# Dunedin 3 Waters Strategy

## Shore Street
## Integrated Catchment
## Management Plan

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DUNEDIN CITY COUNCIL

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# Shore Street Integrated Catchment Management Plan 2010-2060

## Contract No. 3206
## Dunedin 3 Waters Strategy

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# Table of Contents

## List of Appendices

## List of Figures

## List of Tables

# Executive Summary

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

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 receiving environment. These short term consents will be replaced with long term (35 year) consents following the completion of ICMPs.

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 Shore Street catchment is moderately hilly, and covers an area of approximately 100 ha. The catchment extends from the suburb of Andersons Bay towards South Dunedin and includes parts of the suburbs of Tainui, Andersons Bay, and Musselburgh.

The catchment is characterised by steep gullies at the head of the catchment in the east and the Musselburgh Rise in the west of the catchment. The head of the catchment has an elevation of approximately 86 m above mean sea level, and approximately 70 % of the catchment is located on hillside. The topography becomes flatter with low lying areas towards the harbour in the northwest.

Land use within the catchment is and has always been predominantly residential (zoned Residential 1) with a small area of commercial land use. A large area of land was reclaimed near Andersons Bay in the 1950s, and some of this reclaimed land was used to provide grounds for Bayfield High School. The materials used during the reclamation of this area are unconfirmed.

The imperviousness study calculated that Residential 1 zones typically have a total imperviousness of approximately 39 %, of which about 23 % was estimated to be houses and driveways (with the remainder representing areas such as unconnected paving etc.). The Shore 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.

The stormwater network in the Shore Street catchment has two main branches, based on historic stream gullies formed in the catchment. One runs along Tainui Road, picking up flow from the Musselburgh Rise area, with the second following Bayfield Road draining the balance of the catchment. These branches meet at Shore Street, continuing several hundred metres towards a harbour outfall into Andersons Bay. The network is predominantly piped, but includes several lengths of open channel in the upper reaches of the Tainui Road branch, and also several private drainage discharges to roads.

The majority of the pipework in the Shore Street catchment was laid in the early to mid-1900s. Based on the current forecasts of theoretical asset life for stormwater mains, the majority of which have been assigned a theoretical life of 100 years, 66 % of the pipe network will be subject to inspection/condition assessment or be renewed by 2060. There are a small number of 'wellbeing' locations identified in the Shore Street catchment, however all pipes in the DCC stormwater network within the Shore Street catchment are assigned a pipe criticality of 1, indicating a low criticality.

No information on groundwater quality or levels is available, due to a lack of monitoring sites.

There are approximately 13 km of water supply pipes within the Shore Street catchment, most of which are less than 200 mm in diameter. The majority of the supply pipes in this catchment are constructed from ageing cast iron, and a number of renewals are likely to be required in the area over the next few years.

The wastewater system within the Shore Street catchment comprises approximately 13 km of pipeline, approximately 90 % of which are between 150 mm and 300 mm in diameter. Flow data indicates inflow and infiltration (I&I) issues within the wastewater system of this catchment. The suburbs of Sunshine and Musselburgh appear to be the largest contributors of I&I. Flow survey data has also indicated tidal influence and potential saline intrusion in the trunk main upstream of the pumping station at Marne Street. Although this pumping station and its influences are outside of the Shore Street catchment boundary, when there are increased flows within the wastewater system of the pump station's catchment, primarily during rainfall events, a pressure operated relief valve in Marne Street diverts wastewater flows to the Marne Street pumping station which then discharges directly to Anderson's Bay. At the time of writing this report, solutions to reduce the use of the Marne Street pumping station are being investigated.

A linked 1 and 2-dimensional hydrological and hydraulic model of the Shore Street catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different land use, climate change and rainfall event scenarios. Confidence in the model output is considered to be moderate. The model output is not absolute, however it is an adequate tool for the purposes of indicating areas with a potential to flood, and allowing the comparative effects of the different rainstorms and climate change to be assessed.

An assessment of environmental effects, 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 complaints records; and information gathered during workshops with DCC Network Management and Maintenance staff, identified a number of stormwater related issues in the Shore Street catchment.

Currently, much of the stormwater network in the catchment provides has sufficient capacity to accept a 1 in 10 yr Average Recurrence Interval (ARI) rainfall event without overflowing. There are some sections of the network, however that have a lower capacity, and cause nuisance and pockets of deep flooding in localised areas of the catchment during some events. Flood waters are also predicted to enter the South Dunedin catchment from two locations in the Shore Street catchment.

Key areas of issue are in the lower, flatter parts of the catchment, where tidal influence on the network has a significant effect on pipe capacity, and in the upper reaches of the Tahuna Road watercourse, where blocked intake structures are reported to exacerbate flooding predicted due to bottlenecks in the network. Flooding in these areas has been confirmed to some extent by customer complaints and / or DCC Network Management and Maintenance staff.

Stormwater quality information collected from the catchment outfall over the past 4 years indicates that the stormwater discharge is typical of an urban residential catchment. Elevated concentrations of some contaminants (lead, zinc, and polycyclic aromatic hydrocarbons (PAHs)) have been recorded in the sediments in the Andersons Bay Inlet. There are a number of alternative sources, along with stormwater discharge, that could have contributed to this contamination. A single stream in the catchment was assessed, and the assessment indicated that the stream had poor habitat quality, resulting in poor ecology. Because the inputs to the stream are almost entirely from stormwater, the habitat and ecology were as would be expected from a modified urban stream.

