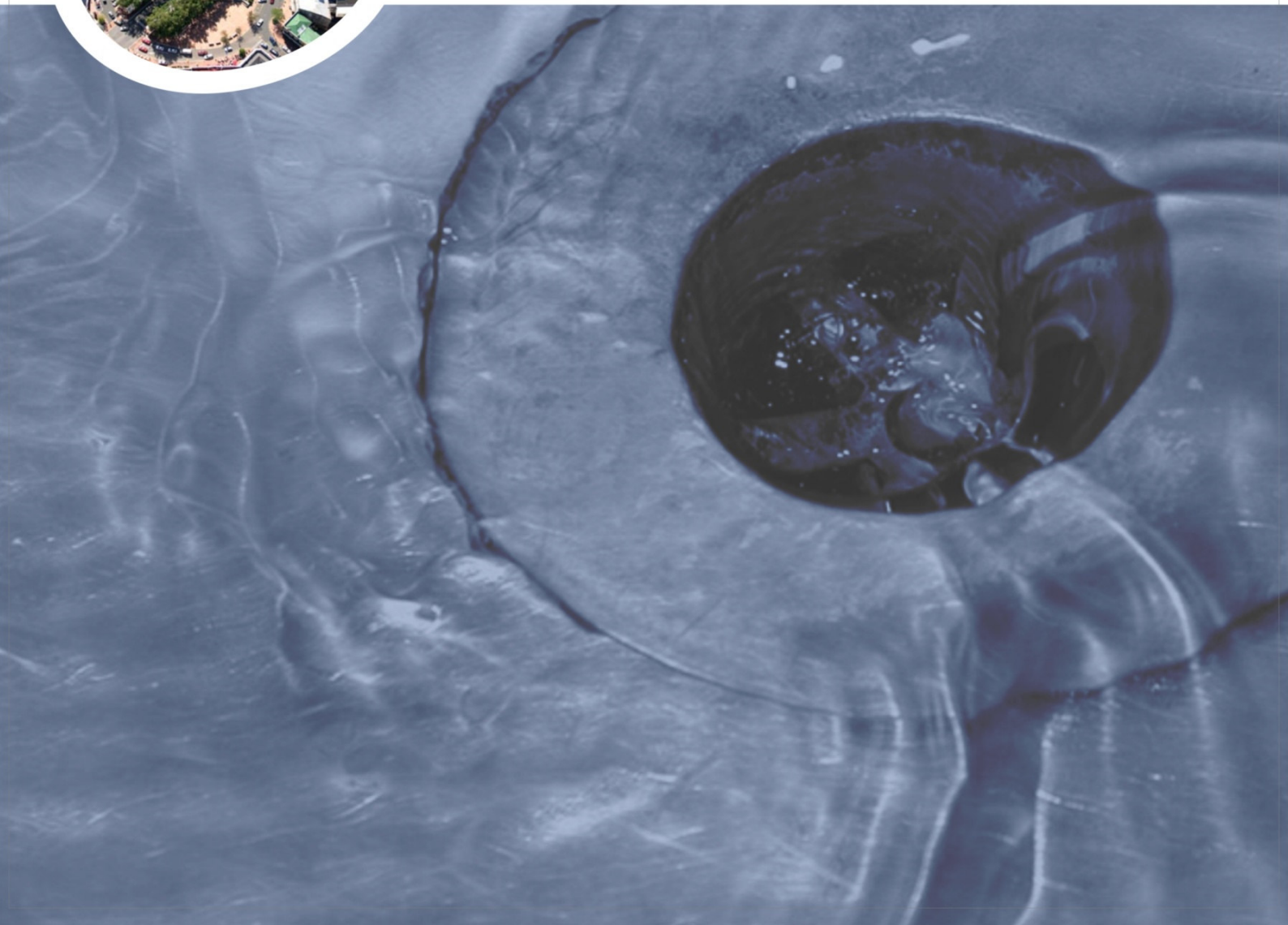
Legend

- Mason Street Catchment Boundary
- Modelled Manhole
- Pruned Manhole (not modelled)
- Drain Manhole (not modelled)
- Catchpit (not modelled)
- Modelled Pipe
- Pruned Pipe (not modelled)
- Drain Pipe (not modelled)
- Catchpit Pipe (not modelled)
- Roads



Part 3

Analysis





8 Assessment of Environmental Effects

This section identifies and summarises the actual and potential environmental effects on the stormwater network and natural environment relating to stormwater quantity and quality within the catchment.

The effects are summarised based on the interpretation of the outcomes of the stormwater network hydraulic modelling and the associated flood maps; the marine and stream assessments; information gathered during catchment walkovers; DCC flood complaint records; and workshops with DCC Network Management and Maintenance staff.

8.1 Stormwater Quantity

8.1.1 Benefits of the Stormwater Network

Urban development significantly increases the area of impervious surfaces from which rainfall quickly runs off. These surfaces include building roofs, paved areas, roads and carparks, and they can also include, but to a lesser extent, grassed and garden areas. In Dunedin, the stormwater network controls the urban runoff, collecting the flows within the system and directing it to the receiving environment. The stormwater network therefore provides a number of benefits to the community.

DCC is responsible for managing the stormwater system in order to provide the best system possible at a reasonable cost to the ratepayer. The objectives set for stormwater management by DCC are outlined in the Stormwater AMP, as follows:

“The key objective of the Stormwater Activity is to protect public health and safety by providing clean, safe and reliable stormwater services to every customer connected to the network with minimal impact on the environment and at an acceptable financial cost. In addition to ensuring effective delivery of today’s service, we also need to be planning to meet future service requirements and securing our ability to deliver appropriate services to future generations.”

The stormwater activity is particularly focused on providing protection from flooding and erosion, and controlling and reducing the levels of pollution and silt in stormwater discharge to waterways and the sea, and the overall objective is broken down into the individual activity objectives of:

- Ensuring stormwater discharges meet quality standards;
- Ensuring services are available;
- Managing demand;
- Complying with environmental consents;
- Strategic investment;
- Maintaining assets to ensure serviceability; and
- Managing costs.



8.1.2 Stormwater Quantity Effects

The hydraulic model results, summarised in Table 7-1 and 7-2, have been used to assess the hydraulic performance of the stormwater network with respect to the criteria shown in the table. This information has been analysed alongside flood maps, observed catchment issues, anecdotal evidence and operational information, to assess the effects of stormwater quantity within this catchment.

Each planning scenario modelled used a range of assumptions which are outlined in Section 7. Flow monitoring was undertaken in this catchment and the model calibrated to replicate observed flow, depth and velocity data as well as possible. A historical rainfall event (February 2005) was also simulated, and model results compared with reported flooding information for the same event in order to validate the model. Due to adequate calibration and validation, confidence in the model is considered to be moderate to high.

It should be noted however, that even with a moderate to high level of confidence, there are still some uncertainties in the model. Assumptions regarding the catchment's hydrology represent the highest area of uncertainty, particularly in the Town Belt, with additional uncertainties due to interpolation of missing GIS data, and the simplistic replication of open channel dimensions within the Town Belt.

The effects of stormwater quantity on the network within the Mason Street catchment are discussed in the following sections. The benefits of the network and the effects on the level of service, flooding and key system structures are identified in relation to current and future land use scenarios and projected climate change.

8.1.3 Infrastructure Capacity

The network analysis and flood mapping undertaken for the current land use show that the predicted level of service provided by the stormwater network in the Mason Street catchment is variable. Overall, it is predicted to be approximately less than a 1 in 10 yr ARI rainfall event.

In general, DCC are particularly concerned with the point at which a manhole is predicted to overflow and cause flooding (particularly to potential habitable floors); however the pipe surcharge state and manholes that are 'almost' overflowing are also of relevance when considering available capacity in the system.

Based on the results presented in Section 7 (manholes overflowing), the model of the stormwater network estimates that the percentage of the network able to accept stormwater flows is as follows:

- 96% of the network can accept a 1 in 2 yr ARI rainfall event
- 82 % of the network can accept a 1 in 10 yr ARI rainfall event
- 70 % of the network can accept a 1 in 100 yr ARI rainfall event

During a current 1 in 2 yr ARI rainfall event combined with a MHWS tide, some surcharging across the modelled network is predicted, with approximately 29 % of the pipes flowing full. Approximately 4 % of all manholes in the catchment are predicted to overflow.

System restrictions during the 1 in 2 yr ARI rainfall event are in the upper part of the network, and manhole overflows predicted are in the vicinity of Serpentine Avenue.



Additional pipes have been installed downstream of the intake structure in the past, potentially to resolve the pipe capacity issue. However, current modelling indicates that this has not been entirely successful, and that overflows are predicted from the pipe network due to capacity restrictions. This is shown in Figure 8-1.

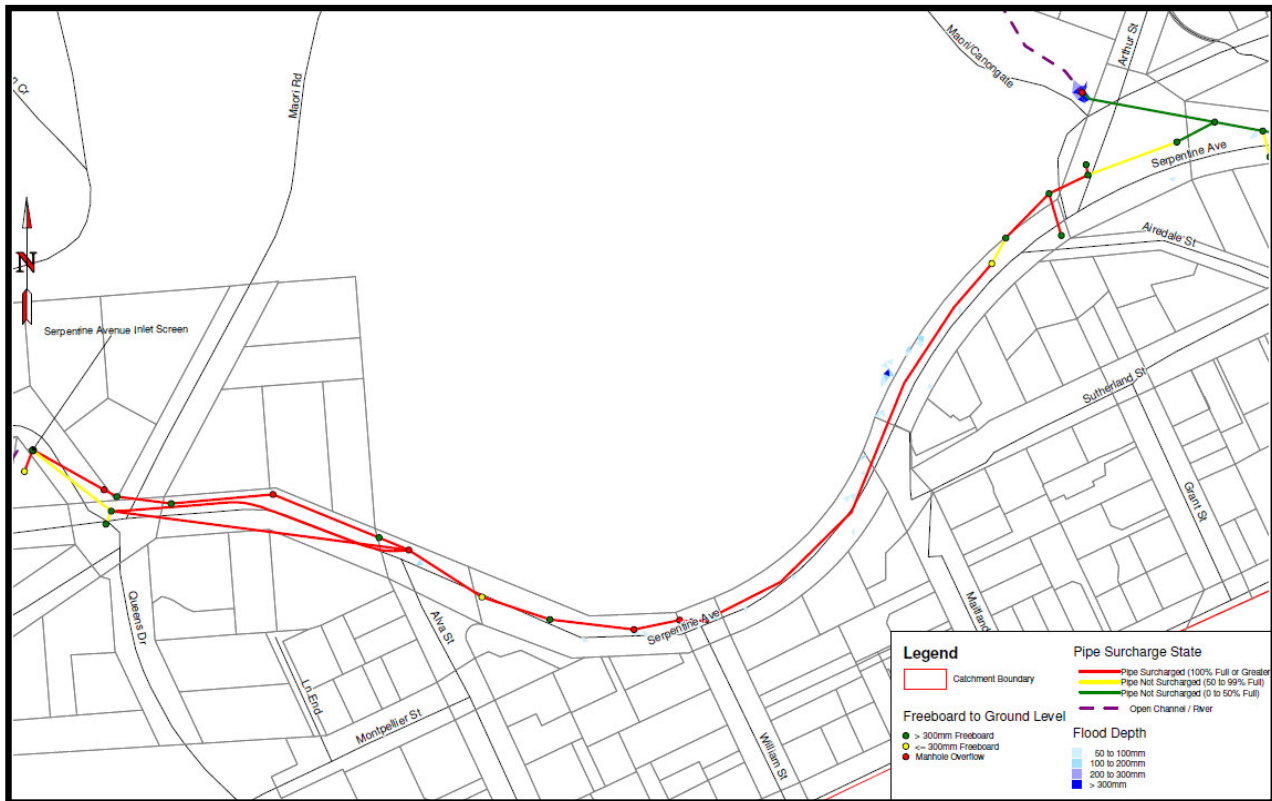


Figure 8-1: 2010 1 in 2 yr ARI Rainfall Event (Model Results)

During a current 1 in 5 yr ARI event, with a MHWS tide the model predicts that approximately 56 % of the pipes will be flowing full and approximately 8 % of all manholes are predicted to overflow.

Further to overflows during the 1 in 2 yr ARI event, the intake structure at Queens Drive/Serpentine Avenue is predicted to overflow, contributing to the flooding from predicted manhole overflows along Serpentine Avenue. The number of manholes estimated to overflow in this area increases from 7 to 8.

During this event, pipe surcharging is also predicted in a large proportion of the pipes on the flat land, adjacent to the harbour. A small number of manhole overflows are predicted in Cresswell Street, Bond Street and on High Street opposite Queens Gardens. This is shown in Figure 8-2.

The increased surcharging during this event in the lower catchment is primarily due to tidal influence on the stormwater network restricting capacity. The single outfall discharges below the high tide water level and so the tide forms a backwater effect causing surcharging of the pipes upstream. The tidal influence extends up the system until Princes Street/High Street. This is shown in Figure 8-2.

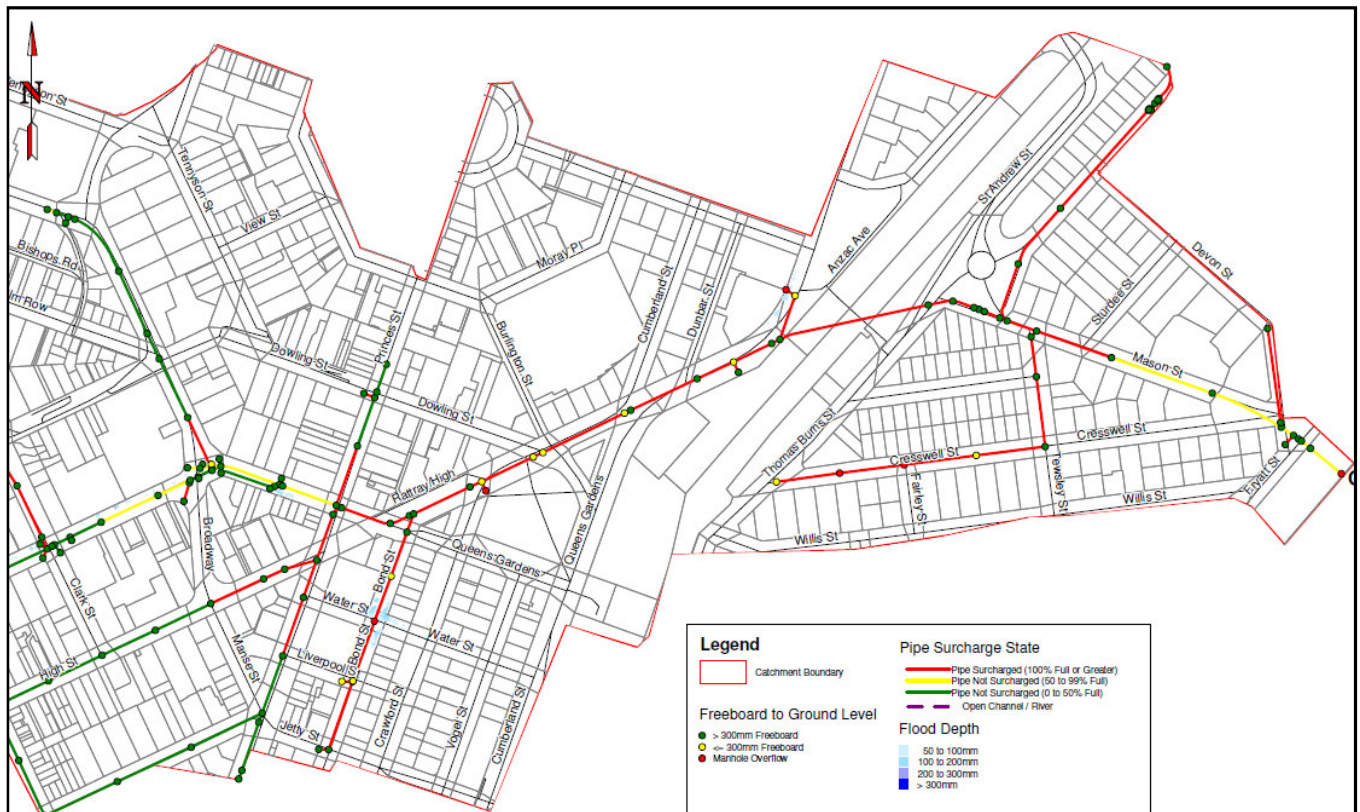


Figure 8-2: 2010 1 in 5 yr ARI Rainfall Event (Model Results)

During a 1 in 10 yr ARI rainfall event, with a MHWS tide, further pipe surcharging is predicted on the flat land of the catchment and additional manholes in the vicinity of Cresswell Street, High Street, and Bond Street are predicted to overflow.

The model predicts that and approximately 18 % of the manholes in the catchment will overflow and approximately 65 % of the modelled network is predicted to be flowing full. This is shown in Figure 8-3.

Flooding resulting from manhole overflows is discussed in the following sections, along with the anecdotal evidence provided by DCC Network Management and Maintenance staff. Regarding network capacity, workshop discussions revealed that intake structure and manhole overflows have been observed at the top of Serpentine Drive, and are exacerbated by blocking of the intake structure, although the size of rainfall event during which this occurs is uncertain. Blocking of intake structures, notably on Serpentine Avenue and Canongate Road was noted as being a problem and resulted in reduced performance of the network.

Similarly it was confirmed that there are known instances of nuisance flooding in Rattray Street, Bond Street/Water Street and Queens Gardens areas.

The manhole overflows in Cresswell Street were unconfirmed by anecdotal evidence from DCC Network Management and Maintenance team or customer complaints.

As this catchment is almost fully developed, with the exception of the Town Belt, future land use changes are unlikely to be significant (approximately 1 % overall). This means that projected growth will not significantly reduce the level of service provided by the stormwater system, and any predicted future increase in flooding predicted by the model is almost entirely as a result of projected climate change effects.



The number of manholes overflowing in the Mason Street catchment during a 1 in 10 yr ARI rainfall event is predicted to increase from 18 % currently, to 25 % when a 2060 mean climate change scenario is modelled.

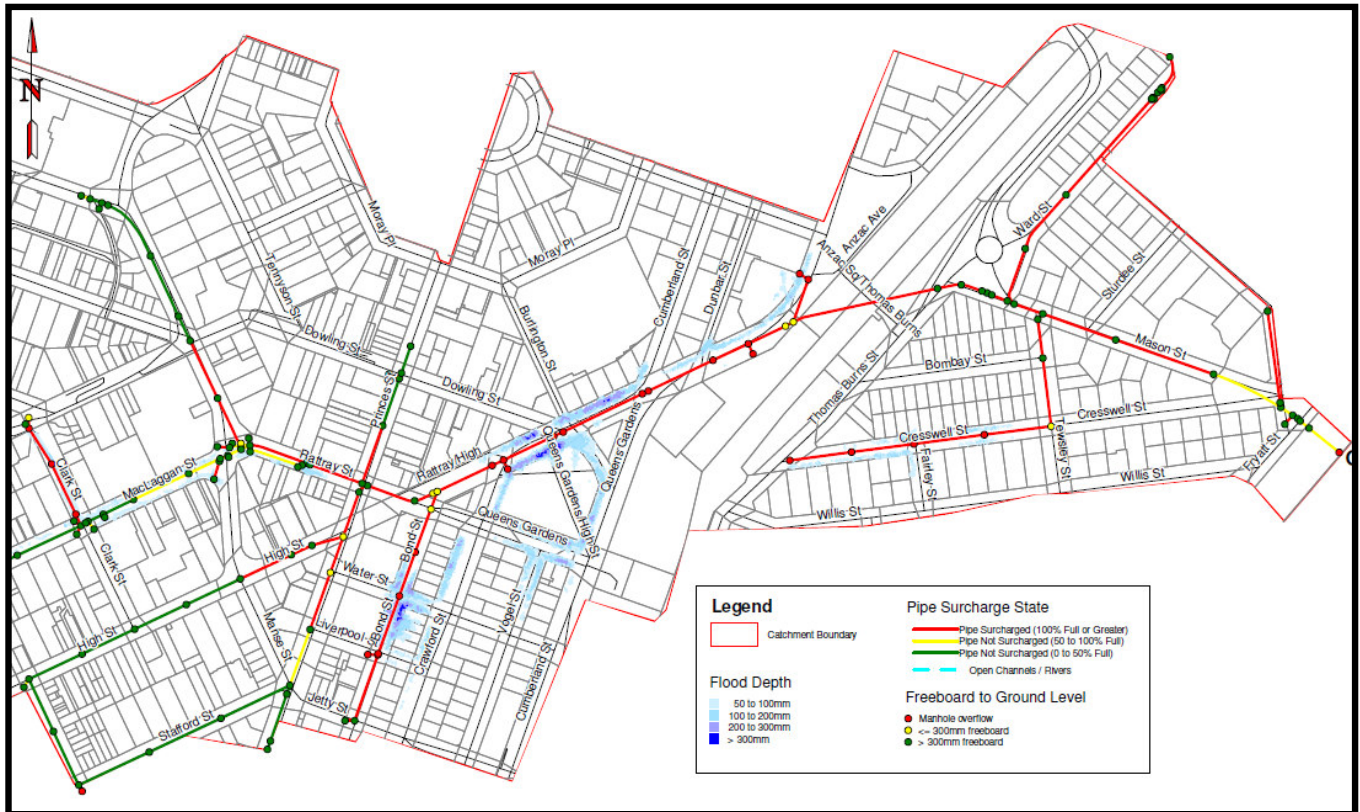


Figure 8-3: 2010 1 in 10 yr ARI Rainfall Event (Model Results)

8.1.4 Flooding

The hydraulic model has been used to indicate areas within the catchment potentially at risk of flooding during a variety of planning scenarios. This includes a range of storm events, current and future land use scenarios and climate change projections, generally modelled with a MHS tide condition (adjusted for climate change where necessary). These predictions have been validated, where possible, with anecdotal evidence from DCC Network Management and Maintenance staff, and observations made on the catchment walkovers. As outlined in Section 4.8, a number of flood complaints have been made in the catchment in recent years.

Predicted nuisance flooding, habitable floor flooding and flood hazard ratings within the catchment have been assessed, and are discussed in the following sections.

8.1.4.1 Nuisance Flooding

Nuisance flooding constitutes predicted flood depths generally between 50 mm and 300 mm, or flooding in locations unlikely to cause habitable floor flooding or serious transport disruption. Flood depths greater than 300 mm deep pose a potential habitable floor flooding risk, and are discussed in the following section.

During a 1 in 2 yr ARI rainfall event, the predicted flood area in the catchment is minimal, inundating approximately 0.02 % of the total catchment. Flood extent and depth is predicted to increase during rainfall events of increasing recurrence interval and also when future planning scenarios are applied



with projected climate change. During a current 1 in 100 yr ARI rainfall event the total flood area is predicted to comprise approximately 3.75 % of the catchment, predominantly in the flatter areas.

Nuisance flooding is predicted within the catchment at a number of locations, the effects and significance of this flooding is described below.

The steep nature of the upper catchment results in high velocity stormwater running along the roads, and the ability of catchpits to accept these flows may be compromised. As the intensity of a rainfall event increases, higher flows and velocities of surface water mean that less can be intercepted by standard catchpits. The hydraulic model makes allowances for this effect.

Serpentine Avenue

During a current 1 in 2 yr ARI rainfall event, the model predicts that a number of manholes at the top of Serpentine Avenue will overflow. This stormwater is predicted to then flow along the kerb of Serpentine Avenue and re-enter the system via catchpits further downhill where there is capacity, before the junction with Maclaggan Street. This is shown in Figure 8-1. Nuisance flooding is exacerbated during rainfall events of increasing recurrence interval (resulting in flows of higher velocity and larger volumes of stormwater leaving the system at capacity 'pinch points'), with stormwater predicted to re-enter the system where capacity is available; (e.g. further along Maclaggan Street after the intersection with Clark Street during a 1 in 5 yr ARI rainfall event). Ultimately, ponding occurs on Rattray Street as the terrain flattens out. This is discussed in further detail below.

Discussions with DCC Network Management and Maintenance staff confirm that overflows and surface flooding along Serpentine Avenue have been observed, matching, and possibly exceeding that predicted by the model.

Additionally, the intake structure at Queens Drive/Serpentine Avenue is known to overflow, particularly when the structure becomes blocked, which is considered to be relatively frequently. However, the size of rainfall event during which overflows have been observed is unknown. During significant rainfall events this is also known to result in ponding in the garden of the adjacent property.

This predicted nuisance flooding along Serpentine Drive and Maclaggan Street is considered minor as the flows will be contained within the kerb of the road and are not predicted to be deep enough to cause traffic disruptions.

Maclaggan Street / Clark Street / Rattray Street

The overflows from Serpentine Avenue, during a 1 in 10 yr ARI rainfall event, are predicted to continue downhill to Rattray Street. The catchment becomes flat in this location and there is a dip in the land on Rattray Street, and the flows are predicted to slow and pond in the road. The model indicates that the pipes in this location are flowing full but that the manholes are not overflowing. As such the catchpits may have some capacity to store the flows within the chamber until the storm peak recedes.

Pipe surcharging in this location is predicted downstream of the Rattray Street pipe due to tidal influence. The main line cannot accept further flows from Rattray Street during this rainfall event, therefore the ponding may be slower to drain. This is shown in Figure 8-3.

The ponding is predicted to be relatively shallow and remain at depths below 300 mm, therefore not providing a risk to habitable floor flooding. Furthermore, the flood extent is not predicted to extend the



full width of the road. It is considered therefore that flooding during this event, in this location, will cause only a minor nuisance.

In relation to the predicted effects on Rattray Street, DCC Network Management and Maintenance staff confirmed that the network response predicted by the model during a 1 in 10 yr ARI rainfall event correctly depicts the response observed in this location during a high tide. However, the size of rainfall event during which this effect has been observed is unknown.

Bond Street / Water Street / Crawford Street

During a 1 in 5 yr ARI rainfall event, the model predicts that manhole overflows will occur on Bond Street. The lateral pipes in this location intersect with the main stormwater line at the Bond Street/Queens Gardens intersection. The main line is predicted to be at capacity and therefore cannot accept further flows from Bond Street. The flows in Bond Street cannot be cleared and the manholes are predicted to overflow. The LiDAR indicates a low point in the road in this location which is predicted to exacerbate the ponding, making it difficult for flows to clear.

The ponding remains shallow, less than 300 mm, and is contained mostly within the kerb of the road around the intersection with Water Street. This will therefore only cause minor nuisance for a short period of time until flows clear.

During a 1 in 10 yr ARI rainfall event, the models predict that the effects are exacerbated. Ponding is predicted along Bond Street and around the Bond Street / Water Street intersection, extending the full width of the road. The flood depths are predicted to exceed 300 mm in some places and therefore present a risk to habitable floor flooding. This is discussed further in the following section. Flooding from this location is predicted to flow overland along Water Street to Crawford Street, which runs parallel to Bond Street. This is shown in Figure 8-3. This flooding is primarily low velocity ponded water so the main risk to the public is the depth of the water predicted.

Discussions with DCC Network Management and Maintenance staff confirmed that flooding around the Bond Street / Water Street / Crawford Street locations has been observed. However, the size of rainfall event during which this has been observed is unknown.

Queens Gardens / High Street

During a 1 in 10 yr ARI rainfall event, the model predicts nuisance flooding around Queens Gardens. The main stormwater line along High Street is predicted to be surcharged and a number of manholes are predicted to be overflowing. The model indicates that the flooding extends the perimeter of Queens Gardens and along High Street. Flooding is covering the width of the road on High Street to the north of the Gardens.

The flooding predicted in this location is primarily due to the tidal influence on the stormwater pipes on the flat land of the catchment reducing capacity in the pipe network.

The flooding around most of the circumference of Queens Gardens is predicted to remain shallow, below 300 mm and is not considered to be significant as the majority of the ponding is within the kerb and grassed areas around the park. However, along High Street some of the depths are predicted to exceed 300 mm. This is discussed further in the following section. This flooding is primarily low velocity ponded water so the main risk to the public is the depth of the water predicted.



Cresswell Street

During a 1 in 10 yr ARI rainfall event, the model predicts that minor ponding of stormwater along the kerb in Cresswell Street will occur. The flood depths are predicted to remain shallow and do not extend the full width of the road. It is therefore unlikely that this will pose any risk to buildings or disrupt traffic in the vicinity. The surcharging and manhole overflow predicted in this location is strongly influenced by the tidal boundary conditions applied to the model.

The manhole overflows in Cresswell Street were unconfirmed as the DCC Network Management and Maintenance team rarely have reason to visit this location as it is an industrial area and there are no intake screens to be maintained by this team in this location. Similarly there are no flood complaints recorded near this location. This suggests that should this flooding occur, it is no more than a minor nuisance.

8.1.4.2 Habitable Floor Flooding

Flood depths equal to or greater than 300 mm present a risk of habitable floor flooding. Habitable floor flooding is the flooding of 'useful floor space' for any zoning (including industrial). This is defined as the floor space of a dwelling or premises inside the outer wall, excluding cellars and non-habitable basements. Land parcels (properties) have been defined as 'at risk' of habitable floor flooding where the property boundary is intersected by a flood plain depth of equal to or greater than 300 mm. It should be noted however, that the exact location of buildings and corresponding floor levels are not documented so it is not usually known whether flooding may only occur within the property boundary or affect the building.

New stormwater systems are designed to avoid habitable floor flooding during a 1 in 50 yr ARI rainfall event. For existing systems, assessment of all rainfall events is undertaken in order to assess the risk of flooding.

Whilst the model predicts that 2 parcels will experience deep flooding (> 300 mm) during a 1 in 2 yr ARI rainfall event, using aerial photos and topographical information, no buildings appear to be at risk.

During a current 1 in 10 yr ARI rainfall event the model predicts that approximately seven land parcels may experience flooding on part of their parcels to depths greater than 300 mm. These are located at the Bond Street/Water Street intersection and along High Street opposite Queens Gardens. Using aerial photographs and topographical information, the flooding appears to affect mainly the car parks of properties with the exception of one location on the corner of High Street and Dowling Street. The risk of habitable floor flooding is therefore considered to be low.

Flood complaint records (2005-2007) indicate that flooding has occurred on the corner of Bond Street and Water Street and that ground floor flooding extended 1 m inside the property door. This complaint was recorded following the February 2005 rainfall event, which is considered to have a peak intensity with a recurrence interval of greater than 1 in 100 years.

During a current 1 in 50 yr ARI rainfall event approximately 24 land parcels are predicted to experience flood depths of greater than 300 mm, an increase of 17 from the 1 in 10 yr ARI event. This is shown in Figure 8-4. The locations that are predicted to flood during this event are as follows:

- Queens Drive/Serpentine Avenue and Canongate intake screens contributing to flooding on Rattray Street.



- Bond Street / Water Street intersection, High Street / Queens Gardens area, increases in depth and scale due to increased flows.

A number of recorded stormwater flooding complaints correspond with these locations and following the February 2005 event, stormwater flooding was reported to have entered a number of buildings in all three of the locations identified above.

During a current 1 in 100 yr ARI rainfall event, the number of land parcels predicted to be at risk of habitable floor flooding rises to 29. These predicted effects are further exacerbated when future planning scenarios and projected climate change is applied to the model. During a future (2060) 1 in 50 yr ARI rainfall event with projected climate change, the number of land parcels predicted to be at risk of habitable floor flooding is increased from 24 to 40.

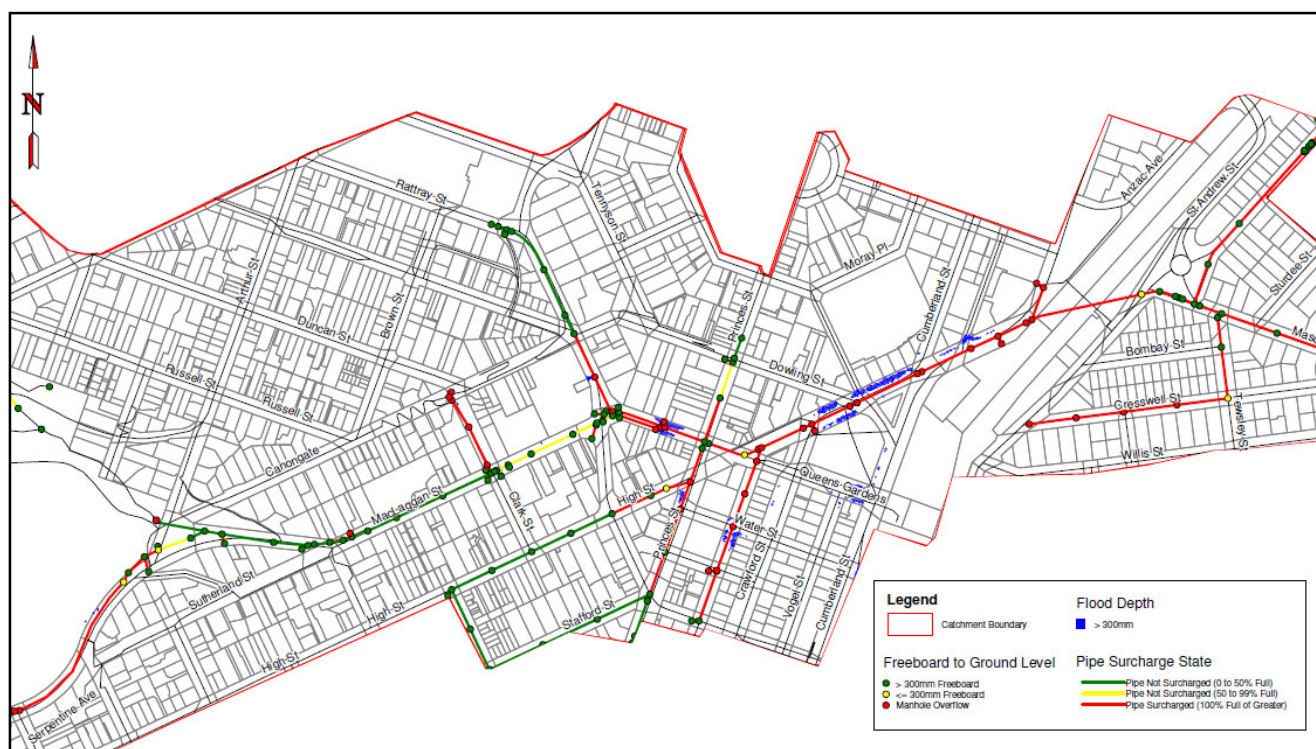


Figure 8-4: 2010 1 in 50 yr ARI Rainfall Event (Model Results)

8.1.4.3 Flood Hazard

The hydraulic model has been used to predict flooding during two 'emergency planning' events: a 1 in 100 yr ARI rainfall event with current land use, and during a future worst case (extreme) climate change scenario. The results from the extreme planning scenario will allow DCC to put emergency planning measures in place to avoid future catastrophic effects within the catchment, and to identify where overland flow paths lie.

A predicted flood hazard rating has been calculated for the current and future (extreme) planning scenario during a 1 in 100 yr ARI event. A flood hazard rating is a factor of velocity and depth calculated from the hydraulic model results. It indicates the likely degree of flood hazard for a given area and the associated risk to the public. A definition of each Rating can be found in Table 8-1 below.



Table 8-1: Flood Hazard Rating

Flood Hazard Rating	Degree of Flood Hazard	Flood Hazard Description
< 0.75	Low	Caution – flood zone with shallow flowing water or deep standing water.
0.75 – 1.25	Moderate	Dangerous for some – (i.e. children). Flood zone with >250 mm deep, or fast flowing water.
1.25 – 2.0	Significant	Dangerous for most – flood zone with 250 mm - 400 mm deep, fast flowing water.
> 2.0	Extreme	Dangerous for all – flood zone with 400+ mm deep, fast flowing water.

The maximum flood hazard rating for the catchment during a current 1 in 100 yr ARI rainfall event is 'significant', the main locations being Serpentine Avenue, due to flow velocity, and Rattray Street, and Queens Gardens / High Street areas, due to depth and extent of predicted flood. This is shown in Figure 8-5.

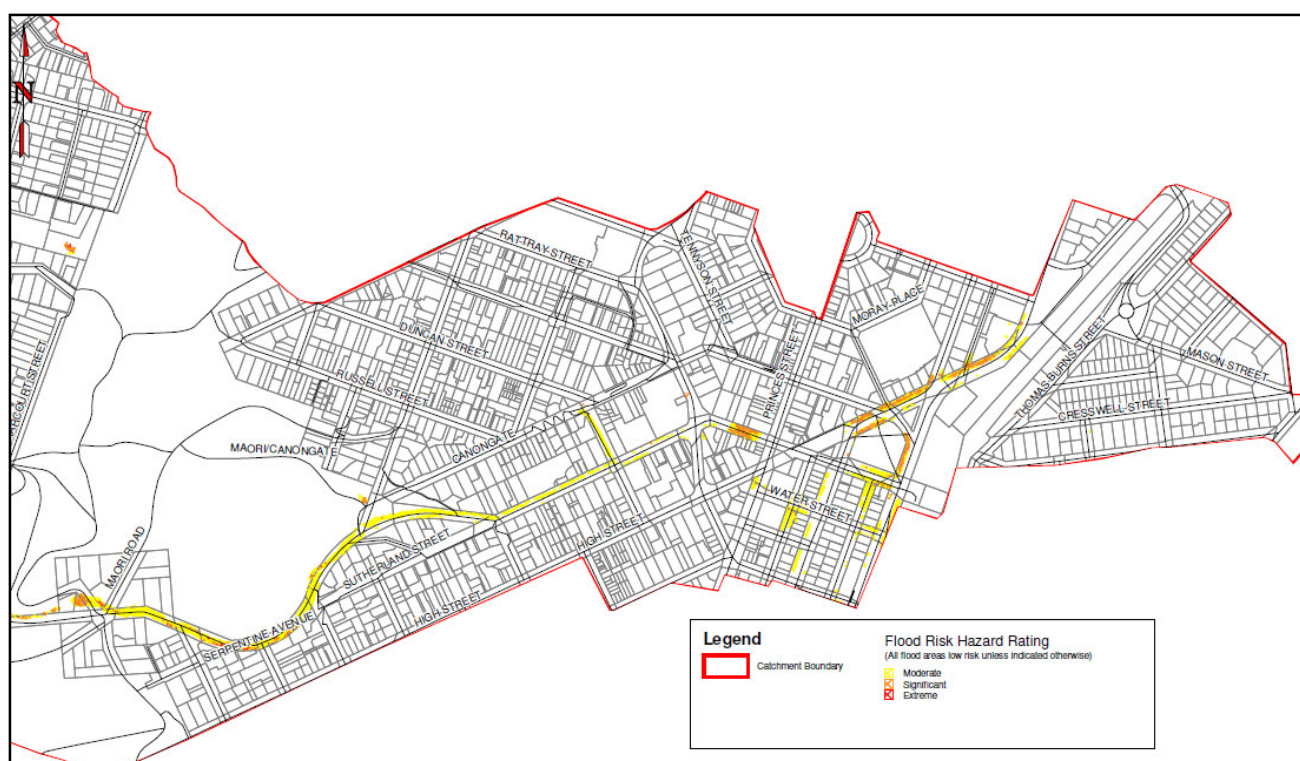


Figure 8-5: 2010 1 in 100 yr ARI Rainfall Event (Model Results)



During a future 1 in 100 yr ARI rainfall event when the extreme planning scenario is applied, it is predicted that the total flood area will comprise approximately 6.79 % of the catchment, mostly on the flat harbourside land. Much of the predicted harbourside flooding, predominantly to the south east of the railway is associated with the extreme tide level and storm surge applied to the model. During this event the maximum flood hazard rating is 'extreme' the location being around the Canongate intake screen, with further areas of 'significant' flood hazard rating on Serpentine Avenue, Clark Street / Maclaggan Street, and Cresswell Street. This is shown in Figure 8-6.

It is predicted that during this future event transport routes, particularly within the CBD, would be significantly disrupted. Several sections of road are predicted to become impassable, notably State Highway 1 (Crawford Street, Cumberland Street and High Street), Rattray Street and Bond Street. In addition, some of the flooding predicted within the CBD would be of significant depth and therefore be a risk to the public.

While the 'extreme' flood around the Canongate and Serpentine Avenue intake screens is likely to be due to catchment hydrology, terrain, and network hydraulics, the extreme flood risk is predicted to be present in the Town Belt area, and therefore is not considered to pose a considerable risk to public health and safety.

It is beyond the scope of this management plan to detail or manage the direct effects of sea level change, however, it is of importance that the stormwater network will not be functioning as designed at these extreme sea levels and that flood hazard risk may develop in the future should current climate change predictions remain valid.

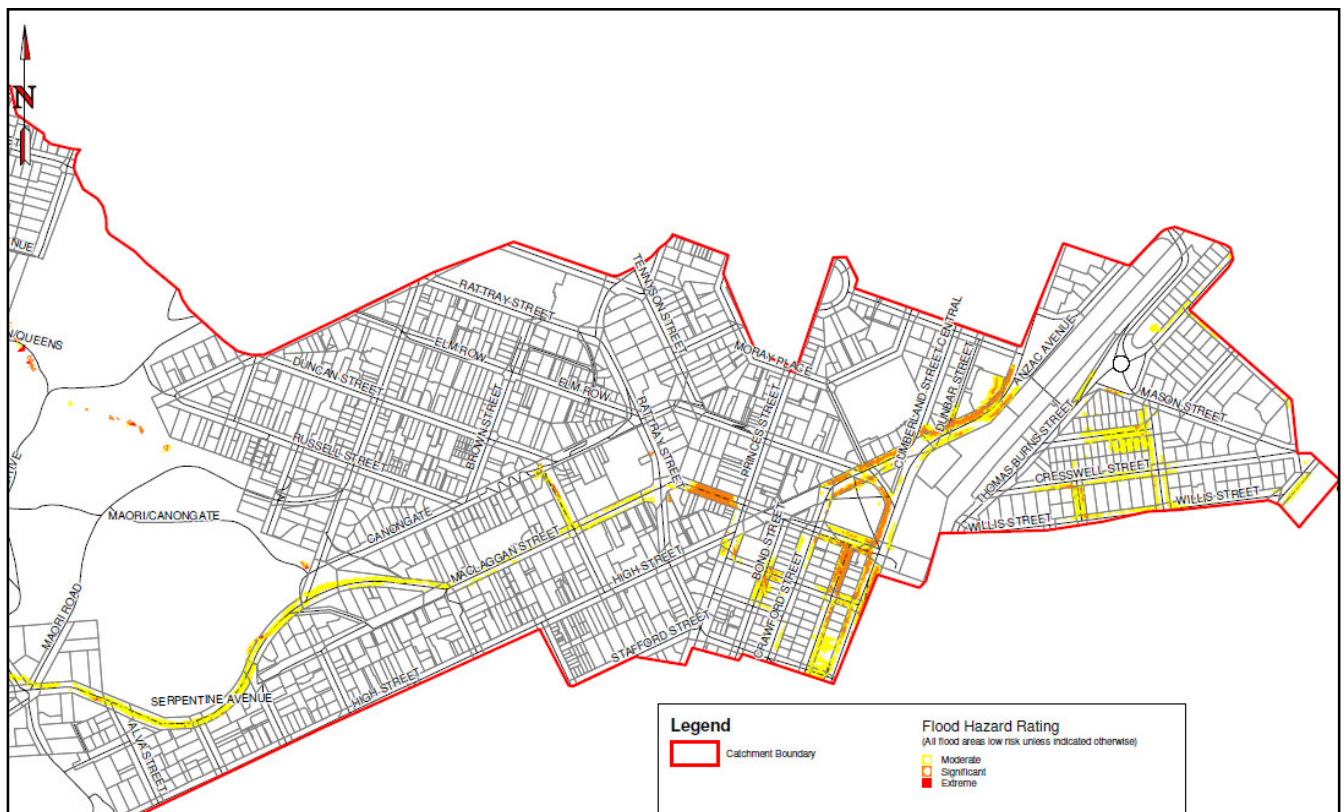


Figure 8-6: 2060 Extreme Flood Hazard 1 in 100 yr ARI Rainfall Event



8.1.5 Network Age, Operation and Maintenance

8.1.5.1 Mason Street Catchment

A number of operational issues relating to flooding have been identified by DCC Network Management and Maintenance team and are described in the sections above. Further catchment specific issues relating to network operation and maintenance are described below.

Intake Structures

The DCC Network Management and Maintenance team have advised that, during autumn months in particular, heavy rainfall can result in debris blocking stormwater catchpits and inlet screens. Of particular importance in this catchment are the inlet screens at Queens Drive/Serpentine Avenue and Canongate Road.

During catchment walkovers the level of blockage observed at the Queens Drive/Serpentine Avenue inlet screen was approximately 30 %. The DCC Network Management and Maintenance team have confirmed that the blocking of this inlet screen is a known problem and overtopping of the screen leads to ponding in the garden of the adjacent property and contributes to overland flows down Serpentine Avenue.

The Canongate inlet screen is unlikely to become completely blocked during a rainfall event, except under exceptional circumstances. However, the level of blockage observed during catchment walkovers was approximately 20 % and based on this level of blockage the model predicts that the structure could overtop during a 1 in 50 yr ARI rainfall event and that flows back up behind the inlet during a 1 in 10 yr ARI event. Should the blockage be increased, overtopping in less than a 1 in 50 yr ARI rainfall event would occur. Once the inlet overtops, the model predicts that flows would be conveyed via road corridor to Serpentine Avenue, ultimately exacerbating the flooding downstream on Rattray Street. The DCC Network Management and Maintenance team have confirmed that the blocking of this inlet screen is a known problem but felt that it would require a significant rainfall event combined with a reasonably high level of blockage for the structure to overtop as the screen is located below the surrounding land so there is capacity for flows to pond at this location before spilling overland.

There is also a significant intake structure on Maori Road. Whilst the screens in this location are considered likely to block during a significant rainfall event due to the debris reservoirs upstream, impact of such an event occurring is considered minor in nature due to the screens location. Should the screens overtop, it is predicted that flows would be intercepted by Maori Road and pond in the road until the crown of the road was overtopped. Flows would then re-enter the open-channel of the network and continue downstream, hence only minor ponding and overland flows in the event of blockage and overtopping. The DCC Network Management and Maintenance team have confirmed that they do not believe that this intake screen causes particular problems within the catchment.

Catchment Outfall

The model results demonstrate that the stormwater outfall in this catchment is tidally influenced affecting the capacity of the network in the lower catchment. It is also predicted that the backwater effect caused by high tide can exacerbate catchment flooding. At the time of modelling the outfall was not fitted with a flap valve, however, fitting one is unlikely to change the system's performance during rainfall events.



8.1.5.2 City-Wide

As outlined in Section 4.7.6, depending on the location, catchpit and inlet maintenance is undertaken by a number of different teams with variations in inspection specification. This means that city-wide, there are variations in catchpit levels of service. During autumn months in particular, heavy rainfall can result in debris blocking the catchpits and inlet screens. A reduction in catchpit capacity due to silt build up can lead to extension of ponding durations and extents during a rainfall event. Similarly, blocking of inlet screens (of culverts or catchpits) prevents flow entering the network, also resulting in extended ponding, as well as increasing overland flow to other locations. This was verified by Network Management and Maintenance team as a potential issue during walkovers and workshops.

8.1.6 Culture and Amenity

The predicted nuisance and habitable floor flooding in this catchment are predicted to occur predominantly in the CBD and railway area, and affect areas listed as Townscape and Heritage Precincts in the District Plan. Further to this, a variety of roads in the CBD are listed as wellbeing locations; Rattray Street, and the roads around Queens Gardens are listed by DCC as minor and major social wellbeing locations respectively (see Figure 4-12), as they are important traffic routes around the city. Coincidentally, these areas are also predicted to be affected by flooding. There are also a variety of major economic wellbeing locations in this vicinity.



8.1.7 Summary of Effects of Stormwater Quantity

A summary of the effects of stormwater quantity is as follows:

- The modelling results indicate that 82 % the stormwater network in the Mason Street catchment has the ability to accept rainfall from a 1 in 10 yr ARI event during MHWS tide conditions, with some areas having less capacity. Hydraulic pinch points in the upper catchment create overland flow in events as small as a 1 in 2 yr ARI rainfall event, while some areas in the lower catchment have levels of service restricted to a 1 in 5 yr ARI rainfall event due to tidal influence. Due to these restrictions in key parts of the network, there is no capacity in this modelled network to accommodate increased rainfall due to climate change.
- Locations predicted to flood most frequently are in the vicinity of the inlet structures and manholes on upper Serpentine Avenue (contributing, via overland flow, to ponding downstream in Rattray Street), Bond Street/Water Street and the area around Queens Gardens.
- Between a 1 in 5 yr and a 1 in 10 yr ARI rainfall event, nuisance flooding is predicted in a number of locations predominantly in the lower catchment. This is not considered significant however as due to shallow depths and low velocity, poses little risk to the public. Further, it is unlikely to significantly disrupt traffic.
- During a 1 in 10 yr ARI rainfall event, seven land parcels are predicted to be at risk of habitable floor/useful space flooding, increasing to 24 during a current 1 in 50 yr ARI rainfall event. In some locations the risk of habitable floor flooding has been verified by flood complaints records, however, some of the deep flooding appears to be within parking areas.
- Inconsistencies in the standard and frequency of cleaning and maintenance of stormwater structures could exacerbate or transfer predicted flooding, and regular blockage of the Serpentine and Canongate inlet screens currently occurs.
- During a current 1 in 100 yr ARI rainfall event, predicted maximum flood hazard rating for the catchment is 'significant', affecting locations on Serpentine Avenue, Rattray Street and Queens Gardens / High Street area.
- During a future 1 in 100 yr ARI rainfall event, with the application of an extreme climate change scenario with sea level rise and storm surge, the model predicts that an extreme flood risk develops on Canongate, in response to overflows from the screen moving at high velocity down the road. Approximately 7 % of the catchment is inundated, mostly the flat harbourside land. Despite the network being tidally influenced, significant proportion of this flooding is, however, the result of tidal inundation directly onto low lying land predominantly to the south east of the railway, and not the performance of the stormwater network.



8.2 Stormwater Quality

Stormwater quality is discussed in detail in Section 6. Annual monitoring of the quality of the stormwater discharged from the Mason Street catchment has been undertaken (2007 to 2010). The following observations must be viewed in the context of a very small dataset and the limitations of the sampling method (discussed below).

- With the exception of microbial contamination, the levels of all stormwater contaminants from the outfall in this catchment are typical of the stormwater quality that would be expected from a catchment with mixed land use.
- The results show variability between years and to date, due to both the sampling method, and an insufficient number of samples to establish trends.
- Microbial contamination within the catchment has been measured at or slightly above the upper limits that are to be expected for stormwater for all years sampled and in 2010 levels of microbial contamination were measured at high levels.

The microbial concentrations measured in the stormwater between 2007 and 2009 were at or above the typical upper limit for stormwater. However during this time FWAs, which are an indicator of human wastewater contamination were relatively low. It is possible therefore that the contamination is from other typical sources such as birds, rodents and pets.

During the dry period preceding sampling in 2010, two wastewater flooding incidents were reported (19th April and 21st April), and it is possible that these events contributed to the microbial contamination levels observed during the rainfall event sampled on 23rd April.

However, there are no known wastewater network related issues in this catchment, and the wastewater flow monitoring carried out for Phase 2 of the 3 Waters project has not indicated any anomalies in flows to suggest otherwise.

It is possible therefore that the isolated wastewater flooding incidents reported in the upper catchment resulted in wastewater being added to the stormwater system on two separate occasions prior to a rainfall event. As the rainfall event during which sampling was undertaken was so small, little dilution would have taken place. Whilst it may be prudent to investigate this incident further, there is no indication of a significant problem with stormwater quality in this catchment. Further monitoring rounds may provide further evidence that this is the case.

The variability in the stormwater quality results is likely to be due not only to the relatively small data set, but also due to other factors, such as the time since the previous rainfall event within the catchment, and the intensity and distribution of rainfall. A long period between rainfall events allows contaminants to build up within the catchment and as such the contaminant concentrations in the stormwater following the first rainfall event for a significant period of time may be higher.

However, the key contributing factor to the data variability is likely to be the use of grab samples to monitor the stormwater. Grab sample results give a 'snapshot' of the stormwater quality at one point in time only. Throughout a storm event, the concentration of contaminants within the stormwater varies depending on the time since the start of the event. This is indicated in Figure 8-7.

The time, during the storm event, that grab samples are taken can significantly affect the results. While stormwater samples taken were targeted at sampling the 'first flush', and consent conditions detailed required storm size and antecedent conditions, it is not known when, during a rainfall event, the stormwater monitoring grab samples were taken for each monitoring year. It is possible that they



were taken at differing times during rainfall events, hence the data variability and lack of clear trends. Time proportional monitoring of stormwater quality would yield results that provide a more accurate profile of contaminant concentrations within the stormwater from the catchment.

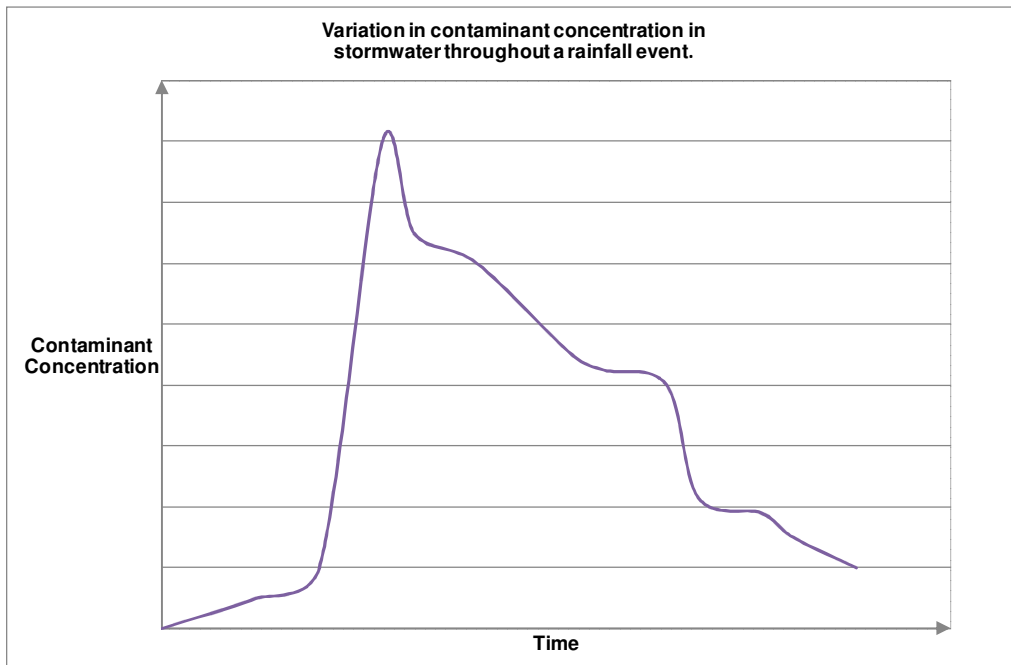


Figure 8-7: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event
(Based on time-proportional sampling carried out in Dunedin)

8.2.1 Harbour Water Quality

The quality of the harbour water will be affected by numerous contaminant sources including, but not limited to, stormwater discharges from the entire harbour catchment, marine vessels and other marine users. Currently, harbour water quality is not monitored by DCC and as such there is no clear link between the quality of stormwater leaving the outfall and the quality of the water in the harbour.

While no national or international guidelines are available for stormwater discharge quality, Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines (2000) are available for harbour water quality (as well as harbour sediment quality), which identify concentrations of contaminants within the marine environment under which 80 % or 99 % of species are protected.

Because of the different contaminant sources identified above, and the dilution that occurs when stormwater enters the marine environment, in order to fully utilise these guidelines, marine water monitoring would need to be undertaken alongside stormwater quality monitoring, and links established between stormwater discharge points and marine water quality within the harbour. Further clarity with respect to longer term environmental effects could then be established using sediment quality information.

Marine water quality is also highly variable both spatially and temporally, and sampling results would also only provide a 'snapshot' of water quality. Many factors influence the water quality, including dilution and dispersion; freshwater inputs; rainfall events; and tidal currents.



8.2.2 Harbour Sediment Quality

Contaminants in urban stormwater entering the marine environment potentially pose a risk to the health of marine organisms, primarily through the accumulation of the contaminants in marine sediments. Contaminants in the stormwater adhere to suspended particles and sediments in the marine environment and accumulate in the marine bed. High levels of contaminants within the sediments may result in adverse impact on marine flora and fauna which come into contact with those sediments.

To assess the potential effects of contaminated sediments on marine ecology, the contaminant concentrations within the sediments can be compared to sediment quality guidelines. It should be noted however, that guidelines provide indicative rather than conclusive evidence of adverse effects; any exceedence of the guidelines therefore indicates only a potential for adverse effects.

ANZECC (2000) sediment quality guidelines provide low and high trigger values. The low values are indicative of contaminant concentrations where the onset of adverse biological effects may occur, thus providing early warning and the potential for adverse environmental effects to be prevented or minimised. The high values are indicative of contaminant concentrations where significant adverse biological effects may be observed. Exceedence of these values could therefore indicate that adverse environmental effects may already be occurring.

8.2.2.1 Mason Street Catchment

Measurement of marine sediment contaminant levels is not required under the resource consent consents conditions for the stormwater discharge from this catchment. It is not considered to be appropriate to use results from adjacent catchments to give an indication of sediment quality in the vicinity of the Mason Street catchment due to the distance of neighbouring outfalls from the Mason Street outfall and the differing land uses within those catchments. Furthermore, any sediment contamination in these areas cannot be attributed to the Mason Street catchment alone, due to tidal currents, freshwater inputs (such as the Water of Leith), and discharges of other large urban catchments and it is impossible to relate stormwater quality from the Mason Street catchment to sediment contaminant levels in other parts of the harbour.

8.2.2.2 Harbour-Wide

Harbour-wide, trends in the levels of contaminants in the sediment remain unclear with just four years' worth of monitoring data revealing high variability among contaminant levels and sites. Many contaminants are present in the sediments at various sites within the harbour at levels exceeding the ANZECC sediment guideline low trigger values.

However, levels of chromium, copper, nickel, lead, zinc and PAHs were generally found to be lower in 2010 than in previous years. It may be that contamination measured in the sediment is historic and sediment quality may be improving over time due to the deposition of 'cleaner' sediments. Deposition rates in the harbour are thought to be reasonably slow, however, and any trend may take some time to observe due to this slow deposition rate.

Further monitoring of the sediments harbour-wide is required to better understand the levels of contamination and establish whether any long term trends exist.

8.2.3 Marine Ecology

The resource consent for the stormwater discharges from this catchment requires that cockles and octopus are sampled and flesh analysed for contaminants. The biological monitoring results to date



to not indicate significantly high levels of contaminants within the samples and where applicable (for lead and cadmium), concentrations have been consistently below the MLs as outlined in Australia New Zealand Food Standards Code (2004). The results indicate that the cockle and octopus communities at this location are not being exposed to significantly high levels of contaminants.

Historical data and the results of biological monitoring carried out harbour wide for DCC stormwater consent compliance indicate that, in general, a reasonably low diversity amongst the benthic and infaunal communities is likely to be symptomatic of a large proportion of the upper harbour basin. The general lack of diversity may be attributable to anthropogenic influences, including stormwater quality, but other factors such as freshwater inputs and exposure at low tide may also be contributing to the ecological health observed. It is not therefore possible to clearly link ecological health with stormwater quality.

Determining the ecological effects of contamination in the harbour environment is difficult. Unless contamination levels are very high it is difficult to distinguish between the adverse effects of contamination from stormwater, contamination from other sources, and the effects of other environmental variables.

The quality of stormwater from the Mason Street outfall was found to be typical for this type of catchment, and no contaminant levels were found to be significantly high. This corresponds with the fish sampling results indicating that the stormwater is not having an adverse effect on ecological health. However it should be noted that the fish sampled in this location are likely to have a considerable range and will be influenced by contaminants in the harbour marine environment outside of the Mason Street catchment and from sources other than stormwater also.

Therefore, whilst the ecological health at this location was not found to be poor, it is difficult to draw any parallels between the ecology and the contaminants.

8.2.4 Freshwater Habitat Quality

There are two streams in the Mason Street catchment (refer Figure 5-3). Both were assessed (Mason Street 1 and Mason Street 2) in 2010. The stream habitat quality was found to be variable at sites on the Mason Street 1 stream with water quality and riparian and aquatic vegetation being 'poor' but bank stability, bed substrate and flow variability being good/excellent. The habitat quality at sites on the Mason Street 2 stream was found to be good with 'excellent' water quality.

The streams are located within the Town Belt and form part of the stormwater network, accepting flows from piped sections of the network upstream and discharging back into piped sections downstream. The piped network upstream of the Mason Street 1 stream collects stormwater from a reasonably large urban area. The Mason Street 2 stream has two tributaries, one accepts stormwater from an urban area upstream the other from within the Town Belt.

Historically the streams assessed were natural streams and whilst in some locations, where open channel exists, they still follow the natural flow path, they are now urban streams with significantly modified in sections (concrete open channel) and are now piped up and downstream of the open channel sections.

Whilst the physical in-stream habitat was found to be of good quality at the sites surveyed on the Mason Street 1 stream, water quality was found to be poor. This may be due to a number of factors such as the quality of stormwater entering the stream from the piped network and urban area upstream, diffuse runoff from surrounding land or management/modification of the channel where it flows through private property.



The good/excellent habitat quality at sites on the Mason Street 2 stream and the features of interest recorded indicate that this stream is of good quality for an urban stream.

Surrounding land use significantly affects the quality of a stream. Investigations by Auckland Regional Council (ARC) found that the quality of urban streams is related to the density of urban development and that in the Auckland region urban stream quality was consistently poor in streams with a contributing catchment imperviousness of greater than 25 % (ARC, 2004). Although Dunedin has many different environmental characteristics relating to urban streams, the relationship between imperviousness and stream quality may still apply. The contributing sub-catchment, to the streams assessed in the Mason Street catchment, are urban residential and have an imperviousness of approximately 60 %. This suggests that the quality of the streams assessed in the Mason Street catchment are as to be expected, or in the case of the Mason Street 2 stream of relatively good quality for an urban stream. This therefore highlights the need for suitable management of the streams to maintain the in-stream quality and protect the ecological values (as described below).

Watercourses running through private property are considered to be private drainage assets. Whilst private maintenance of streams sometimes works acceptably in rural areas, in the urban context, private property owners often lack resources to carry out stream maintenance. High flows, and fast response to rainfall means that the ongoing maintenance of urban streams, clearing of intake structures, and provision of overland flow oaths is vital to the flood protection provided by the stormwater network.

8.2.5 Freshwater Ecology

The aquatic ecology within the streams in this catchment was found to be poor at the Mason Street 1 stream. The poor ecology observed at sites on the Mason Street 1 stream may be attributed to the poor water quality observed in this location as described in the above section.

At the Mason Street 2 stream, a number of notable species were found: banded kokopu, isopods and crayfish, some of which are listed, using the 'threat of extinction' classification, by DOC. The good/excellent ecology observed at sites on the Mason Street 2 stream suggests that even with the stream accepting flows from the upstream piped stormwater network this does not appear to be having a detrimental effect on the in-stream ecology. The excellent ecology in this stream indicates that it is of good quality for an urban stream, better than expected given the land use/imperviousness of the contributing catchment (see Section 8.4.2).

8.2.6 Culture and Amenity

The harbour is an important area for recreation with a number of boat clubs and tourism operators in the area. A decline in the quality of the harbour environment could adversely impact on recreational activities.

The harbour has been used historically by Kāi Tahu and their descendants and the discharge of stormwater and associated contaminants has the potential to significantly impact Kāi Tahu values and beliefs.

To date there is no evidence to suggest that the quality of the harbour continues to deteriorate significantly or that the quality of stormwater from the Mason Street catchment is significantly contributing to any deterioration of the harbour.



8.2.7 Summary of Effects of Stormwater Quality

A summary of the effects of stormwater quality is as follows:

- The levels of contaminants within the stormwater discharged from the Mason Street catchment varied throughout the monitoring years (2007-2010) with no clear trend emerging. The majority of contaminant levels measured were not significantly different from levels considered to be typical from residential/commercial catchments. The exception to this is microbial contaminant levels, with the levels measured in 2010 being significantly high. This is thought to be related to isolated wastewater flooding incidents during dry weather preceding stormwater sampling.
- Harbour water quality is not currently monitored. Monitoring of harbour water quality would allow comparison with ANZECC (2000) marine water quality guidelines and may allow a link to be established between stormwater discharge quality and harbour water quality.
- There is no harbour sediment data available for the Mason Street catchment. It appears that some of the sediment contamination measured at adjacent outfalls may be historical due to a general decline in concentrations of contaminants over time.
- Harbour-wide, levels of key contaminants in the sediments were found to be slightly lower in 2010 than previous monitoring years. Further monitoring is required to better understand the contamination levels and establish any long term trends.
- The marine ecology assessed in the vicinity of the Mason Street outfall does not indicate that any significant effects due to contamination are occurring. Further rounds of ecological monitoring may provide a clearer understanding of the health of the marine ecology adjacent to this catchment.
- Stormwater quality does not appear to be having an adverse effect on freshwater physical habitat quality in either of the two Mason Street streams.
- Stormwater discharges may be affecting water quality in the Mason Street 1 stream, where freshwater ecology was also found to be poor.
- Several notable ecological species were observed in the Mason Street 2 stream indicating that the ecology is not being adversely affected by stormwater quality.
- The harbour has important cultural values and is also an important area for recreation. The results of investigations do not indicate that harbour quality is deteriorating as a result of the quality of stormwater from this catchment.



9 Catchment Problems and Issues Summary

Following the Assessment of Environmental Effects (AEE), and identification of catchment specific targets for stormwater management, a number of key problems and issues can be identified in the Mason Street catchment, and prioritised for action. These are discussed below. Section 10 prioritises these issues, and the remainder of this ICMP involves target setting and development of options to manage the stormwater from this catchment. Figure 9-1 presents the key issues for the Mason Street catchment.

2.1 Stormwater Quantity Issues

9.1.1 Low Level of Service

The modelling results indicate that 82 % the stormwater network in Mason Street catchment has the ability to accept rainfall from a 1 in 10 yr ARI event during MHWS tide conditions, with some areas having less capacity. Hydraulic pinch points in the upper catchment create overland flow in events as small as a 1 in 2 yr ARI rainfall event, while some areas in the lower catchment have levels of service restricted to a 1 in 5 yr ARI rainfall event due to tidal influence. Due to these restrictions in key parts of the network, the modelling indicates that there is no capacity to accommodate increased rainfall due to climate change (2060).

The hydraulic capacity of the network and the tidal influence on the outfall are key factors in the performance of the network, these effects are predicated to increase as climate change occurs.

9.1.2 Network Maintenance

Flooding extents, overland flow, and ponding durations in Mason Street catchment are likely to be exacerbated by blocked catchpits and inlet screens, particularly at the stream inlets at Queens Drive/Serpentine Avenue and Canongate.

City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service. This has the potential to exacerbate or transfer flooding.

9.1.3 Nuisance Flooding

Nuisance flooding (between 50 mm and 300 mm deep) is predicted in the road at locations on Serpentine Avenue, Rattray Street, Bond Street/Water Street, Queens Gardens / High Street and Cresswell Street during high frequency events.

9.1.4 Deep Flooding

Deep flooding (> 300 mm deep) occurs at a number of locations and may present a risk to properties during events as small as a 1 in 5 yr ARI rainfall event, although it may not necessarily threaten building interiors.

Significant deep flooding is predicted during a 1 in 50 yr ARI rainfall event with 24 land parcels at risk, predominantly in the CBD.

9.1.5 Flood Hazard – Current and Future 1 in 100 yr ARI

The model shows that during a current 1 in 100 yr ARI rainfall event, with MHWS tide conditions, Serpentine Avenue, Rattray Street, Queens Gardens / High Street, Cumberland Street, Vogel Street and Bond Street / Water Street, are predicted to have flooding across the full width of the road. A



'significant' flood hazard rating has been assigned to these locations. With the extreme climate change scenario applied (with a storm surge) results in the area of 'significant' flood hazard increasing to encompass a large proportion of the lower catchment, mainly within the road. This is predominantly due to tidal inundation and the area around the Canongate intake screen is predicted to have an 'extreme' hazard rating.

9.2 Stormwater Quality Issues

It is clear that within the harbour there is historical sediment contamination likely to be from a combination of the stormwater outfall and other diffuse sources. There is currently no sediment quality data for this catchment. However, harbourwide, there is potential for ongoing contamination of the sediment from stormwater, yet the results to date are ambiguous and it has not been possible to establish a causal link from available data.

9.2.1 High Variability of Stormwater Quality Results

Inconsistencies in stormwater quality results mean that we are unable to see clear trends in stormwater quality, or confidently identify key contaminants to aid stormwater management.

9.2.2 Limited Confidence in the Knowledge of Effects on the Otago Harbour Environment

The current monitoring regime undertaken to meet consent conditions provides limited confidence in the following:

- The extent of historic versus current/ongoing harbour sediment contamination; and
- Links between stormwater quality, sediment quality, and the health of the harbour environment.

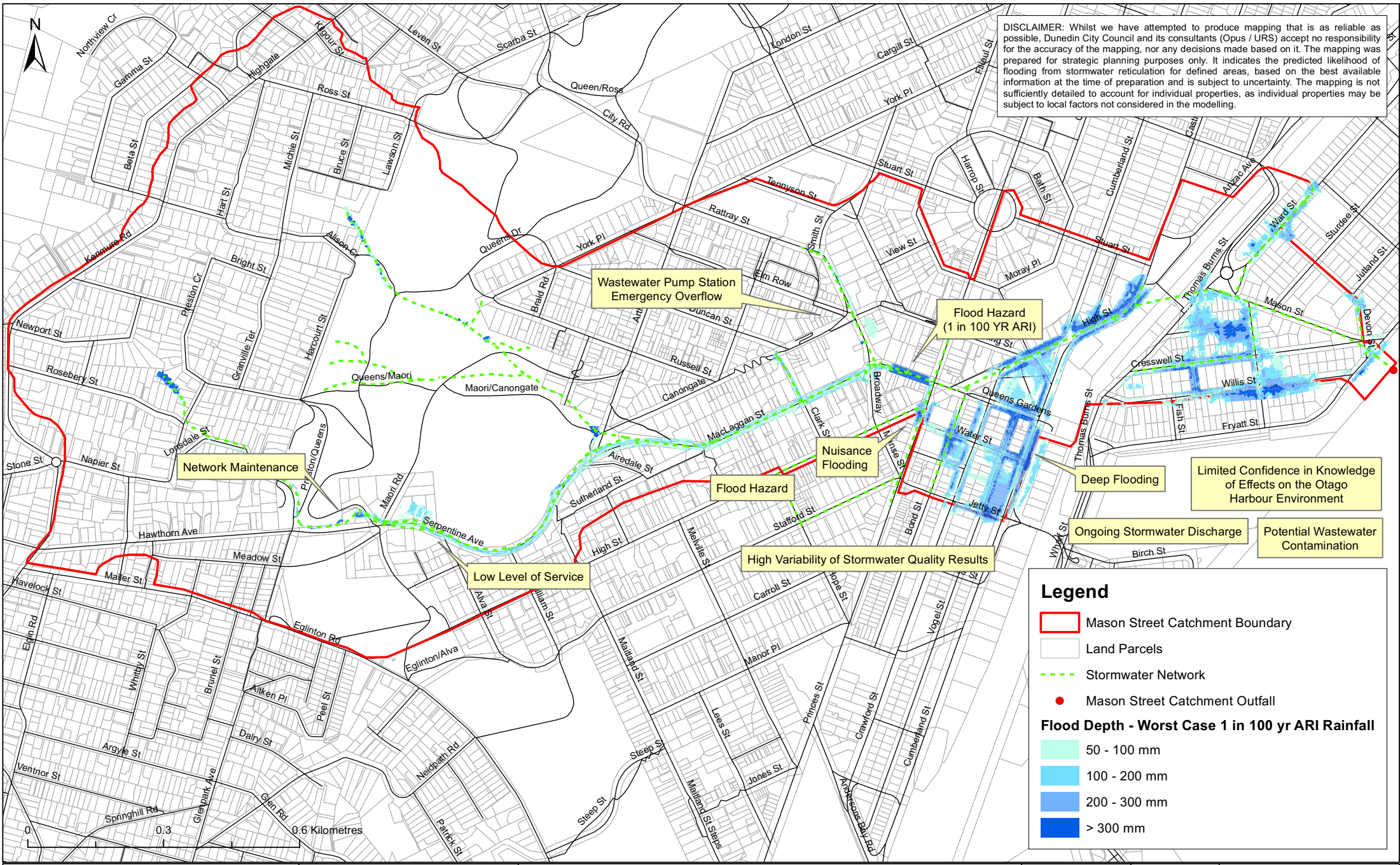
9.2.3 Ongoing Stormwater Discharge

Stormwater quality monitoring indicates that the stormwater quality discharged from the Mason Street catchment appears to be typical of an urban, mixed land use, catchment, and contaminant sources are likely to be this land use. Indications from recent monitoring do not show that current stormwater discharges are having an obvious adverse effect on the receiving environment, however as discussed above, there is limited confidence in some of this information, and further data is required to validate this data.

Mechanisms already in place (e.g. the Dunedin Code of Subdivision and Development and the Trade Waste Bylaw) are designed to encourage source control in order to ensure that contaminant levels in the stormwater discharge do not increase, and that new development and existing land uses are managing stormwater quality in an appropriate manner into the future.

9.2.4 Potential Wastewater Contamination

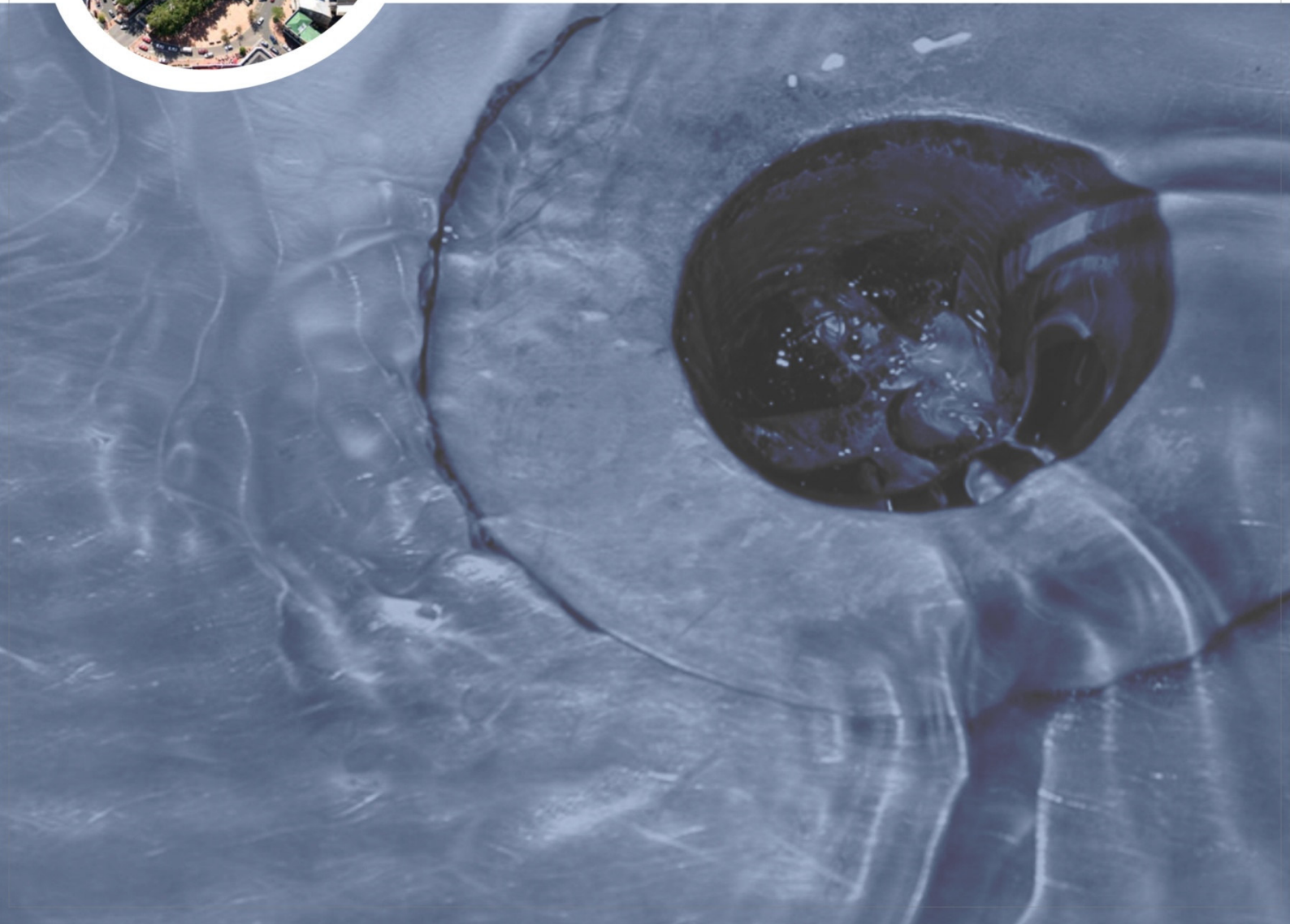
Stormwater quality monitoring (2007 to 2010) indicates high levels, at or above the upper limit typical of stormwater, of microbial contamination in the Mason Street catchment stormwater discharge. The 2010 results indicated significantly high levels of E.coli and faecal coliforms which may indicate wastewater contamination.





Part 4

Targets





10 Issues Prioritisation

DCC have developed a decision making framework (refer Appendix E) in line with the New Zealand and Australian risk management framework AS/NZS 4360 to enable the comparison of issues and options. A Consequence and Likelihood rating has been applied to each of the issues identified to provide a risk matrix score, leading to a definition of problem management. Figure 10-1 below shows the risk matrix used in this scoring. Other information relating to definitions for Consequence and Likelihood are provided in the analysis of each issue, and the guidelines on this are provided in Appendix E.

Table 10-1 provides a list of the main issues identified for the Mason Street catchment, and a risk and consequence score for each, resulting in a 'manage passively' or 'manage actively' categorisation. The passive or active management categorisation then drives the catchment specific management approach for each issue, and later the options considered. Active management indicates that DCC will seek to implement changes to stormwater management in the catchment, whereas passive management would tend more towards monitoring and review of existing management practices to ensure that the targets set can be met.

RISK LIKELIHOOD	CONSEQUENCE				
	Negligible (1)	Minor (10)	Moderate (40)	Major (70)	Catastrophic (100)
Almost Certain (5)	Low (5) Manage Passively	Moderate (50) Manage Passively	Very High (200) Manage Actively	Extreme (350) Manage Actively	Extreme (500) Manage Actively
Likely (4)	Low (4) Manage Passively	Moderate (40) Manage Passively	Very High (160) Manage Actively	Very High (280) Manage Actively	Extreme (400) Manage Actively
Possible (3)	Negligible (3) Manage Passively	Moderate (30) Manage Passively	High (120) Manage Actively	Very High (210) Manage Actively	Very High (300) Manage Actively
Unlikely (2)	Negligible (2) Accept	Low (20) Manage Passively	High (80) Manage Actively	High (140) Manage Actively	Very High (200) Manage Actively
Rare (1)	Negligible (1) Accept	Low (10) Accept	Moderate (40) Manage Passively	High (70) Manage Actively	High (100) Manage Actively

Note

The Risk Matrix includes an indication of the minimum acceptable treatment strategy. In all cases the option of avoiding the risk should be considered first.

Figure 10-1: Risk / Consequence Matrix for Issues Prioritisation



Table 10-1: Mason Street Catchment Issues Prioritisation

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Limited Confidence in Knowledge of Effects on the Otago Harbour Environment	40	4	Past sampling programmes provide inconclusive data which means that the ongoing effects of stormwater discharges are unclear. Without better knowledge, DCC will be unable to meet its strategic objectives and ensure ongoing sustainable stormwater management. Failure to establish clear links between stormwater quality and receiving environment quality may weaken DCC's position both legally and in terms of public perception.	160	Manage Actively
High Variability of Stormwater Quality Results	40	3	Stormwater quality monitoring could be made more robust. Relatively low / moderate confidence in data. Without better knowledge, underpinned by good quality data, DCC cannot reliably meet its strategic objectives.	120	Manage Actively
Deep Flooding	40	2	Deep flooding predicted in a small number of commercial locations. Occurs at high frequency events (1 in 5 yr ARI rainfall event) but suspected to be exterior to buildings. Risk to building interiors predicted to increase with lower frequency events (1 in 10 yr ARI and 1 in 50 yr ARI). Limited knowledge of threat (no building damage assessment undertaken). Numbers likely to increase under future scenarios.	80	Manage Actively
Flood Hazard – Current and Future 1 in 100 yr ARI	70	1	Areas of 'significant' flood hazard currently in roadways. Deep flooding predicted in locations within the CBD under current conditions. Future extreme climate change effects pose significant potential threat. It is predicted that by 2060 during extreme weather and tide events there will be a significant hazard across a large part of the lower catchment. The extent of the threat is uncertain as it is predominantly driven by tidal influence, rather than being a stormwater issue. There is unknown certainty around climate change predictions.	70	Manage Actively



Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Potential Wastewater Contamination	10.	5.	High microbial levels above levels typically measured in stormwater. 2010 results particularly high, potentially indicating wastewater contamination. Confidence in data is relatively low / moderate and without better knowledge difficult to establish a source and significance of the threat.	50	Manage Passively
Network Maintenance	10	5	Inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures. Potential to exacerbate or transfer flooding effects.	50	Manage Passively
Blocking / Maintenance of Intake Structures	10	4	Potential blockage of inlet screens at Queens Drive/Serpentine Avenue and Canongate Road could exacerbate downstream flooding. Likely to occur during significant rainfall.	40	Manage Passively
Low Level of Service	10	4	The current level of service is below DCC's target for new infrastructure, as a result of both tidal influence and inadequate network capacity. Effects will be exacerbated by climate change therefore adaptation is required in order to meet future long term objectives of no increase in properties at risk of flooding due to climate change. However, consequence of this in terms of flood effects is minor.	40	Manage Passively
Nuisance Flooding	10	4	Flooding predicted in a small number of locations, predominantly in road corridor around the CBD. Likely to increase in future, predominantly due to projected climate change. Currently occurring and during high frequency events (1 in 5 yr ARI) but effects minor.	40	Manage Passively
Ongoing Stormwater Discharge	10	4	Ongoing discharge of stormwater (and associated contaminants) to the harbour. The extent of contamination is unconfirmed, but available data indicates that contaminants discharged are typical of the land use, and the consequences are minor. Current discharges not believed to be as significant an issue as historical contaminant issues from a variety of sources.	40	Manage Passively



11 Catchment Specific Approaches and Targets for Stormwater Management

Figure 11-1 provides a breakdown of the link between stormwater management issues identification, objectives development and the setting of targets.

The information presented in the AEE section of this report has been used to identify the key stormwater management issues for the Mason Street catchment. These issues have been prioritised and ranked, according to DCC's risk matrix, which looks at the consequence and likelihood of each issue.

For each issue, DCC's commitment (in terms of strategic stormwater objectives) will be examined, and a catchment specific approach outlined depending on both the strategic objectives, and the issue's priority. SMART targets are then set to guide the design of options, and also to measure the success of the catchment management approach.

Following this section, stormwater management options are developed to ensure targets are met.

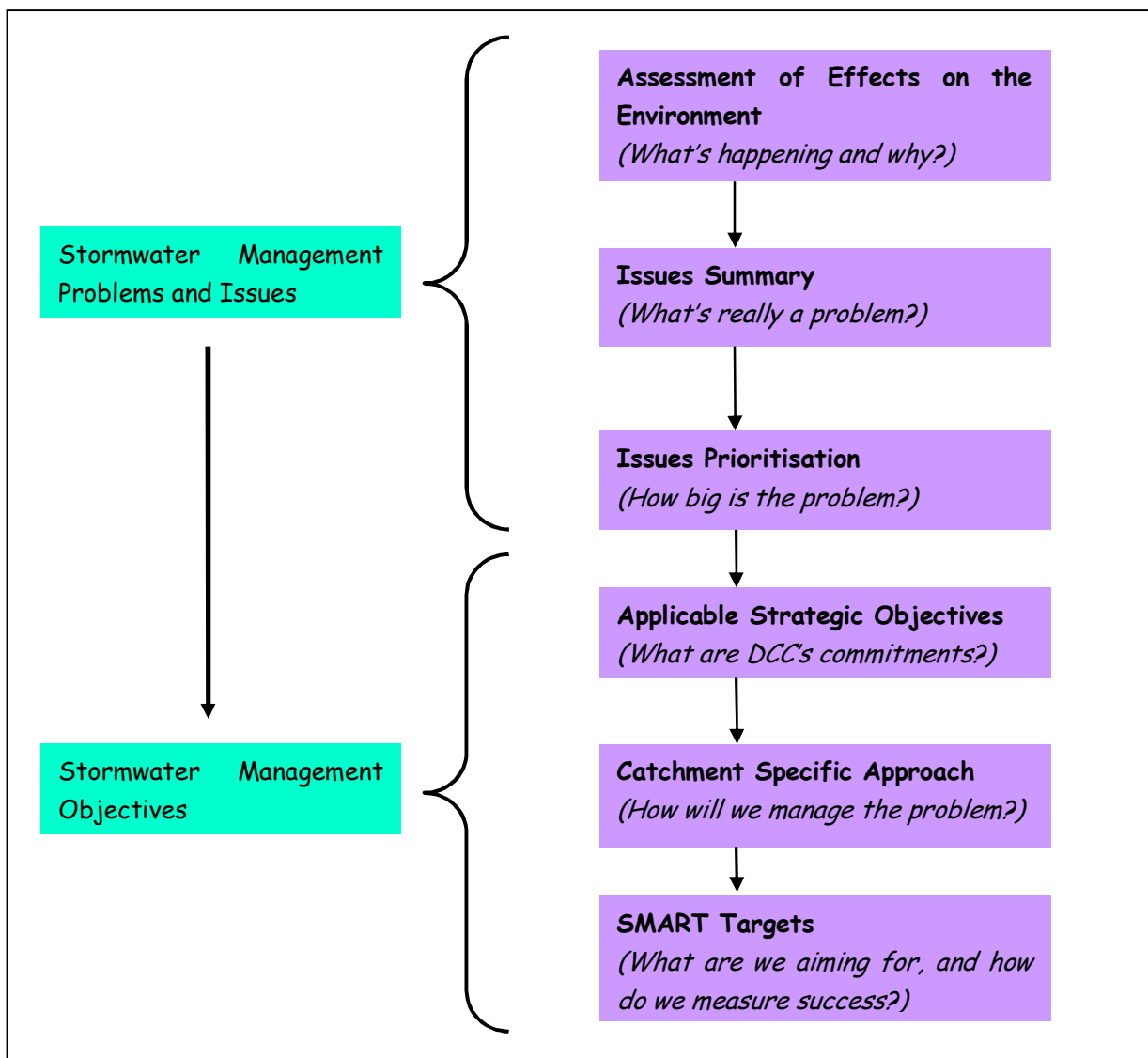


Figure 11-1: Target Development Process



Management approaches and targets are essential for providing information to ensure appropriate funding is made available for stormwater management, and that the management options implemented provide the best value for money to the community. A number of other ICMPs are being prepared by DCC for other outfalls discharging to the harbour. Similar targets will be developed for these ICMPs, and ultimately, issues prioritisation will be used to compare and prioritise recommendations across the catchments.

The catchment specific stormwater management approach is driven by the issues prioritisation, and provides guidance for options development in terms of a broad management approach for each issue, specific to each catchment. Management approaches are driven strongly by the applicable long term (50 year) strategic objectives, outlined in Section 2.

Stormwater management 'SMART' targets are an important tool for DCC; these follow a set of guidelines to ensure that they are well-defined and attainable, as outlined below:

- **Specific** – well defined and clear targets, able to be understood;
- **Measurable** – to provide feedback to continually improve performance;
- **Achievable** – to ensure success;
- **Realistic** – within available resources, knowledge and time; and
- **Time-Bound** – to monitor progress on a number of timescales, and ensure time is available to achieve the goals.

Targets relate both to long and short term objectives outlined in Section 2, depending on the issue. For example, they may refer to maintenance of a certain level of service for the stormwater network, or commitments to minimise adverse effects on the receiving environment where appropriate. The AEE also guides the setting of targets. As some targets may be linked to monitoring information, it is essential that these targets are open to review and adjustment over time. Ongoing monitoring results may indicate a greater or lesser environmental impact than currently understood.

Tables 11-1 and 11-2 outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the Mason Street catchment. These are discussed further below.

11.1 Stormwater Quantity Approaches and Targets

Table 11-1 presents a summary of stormwater management key effects relating to stormwater quantity, and catchment specific targets set for the Mason Street catchment. Approaches and targets developed for 'active' and 'passive' management of stormwater quantity issues in the Mason Street catchment are discussed in more detail below.

The high frequency flooding occurring in the catchment is predominantly nuisance flooding in the road. However, the stormwater network in the catchment is tidally influenced in the lower parts of the catchment, and the number of properties affected by deep flooding is predicted to increase in future scenarios. Increases in deep flooding, flood extent and hazard are predicted under an extreme storm surge situation.



11.1.1 Deep Flooding

The Building Act requires that habitable floors (or 'useful floor space' in relation to non-residential properties) should not be at risk of flooding during a 1 in 50 year rainfall event. Based on an assumed 'danger' depth of 300 mm (relating to a likely floor level above ground), seven commercial or zoned properties in the Mason Street catchment are estimated to be currently at risk during a 1 in 10 yr ARI rainfall event, rising to 24 during a 1 in 50 yr ARI rainfall event. Deep flooding predicted during the current 1 in 100 yr ARI rainfall event is estimated to increase the depth and extent of flooding in already identified flood areas (Rattray Street, Queens Gardens / High Street, Bond Street / Water Street), with predominantly 'significant' flood hazard predicted.

Targets for this flood hazard seek to avoid habitable floor flooding under both current and future land use and climate change scenarios. It is also desirable to avoid any increases in surface flooding of private properties during this event.

Whilst in some areas, modelled flood extents indicate that flooding may not actually enter buildings, some habitable floor flooding during larger rainfall events (February 2005) has been verified with flood complaints records (albeit during an extreme event). However, it is still necessary that parcels identified as potentially being subject to deep flooding during storm events with 1 in 50 yr ARI rainfall and smaller should be surveyed or a damage assessment undertaken to gauge the effects of deep flooding in the catchment.

Planned pipe renewals are expected to reduce the deep flooding predictions by providing increased capacity in the pipe network. However, due to the 'manage actively' classification of this issue, infrastructure options will be investigated, within this ICMP, to alleviate the predicted current deep flooding for events with 1 in 50 yr rainfall or smaller.

The effects of climate adjusted increased rainfall combined with extreme climate change and storm surge is discussed under the issue 'Flood Hazard – Current and Future 1 in 100 yr ARI'.

11.1.2 Flood Hazard – Current and Future 1 in 100 yr ARI

The significant flooding predicted during the future (extreme) climate change scenario modelled is predominantly due to direct tidal inundation (sea level rise plus storm surge), rather than the response of the stormwater system to the rainfall and tide boundaries.

As the flood hazard is predicted to be occurring currently, the recommended targets have been established to ensure that adequate emergency response measure are developed for the catchment to ensure public health and safety in a low frequency event.

As the flood hazard is predicted to increase in the future, due to the timeframe of the extreme climate change scenario (2060), it is appropriate that the potential effects of climate change on this catchment be considered by DCC's Climate Change Adaptation Plan (currently being developed).

11.1.3 Low Level of Service and Nuisance Flooding

The recommended targets and approaches with respect to the stormwater network performance focus on maintaining or improving the existing level of service under reasonable future development and climate change scenarios. The strategic direction provided by the 3 Waters Strategic Direction Statement indicates that the main objective with respect to flooding is to ensure that the risk of flooding does not increase in the future as development occurs, or climate change alters weather patterns and sea levels.



A number of complaints records exist for this catchment, however, in most cases it is not known the size of the storm event during which the complaints were made and the historical data collection methods used for customer complaints logging has resulted in variable information on complaints. Improvements in complaints recording will result in a clearer picture of customer satisfaction in the future.

However, the residents' opinion survey (ROS) has been running in its current format since 2003 and gauges Dunedin city residents' overall satisfaction with the stormwater collection service, amongst other council services. The Mason Street catchment lies within the Dunedin City group of this survey. The results of the 2010 survey indicate that 64 % of respondents were either 'very satisfied' or 'satisfied' with the stormwater collection service.

In general, the council will adopt a long term approach to improving network performance and adapting to climate change by ensuring that all new network components (for example, planned pipe renewals, or upgrades in specific locations) are designed to a 1 in 10 yr ARI level of service, using conservative design storms that incorporate projected changes in rainfall intensity, coupled with conservative tidal boundary conditions. This is consistent with the Dunedin Code of Subdivision and Development, and also with the Building Act.

Currently, 82 % of the pipes modelled in the catchment can accept stormwater during a 1 in 10 yr ARI rainfall without causing manhole overflow, however the majority of the pipes are flowing full. Based on the age of the network, the pipes in the Mason Street catchment will be prioritised for assessment under the DCC pipe renewals programme. Approximately 18 % of the network is currently overdue for renewal, with a further 18 % requiring renewal within the next ten years. By 2060, 71 % of the pipes in the network (including those already at the desired level of service) will need to have been replaced (with new pipes designed to convey the 1 in 10 yr ARI rainfall event).

11.1.4 Network Maintenance and Blocking / Maintenance of Intake Structures

The maintenance and cleaning of catchpits and other stormwater structures is an essential part of maximising the efficiency and level of service of the stormwater network. As the owners of the network, DCC need to be certain that the asset is being maintained appropriately. Currently, the task of maintaining stormwater inlet assets is split between three DCC departments, and one national authority. Contracts for the maintenance of catchpits and inlet structures have some differences in terms of performance criteria. Additionally, there would be benefit in identifying key stormwater structures as part of the catchment management process in order to focus maintenance and cleaning efforts further.

The target set for this issue is to first develop an understanding of the current level of maintenance and cleaning, and then, if required, recommend changes in order to focus efforts and optimise inlet efficiency of the stormwater network.

In the Mason Street catchment, a further target will be to prioritise inlet screens at Queens Drive / Serpentine Avenue and Canongate for cleaning.



Table 11-1: Mason Street Catchment Management Targets: Stormwater Quantity

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 7 parcels affected by deep flooding during 1 in 10 yr ARI rainfall event; rises to 24 properties during 1 in 50 yr ARI rainfall event in current and future planning scenarios. Large number of properties affected during extreme climate change scenario. Flooding during low frequency events mostly predicted exterior to buildings (although surveys not yet undertaken).	Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Reduce number of properties predicted to flood during a current 1 in 10 yr ARI rainfall event. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 24 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event by 2060. Undertake habitable floor survey and / or damage assessment of potentially flooded properties. > 65 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Flood Hazard – Current and Future 1 in 100 yr ARI	Areas of 'significant' flood hazard in roadways, mostly in central city, predicted during current event. 'Significant' flood hazard in roadways in central city, with increased flood extent, predicted in the future (2060) event predominantly due to tidal inundation, exacerbated by predicted climate change effects.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc.) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas will be available. Develop a better understanding of the likely effects and magnitude of climate change.	Develop a catchment specific emergency response plan by 2012. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.
Network Maintenance	Flooding extents and durations in the Mason Street catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013. Develop list of key stormwater assets in Mason Street catchment requiring additional cleaning and maintenance checks by 2013.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Blocking / Maintenance of Intake Structures	Potential blockage of inlet screens at Queens Drive / Serpentine Avenue and Canongate Road could exacerbate downstream flooding.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Work with property owners to ensure intakes and screens are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets in the catchment (in conjunction with city-wide criteria) by 2012. Develop list of key stormwater intake structures in Mason Street catchment requiring additional cleaning and maintenance checks by 2013. Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Low Level of Service	General low level of service of stormwater network (less than 1 in 10 yr ARI), driven by both pipe capacity and tidal influence. 18 % of manholes predicted to overflow during a current 1 in 10 yr ARI rainfall event, pipes flowing full throughout a large proportion of system. Overflow is currently occurring, no capacity for climate change effects. Effects mainly nuisance flooding, affecting approximately 1 % of the catchment currently, and 2 % of catchment in future 1 in 10 yr ARI rainfall event.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Maintain or improve existing level of service in network – ensure no increase in the number of stormwater manholes predicted to overflow in a 1 in 10 yr ARI rainfall event. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	> 65 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. < 18 % manholes predicted to overflow during a 1 in 10 yr ARI rainfall event by 2060. < 1 % of catchment surface predicted to flood during a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Nuisance Flooding	Nuisance flooding on regular basis in a small number of areas, particularly tidally influenced locations. Causes some partial road blockages. Affects < 0.05 % of catchment during 1 in 2 yr ARI rainfall event, and 1 % of catchment during a 1 in 10 yr ARI rainfall event.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Passively Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 0.02 % of catchment surface area predicted to flood during a 1 in 2 yr ARI rainfall event by 2060. > 65 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.



11.2 Stormwater Quality Approaches and Targets

A summary of key stormwater quality effects, and catchment specific approaches and targets set for the Mason Street catchment are presented in Table 11-2. The catchment specific approaches and targets are discussed in further detail below.

Whilst the monitoring information to date does not suggest that the stormwater quality from the Mason Street catchment is adversely affecting the marine environment, approaches and targets set out below describe a city-wide approach to stormwater quality as the Otago Harbour is a common receiving environment for all DCC coastal stormwater discharges.

It should be noted that the Regional Plan: Coast for Otago (ORC, 2009) sets out objectives and policies relating to discharges to the CMA. Objective 10.3.1 seeks *“to maintain existing water quality within Otago’s coastal marine area and to seek to achieve water quality within the coastal marine area that is, at a minimum, suitable for contact recreation and the eating of shellfish within 10 years of the date of approval of this plan”*. Further, Policy 10.4.3 states that where water quality already exceeds these standards, water quality should not be degraded beyond the limits of a mixing zone associated with each discharge.

11.2.1 Limited Confidence in the Knowledge of Effects on the Otago Harbour Environment and Variability of Stormwater Quality Results

There is high variability in stormwater quality monitoring results from each catchment. Whilst stormwater quality is influenced by many variables and it is not unusual to see a wide range of contaminant levels in monitoring results, it is considered that this issue is compounded by the current monitoring technique of obtaining single annual grab samples of stormwater for analysis.

Sediment monitoring has been carried out to date (2007 to 2010) to determine the quality of the marine sediments. Sampling across the catchments has indicated that there are some contaminants of concern within the harbour, measured at relatively high levels, (although not measured directly from the sediments adjacent to the Mason Street catchment outfall). However, it remains unclear whether the contaminant levels observed are as a result of historic contamination or current discharges (from either stormwater or other sources). For this reason, the sources of contamination are difficult to identify, as are any links with the quality of DCC stormwater network discharges.

The biological monitoring undertaken to date does not show any particular trends in diversity or abundance of fauna. The biological monitoring protocol is also highly variable between the catchments and not all catchments are monitored. With only 4 years of biological monitoring data that does not appear to be showing any trends, the variation in sampling protocols throughout the harbour and an absence of ecological baseline or control data for the harbour, it is difficult to draw conclusions from the biological monitoring results.

The monitoring regime to date has been insufficiently robust to enable the identification of any effects or otherwise, with any level of confidence, between stormwater quality and harbour environment health. In order to clearly identify discharges/catchments of concern and select appropriate stormwater management on a catchment by catchment basis to enable DCC to maintain or improve stormwater quality, a suitable monitoring framework, and improved confidence in monitoring data is required.

DCC have a commitment to improve the quality of stormwater discharges to the harbour and, in order to identify necessary and appropriate stormwater management actions within the catchment and city-wide, a sound understanding of the nature and effects of the stormwater discharge is required.



The approach and targets set for this issue include a staged approach that seeks to adjust the current monitoring programme in order to develop and implement an optimised monitoring framework that will provide more comprehensive and defensible information on current stormwater discharge quality and the effects thereof. Following this, it is expected that stormwater management approaches will be reviewed and adjusted to reflect DCC's strategic objectives. The recommended targets are as follows:

- Redesign the monitoring programme to develop a robust framework that will yield good quality, useful data at appropriate sites to enable a sound understanding of both catchment stormwater quality and health of the harbour environment and allow any linkages between the two to be identified.
- Using the monitoring results and other available information (such as land use), identify with confidence, discharges/catchments of concern and potential sources of unacceptable contaminant levels.
- Enable specific city-wide, targeted annual monitoring protocol to be established where necessary, including quality indicators, which can be used to provide feedback on stormwater management practices, and trigger further action as required.
- Use data to contribute to the stormwater management programme for Dunedin. This will include the identification of stormwater management actions to improve stormwater quality where required.

In the interim, while catchment specific stormwater actions and targets are still being established, DCC are committed to looking for quick-win opportunities where point source contamination has been identified, and at a minimum, to ensuring that stormwater quality does not deteriorate as a result of new development or changes in land use in the catchment. Examples of this include:

- Considering the cost and benefit of incorporating stormwater treatment into flood mitigation works where practicable.
- Requiring source control or management of stormwater contaminants in high contaminant generating land uses by enforcing the Trade Waste Bylaw, and working to educate occupiers of high-risk sites with respect to stormwater discharge quality.
- The Dunedin Code of Subdivision and Development indicates that at-source management of stormwater quantity is desirable and Low Impact Design methods are preferred.



11.2.2 Potential Wastewater Contamination

The stormwater monitoring results for the Mason Street catchment show microbial contaminant levels to be at or above the upper level that is typical of urban stormwater, with the 2010 data set showing significantly elevated levels.

As there are no known issues with the wastewater network in this catchment the potential source of contamination is unknown and it is unclear whether isolated incidents have contributed, in particular to the 2010 results, and as such the level of threat remain inconclusive.

However, it is acknowledged that there is low confidence in the current monitoring data; therefore, this issue is related to the above issue regarding ongoing stormwater discharge.

The approach and targets for this issue are related to confidently identifying the levels of microbial contaminants in the stormwater and investigating potential sources of any problems. This will ensure any management options in the catchment, should they be required, to be developed appropriate to the issue

In the meantime, DCC is committed to ensuring that there is no deterioration in current stormwater discharges and reducing the contaminant levels within stormwater discharges over time, as described above.

11.2.3 Ongoing Stormwater Discharge

In general, the monitoring data at present does not indicate that the levels of contaminants in stormwater from the Mason Street catchment stormwater are significantly high. The exception is relatively high microbial contamination which is addressed as a separate issue below. Therefore based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach.

However, it is acknowledged that there is low confidence in the current monitoring data; therefore, this issue is related to the above issue regarding limited confidence in the knowledge of effects on the harbour environment.

The approach and targets for this issue are related to the outcomes of the targets set for confidently identifying the levels of contaminants in the stormwater and any resulting effects on the harbour environment. Following the outcomes of the proposed monitoring and stormwater management prioritisation targets, the approach to stormwater management in this catchment will be revised and catchment specific targets, where appropriate will be applied.

In the meantime, DCC is committed to ensuring that there is no deterioration in current stormwater discharges and reducing the contaminant levels within stormwater discharges over time, as described above.



Table 11-2: Mason Street Catchment Management Targets: Stormwater Quality

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear. Poor information on actual effects of stormwater on harbour environment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the RMA. Ensure stormwater discharge quality does not deteriorate.	Manage Actively Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Develop method for determining linkages between stormwater management and harbour environment. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality. Undertake monitoring to ensure stormwater quality does not deteriorate over time. Incorporate a feedback process to the ICMP if / when monitoring indicates potential adverse effects from stormwater discharges.	Robust city-wide monitoring framework developed and implemented by 2012. Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

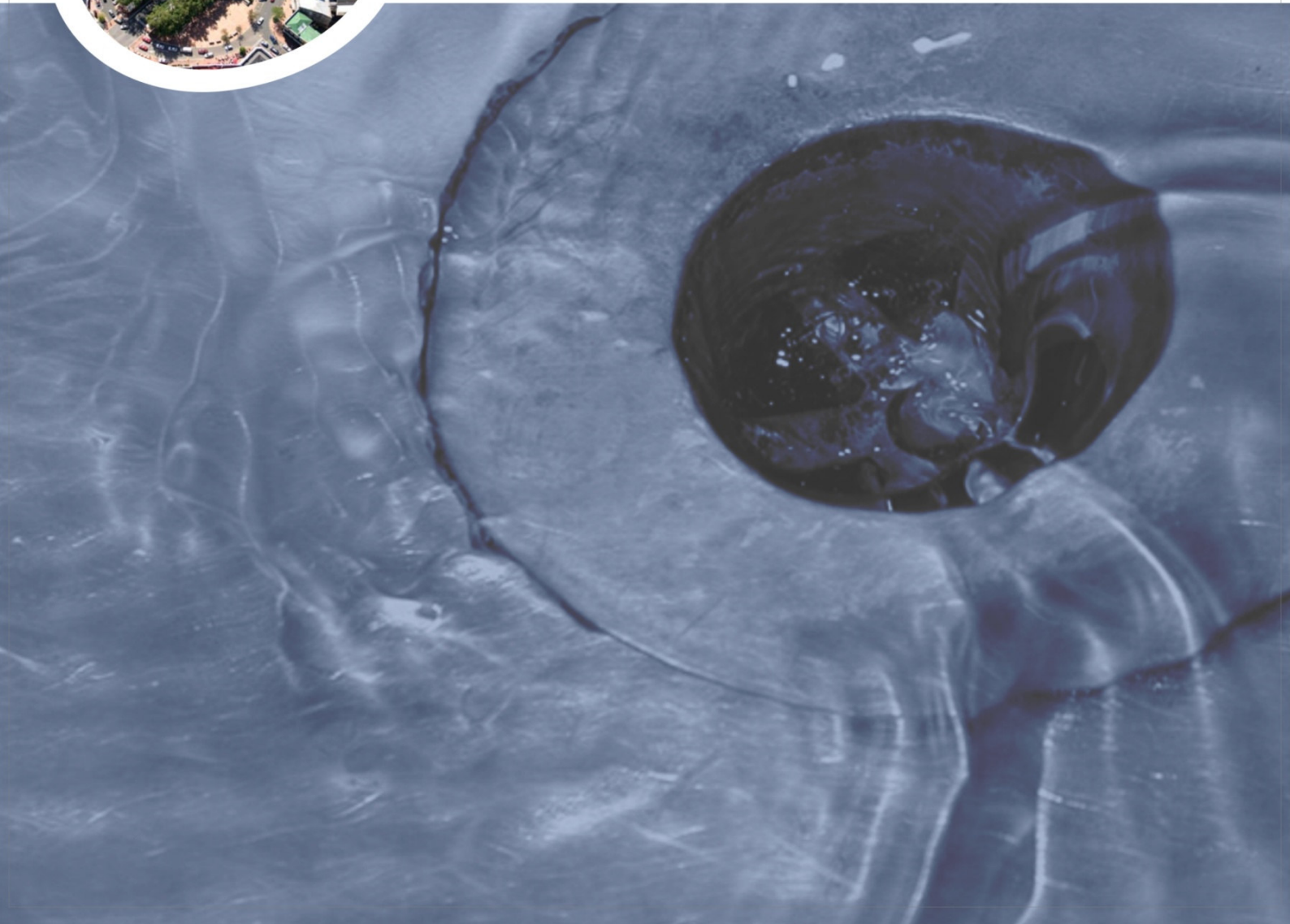


Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Potential Wastewater Contamination	High microbial contamination of stormwater, particularly in 2010, may be cause for concern.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	Manage Passively Undertake targeted monitoring to enable better understanding of potential catchment contamination. Investigate potential sources of wastewater contamination. Develop appropriate management options to remediate problem where necessary.	Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012. Implement management options to remediate problem where necessary.
Ongoing Stormwater Discharge	Could exacerbate existing/historical contaminant issues. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	Manage Passively Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.



Part 5

Solutions





12 Stormwater Management Options

12.1 Introduction

Options are presented below to manage the stormwater issues identified in the Mason Street catchment. Options are generally capital work options, planning options, or operation and maintenance tasks. These have been developed in line with issues prioritisation and catchment specific targets and approaches set in Section 11.

When considering the options available for each issue, options considered to be 'deal breakers' are eliminated from the options to be evaluated. Example definitions of deal breakers are as follows:

- Option must be technically feasible;
- Option must meet relevant legislative requirements;
- Option must be consistent with the principles of the Treaty of Waitangi;
- Option must be aligned with the catchment specific objectives developed in Section 11 of this document;
- Option must not have greater negative environmental, social or cultural consequences than the 'do nothing' option;
- Option should not contravene any explicitly stated political objective;
- Option should not result in an increase in the risk category; and
- Option should not increase health and safety risks compared with the 'do nothing' option.

'Active management' indicates that DCC will seek to implement changes to stormwater management in the catchment, whereas 'passive management' would tend more towards monitoring and review of existing management practices to ensure that the targets set can be met. This section puts forward a number of options (where more than one exists) for each issue identified in the catchment.

Following the elimination of deal breakers, information on options for stormwater management is collated. The options identified for 'manage actively' issues are then evaluated against the QBL evaluation criteria outlined in Section 14, with the most favourable stormwater management option selected.

Following the identification of options for each stormwater management issue, and options evaluation using QBL methodology, a prioritised programme of capital works and additional investigations recommended in the Mason Street catchment is then developed.

The implementation of the programme is expected to progressively improve stormwater management in the catchment as part of the wider 3 Waters Strategic Plan, which incorporates programming of the outcomes recommended in all ICMPs developed across the city.



12.2 Potential Options

Outlined below are preliminary options identified for the key stormwater management issues present in the catchment. Option 'deal breakers' are eliminated and feasible options are described in further detail. Where an issue has been prioritised as 'manage passively', management options are discussed in more general terms, although planning based options may be presented where applicable. Where an issue is prioritised as 'manage actively', where available, a number of alternative options will be considered for further evaluation in Section 14.

12.2.1 Deep Flooding – Manage Actively

A total of seven land parcels in the Mason Street catchment are predicted to experience flood depths of greater than 300 mm during the current 1 in 10 yr ARI rainfall event combined with a MHWS tide. This rises to nine when future land use scenarios and climate change are applied to the model. This is not a particularly large number and this predicted flooding is not confirmed by flood complaints records.

During a 1 in 50 yr ARI rainfall event, 24 and 40 land parcels are predicted to experience deep flooding under current and future scenarios respectively. The risk of habitable floor flooding, predicted by the model, is verified in some cases by flood complaints records. The main locations predicted to experience deep flooding during this event are:

- Rattray Street
- Bond Street / Water Street
- Queens Gardens / High Street

The deep flooding predicted is predominantly due to the low capacity of the network and the tidal influence on the system in the lower catchment. Overland flows from the upper catchment contribute to the flood depths and extent on the flat land in the central city.

The catchment specific targets and approaches identified for this issue are as follows:

- Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event.
- Ensure no increase in the number of properties predicted to flood during a 1 in 50 yr ARI rainfall event.
- Reduce number of properties predicted to flood during a current 1 in 10 yr ARI rainfall event.
- Ensure new development does not increase potential habitable floor flooding in events up to a 1 in 50 yr ARI rainfall event.
- Enhance understanding of effects of deep flooding, particularly on private property.

DCC's target with respect to this flooding is to ensure that the current risk is minimised during high frequency events, and is not increased in the future as development occurs and climate change is taken into account. Management of the effects of new development, therefore, would be as per the requirements of DCC's Code of Subdivision and Development (refer below to a discussion on this regarding levels of service).

In order to fully understand the risk of habitable floor/useful space flooding, particularly during the unconfirmed 1 in 10 yr ARI event, Properties identified as being at risk will require floor level survey



to determine whether flood depths of 300 mm or greater would in fact enter the building. A damage assessment of affected properties which are commercial or industrial in nature is often useful in terms of identifying vulnerable premises. A damage assessment would involve a topographical survey of building floor levels, and a report on the use of the premises by the occupant, and value of stock and/or fittings that would potentially be damaged by a flood event of a certain depth. An assessment would need to be undertaken with every change of use of the premises and potentially could be a requirement of the property owner.

Whilst 18 % of the pipes in this catchment are currently overdue for renewal and a further 18 % due to be renewed in the next 10 years, this may only go some way to alleviating the adverse effects predicted and verified during current rainfall events of 1 in 10 yr ARI and greater. Several options have been developed to alleviate the current and future risk of habitable floor flooding during events up to a 1 in 50 yr ARI. Further detail is provided, in Section 14, of shortlisted options. The preliminary options identified are as follows:

M1: Serpentine Avenue Upgrade

Upgrade the Queens Drive / Serpentine Avenue intake structure and downstream pipes to increase intake performance, provide greater pipe capacity and reduce overland flows to the lower catchment.

M2: Catchpit Capacity (Upper Catchment)

Increase catchpit number and capacity between Serpentine Avenue and Rattray Street to reduce overland flow volumes to the lower catchment.

M3: On-Site Detention (Upper Catchment)

Install on-site detention e.g. rain tanks for all properties upstream of the Queens Drive/Serpentine Avenue intake structure, to reduce intake structure and manhole overflows, hence overland flow to the lower catchment.

M4: In-line Catchment Detention (Upper Catchment)

Provide detention for storm flows from the upper catchment upstream of the Queens Drive / Serpentine Avenue intake structure to reduce intake structure and manhole overflows, hence overland flow to lower catchment.

M5: Off-line Catchment Detention (Upper Catchment)

Provide detention for overland flows off-line along the northern side of Serpentine Avenue where sufficient space is available for detention of peak flows; hence reduce overland flow to lower catchment.

M6: Siphon Flows from Rattray Street to Bubble up at Queens Gardens

Install pipe (bifurcation or separate pipe) to take flows from the low point in Rattray Street and bubble up near Queens Gardens. This will alleviate the flooding in Rattray Street.

M7: Lower the Road Corridor Levels of Princes Street

Lower the road corridor levels of Princes Street to allow overland flow to Queens Gardens to alleviate flooding in Rattray Street.



M8: Increase Inlet Capacity on Rattray Street

Install additional catchpits (double chamber) with oversized leads in the low point of Rattray Street to provide increased capture of overland flows (minimising surface flooding) and drain the area more quickly following the storm peaks and the surcharged state of the main stormwater line.

M9: Fill Dip in Rattray Street

Alter the vertical profile of Rattray Street to Princes Street to allow overland flow to Queens Gardens to reduce flooding on Rattray Street.

M10: System Upgrade with New Outfall

Install a new pipe from Princes Street down lower Rattray Street past the south side of Queens Gardens to the nearest part of the harbour (Steamer Basin) to relieve the surcharged main line reducing ponding water in Bond Street and providing capacity for the overland ponding in Rattray Street.

M11: Fill dip in Bond Street

Fill the dip in the road in Bond Street to reduce ponding in this low point.

M12: Raise Levels of Flood Prone Buildings

Elevate the buildings that currently flood, and are predicted to flood in the 1 in 50 yr ARI future growth scenarios.

The location of these options is shown in Figure 12-1. Section 14 contains the preliminary analysis and shortlisting of these options.

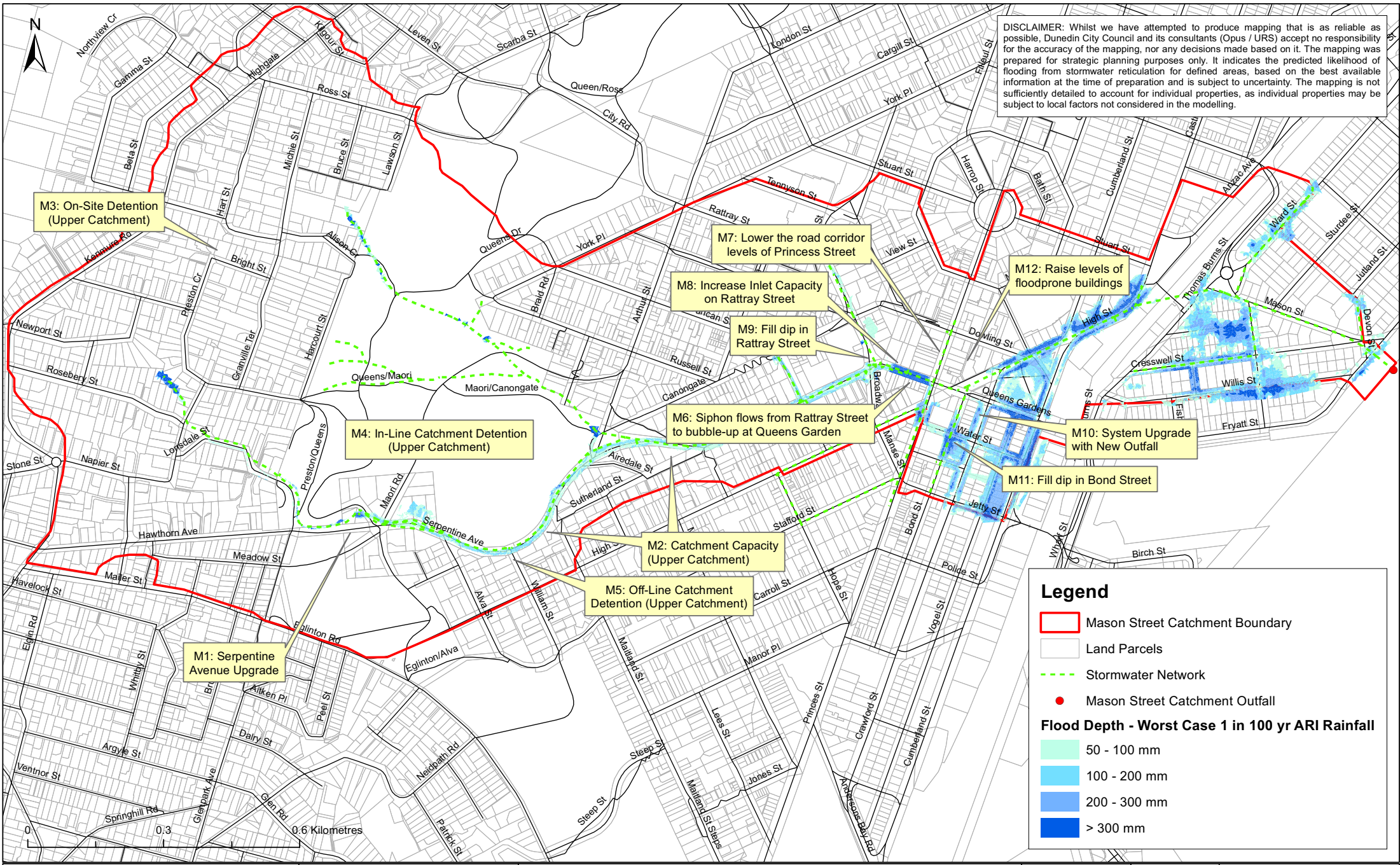
Further catchment-wide options are presented for this issue, they are not presented as alternatives, but rather to be considered to assist with both the renewals programme and further design and development of capital works within the catchment to maximise the potential to alleviate flooding issues.

Improve quality of stormwater network data

To assist with both the renewals programme and the further design and development of stormwater management options in the catchment, there would be benefit in improving the quality of data relating to the stormwater network. To augment the information gathered during the city-wide CCTV inspection programme (in progress at the time of writing this plan), improvements in GIS asset data would be beneficial.

Include additional or improved catchpits in any capital works

By ensuring any future capital works carried out on the stormwater network include either additional or improved catchpits, there would some increase hydraulic capacity in enabling surface flows into the piped network.





12.2.2 Flood Hazard – Manage Actively

During a current 1 in 100 yr ARI rainfall event, with MHWS tide, flooding is predicted to cover approximately 4 % of the catchment, however the majority of the flood extent is concentrated within on the flat land of the lower catchment within the central city. Due to the low capacity of the network, and the tidal influence on the piped network, flooding of properties and roads during this event is unavoidable.

During the extreme future scenario consisting of a 1 in 100 yr ARI rainfall event combined with a 2060 tide (including climate change impacts) and a 1 in 20 yr ARI storm surge, flooding is predicted to cover approximately 9 % of the catchment, with the lower catchment and CBD areas the most affected by the flood extents. Due to the low capacity of the network, and the effect of high tides and storm surge, flooding of properties and roads during an event this large is unavoidable, and much of the flooding is predicted to be due entirely to tide levels inundating the low lying catchment.

Small benefits may be gained, during current and future (extreme) events, from other options seeking to alleviate more regular flooding, or improve network capacity. The catchment specific targets and approaches identified for this issue are as follows:

- Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event.
- Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc.) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas.
- Ensure transport routes around flooding areas are available.
- Develop a better understanding of the likely effects and magnitude of climate change.

In terms of ensuring that development does not further exacerbate flooding, management of the effects of new development would be as per the requirements of DCC's Code of Subdivision and Development (refer below to a discussion on this regarding levels of service).

Two options are presented for this issue, they are not presented as alternative however, both would be required to fully address the issue. One option addresses the current situation, the other the future extreme scenario.

Develop Emergency Response Plan

The 1 in 100 yr ARI rainfall event has been examined for emergency planning purposes and 'active management' in this context is likely to involve appropriate contingency planning only. The extent of the flooding, effect of the tide and lack of critical structures in the catchment means that the approach to flood hazard in this catchment is via an emergency response plan. Consequently, only one option alternative for current flood hazard management is presented.

The areas predicted to have the most significant flood hazard is the lower catchment within the central city. It is predicted that several transport routes into and out of this area will be significantly affected during an extreme flooding situation. An emergency response plan could be prepared to ensure that evacuation from flooded areas was possible during a large storm event. This could also include the identification of vulnerable premises and key industrial premises, and provide a specific evacuation plan for these.



It is anticipated that an emergency response plan would be prepared for all harbour front catchments predicted to be significantly affected by the current 1 in 100 yr ARI rainfall event. The response for the Mason Street catchment would form part of the plan.

Develop Climate Change Adaptation Plan

This issue is predicted to occur in the future, and is predominantly due to climate change impacts, therefore a single option is presented.

In order to develop a better understanding of the likely effects and magnitude of climate change, there needs to be an ongoing re-visitation of new information regarding climate change predictions, and the implications of these for the Mason Street catchment. The hydraulic model developed for this study would be a key tool in assessing the impacts of a range of further climate change scenarios. A climate change adaptation plan for the whole of Dunedin city would incorporate findings in terms of a plan for low-lying catchments such as the Mason Street lower catchment. This plan may affect the options chosen in terms of on-going provision of level of service of the network. Damage assessment of critical and vulnerable sites (such as the electricity substation) would form part of this work.

12.2.3 Low Level of Service – Manage Passively

Hydraulic modelling results indicate that the network in this catchment has a relatively low level of service. Hydraulic pinch points in the upper catchment create overland flow in events as small as a 1 in 2 yr ARI rainfall event, while some areas in the lower catchment have levels of service restricted to a 1 in 5 yr ARI rainfall event due to tidal influence. Due to these restrictions in key parts of the network, the modelling indicates that there is no capacity to accommodate increased rainfall due to climate change.

The results of the ROS indicates that residents/building owners are not dissatisfied with the current level of service provided. This, combined with the fact that the dominant result of the low level of service is nuisance flooding, sets the management of this issue as passive.

The catchment specific approach for this issue includes the following:

- Maintain or improve existing level of service in network – ensure no increase in the number of manholes predicted to overflow in a 1 in 10 yr ARI rainfall event;
- Design new pipes with capacity to convey a 1 in 10 year storm event;
- Undertake pipe renewals programme from 2012;
- Ensure new development does not increase potential habitable floor flooding in events up to a 1 in 50 yr ARI rainfall event; and
- Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.

The 'Dunedin Code of Subdivision and Development' is used by DCC to set requirements for land development and subdivision, but is also used by DCC to guide design of network upgrades undertaken by DCC. Table 12-1 outlines the design criteria required by DCC for new stormwater work. Compliance with this document ensures that the approach to design new pipes to convey a 1 in 10 yr ARI rainfall event is met, and that secondary protection is provided up to a 1 in 100 yr ARI rainfall event.



As development occurs, or pipe renewals are undertaken, the level of service of parts of the network will gradually improve. Under DCC's pipe renewals programme, 36 % of the pipes in the catchment would be due for renewal between 2010 and 2020, based on the age of installation. The pipe renewal process includes inspection and condition assessment, and potentially extends the useful life of a stormwater asset beyond 100 years, if it is in good condition.

The issues in the Mason Street catchment, relating to tidal influence on the network, means that the performance of the network may not improve significantly via local upgrades. However, the details of a climate change adaptation plan for the city would be used to guide future works in the catchment, as identified below.

In the interim, the ROS can be used to gauge satisfaction with the stormwater system performance. The ROS provides a city-wide impression of satisfaction with the stormwater system, and is used to measure progress against a target of 60 % satisfaction. The Mason Street catchment is most aligned with the Dunedin City group surveyed. In 2010 45 % of residents in the Dunedin City area were either very satisfied or satisfied with the stormwater collection service, with 22 % being either dissatisfied or very dissatisfied. This is lower than the DCC target for satisfaction. However, since the survey began in 2003, city-wide satisfaction with the stormwater collection service has been above 60 % in every year except 2004/2005 (Research First, 2010).

Table 12-1: Stormwater Design Criteria

Function	AEP %	Return Period (ARI, years)
Primary protection	10	10
Primary protection in areas where secondary flow paths are not available or are through private property	1	100
Secondary protection	1	100

12.2.4 Nuisance Flooding – Manage Passively

The strategic direction provided by the 3 Waters Strategic Direction Statement indicates that the main objective with respect to flooding is to ensure that the risk of flooding from the stormwater system does not increase in the future as development occurs, or climate change alters weather patterns and sea levels. Because the existing network has minimal capacity for increased flows, and the effects of future flooding are predominantly driven by climate change, the climate change adaptation plan will be needed to guide any flood mitigation options in this catchment.

Approximately 0.02 % of the surface area in the Mason Street catchment floods during a 1 in 2 yr ARI rainfall event, 0.13 % during a 1 in 5 yr ARI. This flooding is confined to road corridors, and is likely to dissipate in a short time.

Rules set for future development in DCC's Code of Subdivision and development will ensure that into the future, new or re-development of sites will include the provision of stormwater detention or conveyance up to a 1 in 10 yr ARI rainfall event. It is likely that this, along with planned pipe renewals, will somewhat relieve the frequent nuisance flooding in the catchment over time.



12.2.5 Network Maintenance and Blocking / Maintenance of Intake Structures – Manage Passively

Flooding extents and durations in the Mason Street catchment could potentially be exacerbated should critical catchpits and inlet screens not be adequately cleaned.

Regular cleaning and maintenance of catchpits and stormwater structures is essential across the city, and city-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service. The following catchment approaches have been developed for these issues:

- Ensure consistency city-wide of stormwater structure cleaning and maintenance.
- Ensure cleaning and maintenance schedules and contracts are sufficiently robust.

A review of schedules and methods used across the city could be undertaken to ensure that all possible contaminant sources (e.g. catchpits) are cleaned regularly, and the flood risk is reduced as much as possible. Alignment of contracts for this maintenance (currently with a number of agencies) would provide confidence that catchpit and stormwater structures were operating optimally.

As part of the contracts, key structures identified in each catchment management plan could be incorporated as requiring additional or more frequent attention. In the Mason Street catchment, the following structures would be included:

- Queens Drive / Serpentine Avenue – Inlet Screen
- Canongate - Inlet Screen

12.2.6 Limited Confidence in Knowledge or Effects on the Otago Harbour Environment and Variability of Stormwater Quality Results – Manage Actively

In general the stormwater quality results from the Mason Street catchment do not indicate high contaminant levels (with the exception of microbial contamination which is discussed below), however, no sediment monitoring is carried out in the vicinity of the outfall so links between stormwater and marine sediment quality in this location are not possible. In general, the stormwater and harbour environment monitoring regime to date has been insufficiently robust to enable the identification of any relationship between stormwater quality and harbour environment health.

In order to clearly identify discharges / catchments of concern and select appropriate stormwater management on a catchment by catchment basis to enable DCC to meet their objectives regarding stormwater quality, a suitable monitoring framework, and a high confidence in monitoring data is required. The catchment specific approaches recommended for this issue in the Mason Street catchment (and city-wide) are:

- Redesign the monitoring programme to develop a robust framework that will yield good quality, useful data at appropriate sites to enable a sound understanding of both catchment stormwater quality and health of the harbour environment and allow any linkages between the two to be identified.
- Using the monitoring results and other available information (such as land use), identify with confidence, discharges/catchments of concern and potential sources of unacceptable contaminant levels.



- Enable specific city-wide, targeted annual monitoring protocol to be established where necessary, including quality indicators, which can be used to provide feedback on stormwater management practices, and trigger further action as required.
- Use data to contribute to the stormwater management programme for Dunedin. This will include the identification of stormwater management actions to improve stormwater quality where required.
- Considering the cost and benefit of incorporating stormwater treatment into flood mitigation works where practicable.
- Requiring source control or management of stormwater contaminants in high contaminant generating land uses by enforcing the Trade Waste Bylaw, and working to educate occupiers of high-risk sites with respect to stormwater discharge quality.

Due to the importance of this information in developing stormwater management options for stormwater quality (where required), the SMART targets identified for this issue seek to obtain and analyse information as quickly as possible. The primary target is as follows:

- Develop and implement a robust monitoring framework by 2012.

The approach and targets recommended include a staged approach that seeks to redesign the current monitoring framework to ensure that it will provide more comprehensive and defensible information on current stormwater discharge quality and the effects thereof. Following this, it is expected that the ICMP approaches will be reviewed and adjusted where necessary to reflect DCC's strategic objectives.

Despite a 'manage actively' classification, the issue of undefined effects of stormwater on the harbour environment has led to the approach of resolving the issue via the development of a suitable monitoring framework. Consequently, only one option alternative is presented:

Design a Framework for Stormwater Quality and Harbour Environment Monitoring

The augmentation of the current monitoring framework to result in the implementation of a more robust monitoring framework would allow the identification, with an improved level of confidence, any effects or otherwise of stormwater quality on the stormwater quality and harbour environment health.

The monitoring framework should be re-designed to focus on the following outcomes:

- Improved confidence in stormwater quality data;
- Sound understanding of marine sediment quality, including the extent of historic contamination and rate of any ongoing contamination and potential sources;
- Identification of harbour biological health, using suitable indicators to attempt to 'single out' effects of stormwater discharges on the harbour environment;
- Identification of any links between pipe discharge and sediment quality, marine water quality, marine biology; and
- Identification of catchments / discharges of concern and associated stormwater contaminants of concern.



The results of the monitoring undertaken according to the revised framework will allow the following targets to be met:

- Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013.

Use of data following the outcomes of the monitoring framework will be via the monitoring and continuous improvement of the ICMPs, as described in Section 17. The improved data confidence will allow the prioritisation of stormwater management recommendations based on the significance of stormwater quality issues. This would occur city-wide and form part of the 3 Waters Strategic Plan.

12.2.7 Potential Wastewater Contamination – Manage Passively

High levels of microbial contaminants have been observed in the stormwater monitoring result from the Mason Street catchment throughout the monitoring years (2007 to 2010), measured at the upper levels or higher, than is typical for urban stormwater. Further, the 2010 monitoring results showed significantly high microbial contaminant levels. The results could indicate wastewater contamination within the stormwater network. However, there are no known issues with the wastewater network in this catchment.

In order to enable DCC to maintain or improve stormwater quality, and implement appropriate management options to remediate any potential threat from microbial contamination a high confidence in monitoring data and identification of potential contaminant source/s is required, which can be gained through further investigation into this issue.

The catchment specific approaches recommended for this issue in the Mason Street catchment are strongly related to those associated with the 'Ongoing Stormwater Discharge' issue, and are as follows:

- Improve data relating to levels microbial contamination and potential sources of microbial contamination within the catchment by 2012.
- Revise ICMPs to include new information, management approaches and ongoing monitoring protocols by 2014.

The approach to stormwater quality management in this catchment, relating to this issue will be revised following determination of the significance of this issue and identification of potential sources of contamination. This will be implemented by updating the ICMP and the continuous monitoring and improving of SMART targets.

12.2.8 Ongoing Stormwater Discharge – Manage Passively

The monitoring data at present indicates that the levels of contaminants in stormwater from the Mason Street catchment are not significantly high (with the exception of microbial levels which are addressed in a separate issue). Therefore based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach. Options for management, detailed below, take into account the industrial nature of parts of this catchment. It is recommended that all options are applied.

The approach to stormwater quality management in this catchment will be revised following the outcomes of the proposed new monitoring framework. This will be implemented by updating the ICMP and the continuous monitoring and improving of SMART targets.



The management of stormwater discharges as new development occurs could be undertaken using several mechanisms:

- **Development Controls:** DCC have a preference for at-source management and low impact stormwater design as outlined in the draft Code of Subdivision and Development. This document also requires a minimisation of damage to the environment from adverse effects of stormwater runoff; that habitat requirements are taken into account; that stormwater treatment is put into place where practical and that road drainage applies appropriate stormwater treatment.
- **An amendment to the business processes used to manage subdivision and development.** This would be aimed at ensuring that the developer/DCC representative review the appropriate ICMP for the area of development, in order to direct stormwater treatment based on catchment specific requirements.
- **Trade Waste Bylaw:** The Trade Waste Bylaw currently includes standards for stormwater discharge quality. Enforcement of this Bylaw would result in an improved quality of stormwater discharge leaving industrial or commercial sites. The Bylaw currently includes standards for stormwater discharge relating to the ANZECC (2000) guidelines for Fresh and Marine quality. Following improved understanding of stormwater discharge quality and its effects, this Bylaw may require review.

Education and Assistance: Also under the Trade Waste Bylaw, inspections of industrial premises could be undertaken to ensure that adequate on site management practices are being applied. Assistance could be provided by DCC to help achieve higher stormwater quality. It is anticipated that ORC would be involved in this type of scheme for consented discharges, and potentially have resources available to assist in city-wide education.



13 Three Waters Integration

13.1 General

A key driver for the 3 Waters Strategy Project and indeed for the re-organisation of the DCC Water and Waste Business Unit, was to break down the “silo” based approach to the three waters and to encourage integration and efficiencies that can be gained by developing a holistic approach and understanding the inter-relationships and interactions between the three waters. Key advances in this respect relate to business systems integration; simultaneous and complementary modelling; use of identical growth and planning assumptions; and the consideration of integrated solutions.

Provided below is a summary of integration opportunities explored as part of this project, between stormwater and raw water / water supply and wastewater respectively. Reports relating to raw water, water supply, and wastewater studies undertaken as part of the 3 Waters Strategy Project are available from DCC upon request.

13.1.1 Raw Water and Water Supply

The key opportunity for integration between the water supply and stormwater systems is perhaps the need/potential for stormwater harvesting. Analysis of the water supply now and to the 2060 planning horizon indicates that generally the existing water sources will be adequate to meet future demand needs. The strategic water network and the reticulation is well placed to meet future demand and daily demand patterns. However, climate change predictions indicate that Dunedin will become drier for extended periods.

Population growth in Dunedin is relatively small and there is certainly potential to reduce leakage to counter the increased demand. Consequently, there is no need to encourage wide scale stormwater harvesting to meet system demand.

The suggested use of rain tanks is a frequent feature during public consultation. Whilst there are potential water quantity and quality benefits to the use of rain tanks, their widespread use has potential economic implications. Dunedin has adequate raw water sources to supply the city. Furthermore, the variable costs of treating water and wastewater are small when compared with fixed costs (including loans and depreciation). Consequently, any widespread initiatives to reduce water demand are likely to simply increase the unit cost for water and deliver little if any economic benefit to ratepayers. The environmental benefits of rain tanks, or any other demand management initiative need to be carefully balanced against the social and economic aspects of sustainability.

Leakage from the water supply can enter storm drains as infiltration. Whilst the amount of water entering the stormwater system is likely to be relatively small, any reduction in leakage will provide some limited benefit to the stormwater system through increasing the “headroom” by reducing the base flow in the pipes. This is a minor benefit however, and should not be considered as a main driver for leakage reduction or as a possible solution to stormwater system under-capacity.

13.1.2 Wastewater

There are many ways in which stormwater can enter into the wastewater system and vice versa. Upgrade / capital works of the wastewater systems can lead to changes in the quantity and quality of stormwater discharge.



In Dunedin, the following issues influencing both wastewater and stormwater have been identified:

- I&I has been identified as a problem in number of wastewater catchments city-wide. I&I may be occurring from any location in the network, for example, from mains right up to private laterals. Stormwater can enter through manhole joints and covers, broken pipes or dislodged joints. A portion of the I&I may be due to cross connections between the stormwater and wastewater, a result of illegal connections, or old combined connections which are a legacy of the once combined system.
- There are known constructed wastewater overflows which discharge wastewater to the stormwater system during wet weather. DCC state in the 3 Waters Strategic Direction Statement that they want to limit the use of these overflows in the short term with the long term target being total removal. As the overflows only occur in wet weather, if I&I can be limited in the first instance, the use of these overflows would reduce.

The successfulness of any wastewater system rehabilitation and disconnection of cross connections will be dependent on the stormwater system having adequate capacity to take the additional flow.

To date there have been no specific issues identified with the wastewater network within the Mason Street catchment, aside from sea water intrusion into the network, which has resulted in a small number of pipe rehabilitations in the lower catchment.

A further opportunity for integrated solutions in this catchment between the wastewater and stormwater networks is likely to be in the co-ordination of the capital programme. This co-ordinated approach will be developed within the 3 Waters Strategic Plan.



14 Options Evaluation

14.1 Options Evaluation Criteria and Methodology

Options evaluation criteria has been developed based on objectives and decision making criteria set in the following:

- The 3 Waters Strategic Direction Statement;
- DCC's Optimised Decision Making Matrix; and
- DCC's LTP.

Stormwater specific criteria have been developed for the QBL (economic, social, cultural and environmental) analysis, with two additional 'risk' categories, Implementation Risk and Effectiveness (risk reduction). These are separated from the core QBL by DCC and given significant weighting; the first to ensure that operationally, capital works installed will be effective, and the second to highlight the benefits of each option in terms of reduction of current risk and the levels of service. The scoring framework is presented in Table 14-1. Weighting for each of the criteria has been assigned by DCC.



Table 14-1: Option Assessment Criteria and Scoring System

QBL	Option Assessment Criteria	-10	-5	0	5	10
Environmental (10)	Removal of known wastewater cross connections	Does not remove cross connection.	Reduces likelihood of cross connection occurring.	Assists in finding unknown cross connections.	Removes cross connection for design events (emergency overflow still exists).	Removes cross connection under all events.
	Contaminant reduction	None.	5 - 25 %	25 - 40 %	50 - 75 %	75 - 100 %
	Use of source control / LID	No treatment or control.	End of pipe treatment (catchment or sub-catchment based).	Site based in-line treatment / collection of contaminant.	LID with water reuse up to design event.	Source control - avoid generation of contaminant of concern.
	I&I reduction	No I&I reduction possible.	-	-	Minor I&I reduction possible without exacerbating stormwater flooding.	Major I&I reduction possible without exacerbating stormwater flooding.
	Construction effects	Major discharge of contaminants into environment during construction.	Minor discharge of contaminants into environment during construction.	-	All contaminants generated contained on site and disposed of appropriately.	No effects on environment - no contaminants generated during construction.
	Replication of current flow patterns	No volumetric control.	Minimal attenuation.	Replicates or reduces current flow patterns up to 1 in 2 yr ARI event.	Replicates or reduces current flow patterns up to 1 in 10 yr ARI event.	Replicates or reduces current flow patterns up to a 1 in 100 yr ARI event.
	Option flexibility	Constrained.	Flexible for short term scenarios but cannot be staged.	Will accommodate all scenarios but minimal staging.	Flexible for all but extreme scenarios and can be staged.	Flexible for all scenarios and can be staged.



QBL	Option Assessment Criteria	-10	-5	0	5	10
Social (10)	Interest / support of community / social interest groups	Major opposition from community / special interests groups.	Some opposition from community / special interests groups.	-	Some support from community / special interests groups.	Major support from community / special interests groups.
Cultural (10)	Fit with Māori cultural values	Contradicts key cultural values.	Unlikely to fit with values and preferred approaches.	Not specifically identified as preferred approach, but likely to fit.	Fits with preferred approach recommended by local iwi.	Involves iwi in development and design of option.
Implementation Risk (20)	Risk of operational failure	Likely operational failure. Unproven technology.	New technology. Extensive training required.	Moderately complicated new technology.	Minor modifications to technology already used. Simple new technology.	Proven technology, already utilised throughout city.
Economic (10)	Estimated Capital Cost - order of magnitude (note does not allow for internal costs)	\$ 10m+	\$ 1 - \$ 10m	\$ 500k - \$ 1m	< \$ 500k	Free
	Risk of cost escalation due to construction unknowns	High - escalation likely as no alternatives and insufficient information.	Moderate risk. Low number of alternatives available.	-	Can be managed via alternatives.	Low risk. Well known issue and design criteria.
	Risk of land availability	Unlikely to secure land.	Long process for negotiation, or high cost of land expected.	Moderate process / costs anticipated.	Unutilised land likely easy to secure.	Land already owned by DCC.
	Risk of protracted consent process with authorities	Consent unlikely.	High risk of long process.	Medium consent process anticipated.	Short consent process anticipated.	No consent necessary.



QBL	Option Assessment Criteria	-10	-5	0	5	10
Effectiveness (Risk Reduction) (30)	Risk reduction	Extreme risk reduced to very high; Very High reduced to high.	Extreme risk reduced to High.	Extreme or Very High risk reduced to Moderate; High risk reduced to Moderate or low.	Extreme or Very High risk reduced to Moderate; High risk reduced to Low or negligible.	Extreme or Very High risk reduced to Low or negligible.
	Deep flooding 1 in 50 yr ARI future - current	Increase in number of properties flooding in current scenario.	No change in number of properties predicted to flood, current or future.	No change in properties flooding currently, reduction in future flooding.	Number of properties predicted to flood in future scenario same as predicted for current scenario.	Number of properties predicted to flood in future scenario less than predicted for current scenario.
	Manholes overflowing 1 in 10 yr ARI future-current	Increase in number of manholes overflowing in current scenario.	No change in number of manholes overflowing, current or future.	No change in number of manholes overflowing currently, reduction in future number of manholes overflowing.	Number of manholes overflowing in future scenario same as predicted for current scenario.	Number of manholes overflowing in future scenario less than predicted for current scenario.
	Improvement in level of service	Significant reduction in perceived level of service, increase in % customer complaints.	Perceived level of service likely to decrease, some increase in % customer complaints.	No change to perceived level of service or % customer complaints.	Minimal improvement to perceived level of service, some reduction in % customer complaints.	Significant improvement to perceived level of service, large reduction in % customer complaints.



14.2 Options Comparison

Multiple options were not developed for all issues identified as requiring 'active management', as often the assessment of a number of issues resulted in only a single management option being identified, or the need for further study.

Where multiple options are available, these options have been screened further using the hydraulic model and a qualitative assessment, to determine technical feasibility and the likelihood of meeting the targets set for this catchment. The outcomes of this preliminary evaluation are presented in Section 14.3.

Only one 'manage actively' issue has prompted an options evaluation: this is to manage deep flooding. Options developed have been designed to alleviate the deep flooding effects predicted during a 1 in 10 yr ARI rainfall event and up to a 1 in 50 yr ARI rainfall event.

Areas of predicted deep flooding (i.e. presenting risk to habitable floors) are located throughout the catchment, the majority of which are in the following three locations:

1. Rattray Street;
2. Bond Street / Water Street; and
3. Queens Gardens / High Street.

Preliminary evaluation of the options combined engineering judgement with hydraulic modelling of a number of options to assess the likely effectiveness of those options for reducing flooding. The two-dimensional component of the InfoWorks model was used to calculate 'flood volume' leaving the pipe network, or the depth of overland flow during the 1 in 10 yr ARI rainfall event. The options developed and outcomes of the preliminary evaluation are described below.

14.3.1 Preliminary Options Evaluation

The following details the options and outcomes of the preliminary evaluation. Where options have been found to be 'deal breakers' they have not been taken forward for QBL evaluation.

From the preliminary evaluation a short list of options has been identified comprising those options which are deemed to be technically feasible and likely to meet the objectives and targets set for this catchment.

Option M1: Serpentine Avenue Upgrade – Deal Breaker

This option involves the upgrade the Queens Drive / Serpentine Avenue intake structure and downstream pipes to increase the intake performance, provide greater pipe capacity and reduce overland flows to the lower catchment.

The upgrading of the inlet structure and pipe work would allow more water into the piped network upstream, potentially surcharging Rattray Street sooner. This may coincide with surcharging and overland flow from Duncan Street creating a worse effect on local flooding. This outweighs the benefits for reducing surcharge at the single Queens Drive property affected at the inlet structure.

While upgrading the screens may be desirable, as a standalone option it will not solve any deep flooding issues experienced for current or future scenarios and is therefore considered as a deal breaker for this particular issue. However, it could be considered further as part of the catchment upgrade / renewals process, to alleviate a proportion of overland flows from the upper catchment, to assist in maintaining / improving the level of service into the future. This would be dependent on the



renewals / upgrades proposed and would require further study at that time to assess any benefits in combination with planned renewals / upgrade works.

Option M2: Catchpit Capacity (Upper Catchment) – Deal Breaker

This option proposes to increase the catchpit number and capacity between Serpentine Avenue and Rattray Street to reduce the overland flow volumes to the lower catchment. Although this may alleviate the overland flows by providing more frequent discharge points into the reticulation, it will not relieve the deep flooding issues in Rattray Street which is currently predicted to experience deep floods in a 1 in 10 yr ARI rainfall event.

Option M3: On-Site Detention (Upper Catchment) – Deal Breaker

This option involves the installation of on-site detention e.g. rain tanks for all properties upstream of the Queens Drive / Serpentine Avenue intake structure in order to reduce intake structure and manhole overflows, and hence overland flows to the lower catchment.

Retrofitting residential properties, and requiring any infill development in the upper catchment to install on-site detention, could be used to maintain current levels of service for future planning scenarios across the catchment by removing peak storm flows/volumes from being conveyed downstream.

While the upper catchment modelling results do not show any capacity or flooding problems associated with the upper catchment / residential pipework, there are issues with the intake structure and pipe capacity that the upper catchment discharges into at the Queens Drive / Serpentine Avenue intersection (the upper/lower catchment interface). These capacity issues lead to overland flows down Serpentine Avenue, ultimately ponding at Rattray Street.

To relieve the downstream effects of the upper catchment discharges, a high level investigation into the volume of storage that would be required to maintain the current levels of service for future growth scenarios with respect to catchment wide flooding was carried out. The increased levels of stormwater generated by the future scenario (2060) was modelled (a 15 % increase) and applied over the upper catchment area (33 % of the total catchment area).

To maintain the current level of service in future scenarios, storage of approximately 2800 m³ of roof water, over the upper catchment, for the 1 in 50 yr ARI rainfall event would be required. In conjunction with this, a by-law would need to be written and enforced by DCC to ensure that any detention device on private property was installed, operated and maintained correctly.

Given that the upper catchment is fully developed, it is unlikely that residents will retrofit tanks large enough to provide the volume of storage required, and it could be considered that this option presents negative social consequences in the locality, when compared to the 'do nothing' option. In addition, DCC may also encounter difficulties enforcing any such by-law. This option is therefore not considered to be a viable option.

Option M4: In-line Catchment Detention (Upper Catchment) – Deal Breaker

This option proposes the provision of detention for storm flows from the upper catchment upstream of the Queens Drive / Serpentine Avenue intake structure, in order to reduce intake structure and manhole overflows, hence overland flow to lower catchment.

Constructing multiple storage tanks within the road corridor, or constructing a series of retention dams, or realigning the existing watercourses in the existing waterways within the Town Belt area, could be carried out to attenuate peak flow / volumes and maintain current levels of service for future



scenarios across the entire catchment by preventing peak storm flows/volumes from being conveyed downstream.

This option is similar to Option M3, except the detention requirements would be provided by DCC owned and maintained devices within the Town Belt area. An example approach may be to dam up the open channels and allowing the required 2800 m³ to fill up behind the dam structure. While this would be technically feasible in many areas around the country, given the hilly topography and sensitivity of the Town Belt of Dunedin, it is unlikely that a suitable detention device could be provided.

Alternatively, large underground tanks could be used within the upper catchment. However, these would need to be constructed within the road corridor, and would have associated problems such as requiring significant amounts of space which is not readily available, have issues with road grades, and on-going maintenance difficulties. Therefore as with Option M3, this not considered to be a viable option.

Option M5: Off-line Catchment Detention (Upper Catchment) – Deal Breaker

This option involves the provision of detention for overland flows, off-line, along the northern side of Serpentine Avenue, where space may be available for the detention of peak flows and hence reduce overland flow to the lower catchment.

By providing off-line detention in shallow (approximately 300 - 500 mm) bunded swales, with restricted low and unrestricted high flow controls in open areas on the northern side of Serpentine Avenue, there could be some benefit for buffering the overland flow volumes and provide sufficient detention to allow the ponding water in Rattray Street, caused by the lower catchment issues, to drain away before the upper catchment overland flows contribute to the downstream problems.

This option would use areas of open space on the northern side of Serpentine Avenue to construct short lengths (approximately 20 m) of off-line attenuation swales designed to collect and slowly release the overland flow from the existing road edge. However, as Serpentine Avenue is steeply graded (approximately 1:10) the potential for long devices is limited, thus reducing the effectiveness of this option. Suitable inlet and outlet channels e.g. concrete channels, kerb cutouts etc., will need to be provided, as will orifice and high level weir outlet controls.

There may be some additional stormwater treatment benefit provided by settlement of suspended solids within the bunded swales. However, as the bunded swales are off-line and will only be required to buffer the peak flows, the majority of the contaminants in the kerb and channel will be mobilised and transported downstream before the detention will be required.

However, given the volumes of storage required to relieve the downstream flooding (as discussed in Option M3 above) and the lack of available space in the locality, this option is not considered feasible as a stand-alone option to resolve this particular issue and therefore not considered to be a viable option.

However, there may be some merit in providing detention for a percentage of the upper catchment flows, as space would allow, to alleviate a proportion of overland flow to Rattray Street if carried out in conjunction with another option or the catchment renewals/upgrades process. This would be dependent on the renewals/upgrades proposed would require further investigation as to feasibility and benefits at that time.



Option M6: Siphon Flows from Rattray Street to Bubble up at Queens Gardens – Deal Breaker

This option involves the installation of a pipe (bifurcation or separate pipe), to take flows from the low point in Rattray Street and bubble up near Queens Gardens. This will alleviate the deep flooding in Rattray Street.

This option would provide relief to the deep flooding problems in Rattray Street, which are most severe at the low point of the road. The flows would be collected and discharged on the eastern side of Princes Street by the Queens Gardens.

The basic principle is to “move” the ponded water in the low point of Rattray Street to the Queens Gardens area. By constructing a siphon using catchpits at the up and downstream extents, and the hydraulic head available between the entry and discharge points, the flood water can be moved from one section of the lower catchment to another.

Modelling of this option demonstrates that there will be an overall reduction to flood area in the catchment, in the current 1 in 10 yr ARI rainfall event, of 4.4 %, and an associated reduction of habitable floor flooding of 8 parcels in the 1 in 50 yr ARI event.

Although this provides an engineering solution that may be suitable to solve this particular issue, by resolving deep flooding issues in the locality and reduce the overall number of parcels at risk from deep flooding catchment wide, it also increases nuisance flooding volumes in an area already experiencing a minor flood issue, thus reducing the level of service in the location of Queens Gardens. The overall perception in the lower catchment is likely to improve as the flooding in Rattray Street will be reduced/removed, and the increased flooding around the Queens Gardens would be difficult to quantify by the general public, due to the large area already inundated and the relatively small increase in depth proposed. However, this option is considered unacceptable as it would be contrary to DCC stormwater Strategic Objectives and the catchment specific management approach highlighted in Section 11. This option is therefore not considered a viable option.

Option M7: Lower the Road Corridor Levels of Princes Street – Deal Breaker

This option proposes to lower the road corridor levels of Princes Street to allow overland flow from Rattray Street to Queens Gardens, in order to alleviate the deep flooding in Rattray Street.

One of the contributing factors to the deep flooding associated with Rattray Street is the interruption to the overland flow path from the upper catchment down Serpentine Avenue/Rattray Street to the harbour due to the elevated level of Princes Street. Therefore by lowering the intersection of Princes Street/Rattray Street, theoretically, the flood waters will be able to flow overland to the harbour. Alteration of the existing road levels on Princes Street would minimise the current level of ponding in Rattray Street by providing a secondary flow path towards the harbour. This however, assumes that there aren't any further impediments to the overland flow paths downstream.

While this option is technically feasible, there are a multitude of associated issues such as deepening underground services, matching adjacent property entrance levels, creating an acceptable vertical curve along Princes Street, and potential for creating new ponding areas downstream, upstream of the railway “ridge”. In addition, this option would involve significant capital works, and whilst reducing the deep flooding in the vicinity of Rattray Street, it would not resolve flooding issues, rather create overland flow and potential for pockets of deep flooding elsewhere. This would not maintain or improve the existing level of service in the catchment and could be considered to be contrary to the catchment specific targets and approaches in Section 11, notably those relating to nuisance and deep flooding. This option is therefore not considered to be a viable option.



Option M8: Increase Inlet Capacity on Rattray Street – Deal Breaker

This option involves the installation of additional catchpits (double chamber) with oversized leads in the low point of Rattray Street, to provide increased capture of overland flows (minimising surface flooding) and drain the area more quickly following the storm peaks and surcharging of the main stormwater line.

Although this option may remove some of the overland flow by providing more frequent discharge points into the reticulation, it will not relieve the deep flooding issues in Rattray Street predicted during a 1 in 10 yr ARI event and greater. For this reason it is not considered a viable option for this issue.

However, there may be some benefit in considering this option further as part of the catchment upgrade / renewals process or in combination with another option, to assist in alleviating some ponding in the locality. This would be dependent on the works proposed and would require further investigation as to feasibility and benefits at that time, but it may assist in maintaining/improving the level of service into the future.

Option M9: Fill Dip in Rattray Street – Deal Breaker

This option involves alteration of the vertical profile of Rattray Street up to Princes Street to allow overland flow to Queens Gardens to reduce flooding on Rattray Street.

Any alteration to the road will cause issues with the existing building entrance levels e.g. may cause runoff to enter the buildings lower levels, impede access to ground floor levels, and / or affect existing services. This is not considered to be a viable option.

Option M10: System Upgrade with New Outfall - Shortlist

The installation of a new pipe from Princes Street down lower Rattray Street past the south side of Queens Gardens to the nearest part of the harbour (Steamer Basin), could relieve the surcharged main line, reduce ponding water in Bond Street and provide capacity for the overland flow and ponding in Rattray Street.

This option involves the construction of a new pipeline with a new harbour outfall, and the construction of a weir chamber on the existing main stormwater line. The pipeline would be aligned along Queens Gardens, pass under the railway lines, Wharf Street and pass thorough the harbour land and discharge into the Steamer Basin. This would remove the sub-catchment around Bond / Waters Street from the main stormwater line. A weir chamber on the existing main stormwater line would allow some of the surcharged water to spill into the new pipeline, providing some relief.

The pipeline for this option has been modelled as a 1350 mm diameter pipe (approximately 400 m long) and demonstrates that for the 1 in 10 yr ARI event, the levels of surcharge in the main stormwater line are below ground level, and that the amount of local flooding in all areas, including the Queens Gardens is reduced.

In addition to this form of an option, there could be variations also investigated such as the duplication or upgrade of the existing main stormwater line to the Mason Street catchment. These variations to the option may have the benefit of not needing the construction and consenting of a new harbour outfall, but would likely be much more costly to construct. These various options could be investigated further at an option feasibility phase. In addition, some of the options described above, which do not provide a stand-alone solution for the deep flooding issue, may be considered as part of this proposal to alleviate catchment issues.



Option M11: Fill dip in Bond Street – Deal Breaker

This option proposes to fill the dip in the road in Bond Street to reduce ponding at the low point.

Any alteration to the road will cause issues with the existing building entrance levels e.g. may cause runoff to enter the buildings lower levels, impede access to ground floor level and / or affect existing services. This is therefore not considered to be a viable option.

Option M12: Raise Levels of Flood Prone Buildings – Deal Breaker

This option involves the elevation of the flood prone buildings. The buildings experiencing deep flooding problems are predominantly unreinforced, brick / masonry buildings with basement levels within the Bond Street / Water Street area. Raising the floor levels would be impractical, technically difficult and likely to be cost prohibitive.

14.3.2 Options Shortlist Evaluation

Following the preliminary evaluation, only a single option was considered viable (shortlisted) as a stand-alone option to resolve the deep flooding issues in this catchment. As such no QBL assessment was carried out as there were no alternative options to compare.

The option shortlisted was Option M10 which proposes a stormwater system upgrade (including new harbour outfall) to alleviate the deep flooding issues.

Comparison of all the recommendations for this catchment, alongside other catchments, will be undertaken as part of the 3 Waters Strategic Plan.



15 Option Selection

15.1 Approaches for Active Management

The issues that have been prioritised in the Mason Street catchment as requiring 'active management' are identified below.

1. Deep Flooding – Current and Future
2. Flood Hazard – Current and Future (1 in 100 yr ARI);
3. Limited Confidence in Knowledge of Effects on the Otago Harbour Environment; and
4. High Variability of Stormwater Quality Results.

The majority of the management options for issues requiring 'active management' did not have any feasible alternatives and therefore all options presented have been recommended. However, a number of different options were considered relating to the 'deep flooding' issue.

Two catchment-wide management options are presented for this issue, they are not presented as alternatives, but rather to be considered to assist with both the renewals programme and further design and development of capital works within the catchment to maximise the potential to alleviate flooding issues and generally improve the level of service within the catchment.

- Improve quality of stormwater network data.
- Include additional or improved catchpits in any capital works.

In addition to the catchment-wide management options, a number of alternative management options were evaluated. However, preliminary evaluation highlighted a single infrastructure option which was considered viable to resolve the deep flooding issue.

The option highlighted as feasible for the active management of stormwater quantity (deep flooding) issues in the Mason Street catchment is as follows:

- Option M10: System Upgrade with New Outfall

Option M10 was evaluated as the only solution that will provide a reduction in the levels of flooding across all of the lower catchment areas within the one option. This is a flexible option in that there are possible variations to the works that could be considered, as well as carrying out this option in conjunction with the catchment renewals / upgrade process and elements of other options that were not suitable for solving the deep flooding issue as stand-alone options. However, it would be a costly option to implement.

It is recommended that the potential variations to this option, including the combination with other options, be investigated further at an option feasibility phase. This could be considered once the data from the current CCTV inspections programme, level survey and GIS confirmation inspections have been collected. This would:

- Allow the existing model to be expanded and the network performance to be assessed with greater confidence;
- Provide a renewals / upgrade programme based on age and condition; and
- Provide the optimal solution to resolve the deep flooding issue within the catchment.



By focusing on further detailed investigation rather than simply considering the single proposed capital works, DCC would be able to optimise capital works within the catchment and take into account the catchment renewal / upgrades as part of the solution. Thus providing the most robust long-term solution for managing current and future catchment flooding.

For other issues that have been prioritised as requiring 'active management', a comparison of alternative options was not undertaken, as they either involved non-infrastructure options or did not have any feasible alternatives. The following options are recommended in order to manage those issues:

- Development of a Climate Change Adaptation Plan (city-wide)
- Development of an Emergency Response Plan for Mason Street catchment
- Redesign the current monitoring framework for stormwater quality and harbour environment monitoring.

The improved data confidence will allow the prioritisation of stormwater management recommendations based on the significance of stormwater quality issues. This would occur city-wide and form part of the 3 Waters Strategic Plan.

15.2 Approaches for Passive Management

A number of other issues that have been prioritised as requiring 'passive' management will have targets achieved through measures already in place, or via the options identified for other issues in the catchment. The following options have also been identified to aid management of some of these issues:

- Utilise stormwater complaints information to continuously gauge customer satisfaction with the stormwater service;
- Ensure planned renewals are designed to accommodate a 1 in 10 yr ARI rainfall event, and incorporate allowances for climate change effects;
- Undertake a review of schedules and methods used across the city to maintain stormwater intake structures (catchpits and inlets);
- Incorporate inlet screens on Serpentine Avenue and Canongate Road into a priority list for more regular catchpit inspection and cleaning;
- An amendment to the business processes used to manage subdivision and development to direct stormwater treatment based on catchment specific requirements;
- Enforcement of the Trade Waste Bylaw with respect to stormwater management; and
- Investigate and potentially expand current education programmes in relation to site management of industrial premises.

The following options are also highlighted as being acceptable options for pursuit in terms of stormwater quality management:

- Amendment of Code of Subdivision and Development to refer to ICMP and targets with respect to ensuring future development incorporates suitable stormwater quality treatment; and



- Improve data relating to microbial contamination within the stormwater and potential sources of contamination within the catchment.

It is also anticipated that future confirmation of water quality targets will lead to the development of options for specific contaminants of concern, where mitigation of adverse effects is required.

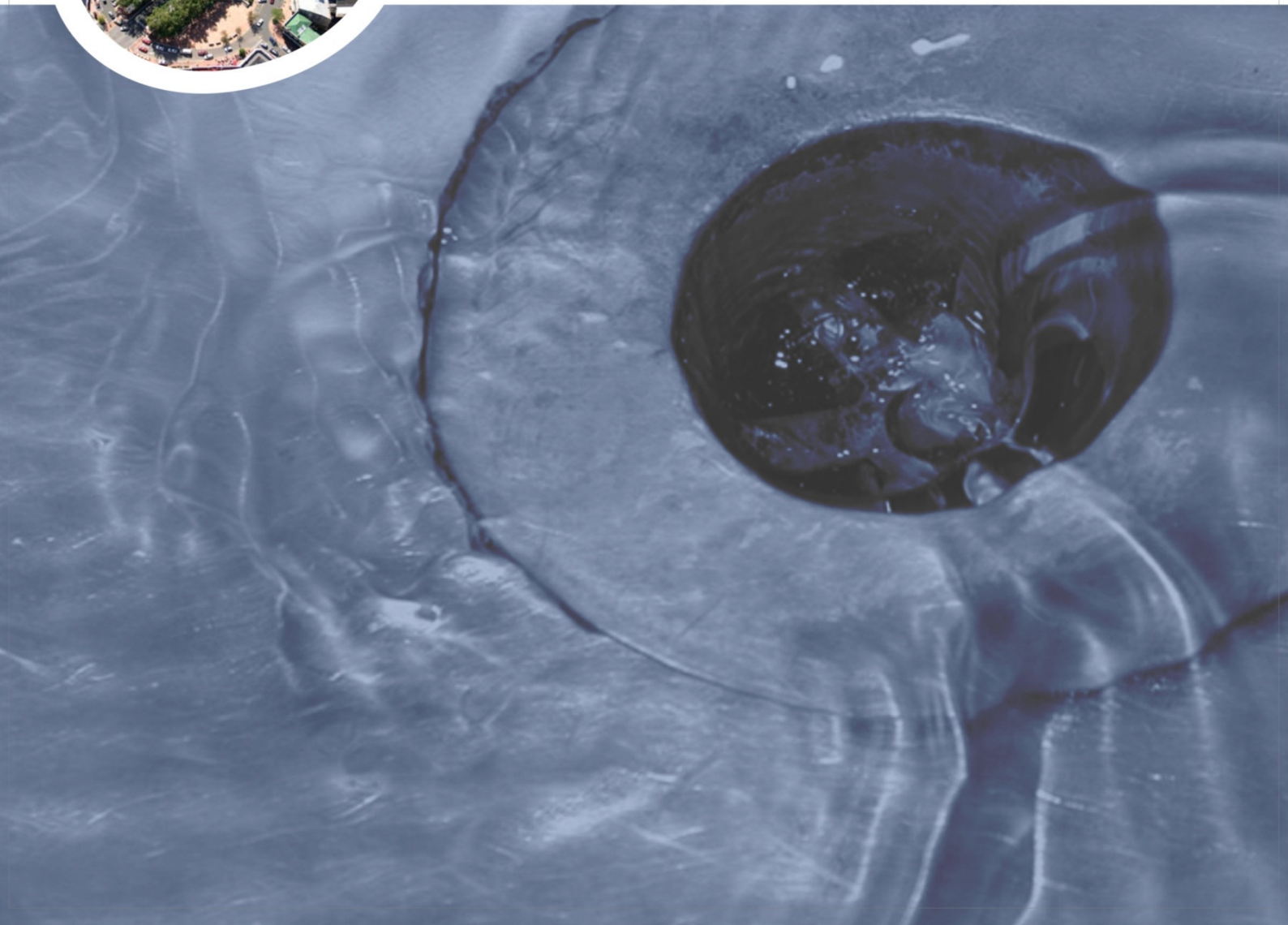
A number of other issues that have been prioritised as requiring 'passive' management will have targets achieved through measures already in place, or via the options identified for other issues in the catchment. The following options have also been identified to aid management of some of these issues:

- Network maintenance review – ensure that the network is being operated as best it can, due to low level of service and potential for poor maintenance to exacerbate issues.
- Ongoing harbour sediment monitoring to establish effectiveness of monitored natural recovery.
- Checks of industry in the area to minimise contaminant discharge from high risk land uses.



Part 6

Way Forward





16 Recommendations

The following tables provide a list of recommendations relating to stormwater management in the Mason Street catchment and provide an indicative cost and work period for each recommendation. The recommendations are listed in order of priority, relating predominantly to issue prioritisation. The intention is that as each task is carried out, the influence on catchment management targets is assessed, and further tasks are undertaken as necessary to achieve targets. Where a cost of \$ 0 has been applied, it is intended that DCC staff undertake the work. The recommendations will have their delivery dates set by the 3 Waters Strategic Plan, yet to be developed. Refer to the following Section regarding implementation of the Plan.

Recommendations are split into further studies, planning and education, operation and maintenance, and capital works tasks. Further studies recommended will assist in improving certainty around catchment management targets, or where further information is required in order to develop options.

Table 16-1: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	\$ 20 k	3 - 6 months
50	Undertake further stormwater monitoring to investigate the extent of potential wastewater contamination and likely sources within the catchment.	\$ 20 k	6 - 8 months
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	\$ 0	Ongoing
80	Improve quality of stormwater network data (through level survey, GIS confirmation, CCTV).	\$ 0	Ongoing
80	Undertake feasibility study to optimise capital works and enable design of the most robust, long term solution for resolving catchment flooding.	\$ 100 – \$ 150 k	tba
80	Identify and undertake floor level survey and damage assessment of properties potentially internally affected by deep flooding (up to a 1 in 50 yr ARI).	\$ 20 k	3 - 6 months


Table 16-2: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
70	Develop a city-wide climate change adaptation plan, including ongoing monitoring of climate change predictions, incorporating damage assessment of the vulnerable infrastructure.	\$ 0	6 - 12 months
70	Develop an emergency response plan for the catchment to ensure evacuation from flooded areas is possible during a large storm event.	\$ 0	6 - 12 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	\$ 0	2 months
40	Work with ORC to develop a plan for education programmes in relation to best practice site management of industrial premises.	\$ 20 k	6 months

Table 16-3: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Implement the revised city-wide monitoring framework.	\$ 25 k	Annual
50	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance. Include the Queens Drive / Serpentine Avenue and Canongate intake screens.	\$ 5 k	2 months
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	\$ 20 k	2 months

Table 16-4: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
80	Include additional or improved catchpits in all stormwater capital works.	tba	Ongoing



17 Implementation, Monitoring and Continuous Improvement of the ICMP

17.1 Implementation

As detailed in Section 1 of this report, there are a number of DCC documents linked to the outcomes of this ICMP. These include the Code of Subdivision and Development, the District Plan, and the 3 Waters Strategic Plan. A number of other documents are consequently also influenced by this document.

The DCC 3 Waters Strategic Plan pulls together the recommendations from all ICMPs, as well as other 3 Waters work prepared by DCC. Currently, 10 ICMPs are under development, and the recommended options presented by each ICMP will need to be managed in a coordinated manner. Targets set within each ICMP, and issue prioritisation will be used to determine the programme for commitment of staff resources, and both operational and capital funds for recommended works across the city over the coming years.

17.2 Monitoring and Continuous improvement

The continuous monitoring and reporting with respect to the SMART targets developed for each of the critical stormwater issues ensures that the success of this ICMP will be measurable.

Recommendations presented in Section 16 above have been prioritised, and provide the opportunity for DCC to progressively work towards these targets. It also ensures that when targets have been reached, DCC can re-evaluate recommended works appropriately.

The revision of the ICMP will be required at a number of milestones, and may either be minor updates or major changes as follows:

1. When the revised stormwater and harbour environment monitoring programme has been implemented and information collated and assessed to confirm any key stormwater quality issues requiring management;
2. Due to changes in climate change predictions; and
3. As monitoring data is collected and reviewed for trends. The monitoring framework developed for assessing the effects of stormwater discharges on the harbour environment will need to be refined as more information is learnt about the effects on the harbour, and key areas of concern.



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