Stormwater issues were prioritised, and management targets and catchment specific approaches were developed for the Shore 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 Shore 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.

Tables ES-2 to ES-4 below outline the recommendations, split into further studies, planning and education, and operation and maintenance 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: Shore Street Issues, Approach and Targets Summary**

| Issue (Problem Description) | Effects Summary | Strategic Objectives and Targets | Catchment Specific Approach | SMART Targets |
|---|---|---|---|---|
| Blocking / Maintenance of Intake Structures | A number of catchpits and intake structures in the Chisholm Place and Tahuna Road area are prone to blockage, resulting in small areas of deep flooding in these areas. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Actively***<br>Undertake an inspection of all open channel sections, to record status of intake structures.<br>Ensure damaged screens are replaced / fixed.<br>Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.<br>Work with property owners to ensure screens and intakes 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.<br>Develop list of key intake structures in Shore Street catchment requiring additional cleaning and maintenance checks by 2013.<br>Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013.<br>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 |
|---|---|---|---|---|
| Potential Wastewater Contamination | Known emergency discharge into the Andersons Bay Inlet from Marne Street pumping station.<br>Suspected overflow in Tainui Street area, although no evidence in stormwater sampling to date. | Improve the quality of stormwater discharges to minimise the impact on the environment.<br>Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.<br>> 75 % compliance with stormwater discharge consents.<br>Ensure stormwater discharge quality does not deteriorate. | ***Manage Actively***<br>Use improved monitoring programme to enable better understanding of potential catchment contamination. | No discharges from the Marne Street pumping station during 1 in 10 yr ARI rainfall event or less.<br>Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012.<br>Implement management options to remediate problem where necessary. |

| 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, however results to date indicate moderately low contaminant concentrations in stormwater discharge.<br>Poor information on actual effects of stormwater on harbour environment.<br>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.<br>Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.<br>No recorded breaches of the Resource Management Act.<br>Ensure stormwater discharge quality does not deteriorate. | ***Manage Actively***<br>Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework.<br>Develop method for determining linkages between stormwater management and harbour environment.<br>Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable.<br>Require source control of stormwater contaminants in new development of high-contaminant generating land uses.<br>Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.<br>Undertake monitoring to ensure stormwater quality does not deteriorate over time.<br>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.<br>Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013.<br>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 |
|---|---|---|---|---|
| Network Maintenance | Flooding extents and durations in the Shore Street catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen cleaning and maintenance.<br>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.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Ensure consistency city-wide of stormwater structure cleaning and maintenance.<br>Ensure cleaning and maintenance schedules and contracts are sufficiently robust.<br>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.<br>Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013.<br>Develop list of key stormwater assets in Shore Street catchment requiring additional cleaning and maintenance checks by 2013. |
| Tidal Influence on Network | Tidal influence on the network results in reduced capacity in lower network.<br>May be exacerbating nuisance flooding issues in some locations.<br>Will be affected by climate change, resulting in increased extent of flooding in lower catchment. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Develop a better understanding of the likely effects and magnitude of climate change. | > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.<br>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 |
|---|---|---|---|---|
| Nuisance Flooding | Nuisance flooding is predicted and confirmed in two areas in the catchment – in the vicinity of Lochend Street in the lower catchment, and from Tainui Road, causing flooding into the South Dunedin catchment.<br>Flooding is affected by tidal influence, and may be causing an issue on private properties. The resolution of the ground model, however, means that the exact location of the flooding is not confirmed. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Monitor customer complaints and / or undertake site visits to confirm locations of flooding. | > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. |
| Flood Hazard –<br>Current and Future 1 in 100 yr ARI | Flood hazard issues in this catchment are considered to be fairly minor, with hazard being identified in areas predicted to have deep flooding during a number of events. The majority of these locations are near or within watercourses in the upper catchment.<br>Transport routes are not predicted to be severely affected – inundation across roads is predicted to be shallow.<br>Small parts of lower catchment at risk of direct tidal inundation. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. | ***Manage Passively***<br>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.<br>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.<br>Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances). | 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 |
|---|---|---|---|---|
| Ongoing Stormwater Discharge | Could exacerbate historical contaminant issues in the harbour. Extent to which this is likely to occur is unconfirmed.<br>Key stakeholder issue.<br>Based on available data, consequence currently believed to be minor. | Improve the quality of stormwater discharges to minimise the impact on the environment.<br>Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.<br>> 75 % compliance with stormwater discharge consents.<br>Ensure stormwater discharge quality does not deteriorate. | ***Manage Passively***<br>Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable.<br>Require source control of stormwater contaminants in new development of high-contaminant generating land uses.<br>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.<br>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 |
|---|---|---|---|---|
| Low Level of Service | 15 % of network manholes overflow during a 1 in 5 yr ARI rainfall event.<br>Low level of service in some locations contributing to nuisance (and deep) flooding. | Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.<br>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.<br>95 % of customer emergency response times met.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Use customer complaints and residents' opinion survey (ROS) to gauge satisfaction with the stormwater system performance. | > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.<br>> 60 % residents' satisfaction with the stormwater collection service (ongoing). |

| Issue (Problem Description) | Effects Summary | Strategic Objectives and Targets | Catchment Specific Approach | SMART Targets |
|---|---|---|---|---|
| Deep Flooding | Model results indicate 21 parcels affected by deep flooding during 1 in 10 yr ARI rainfall event; rises to 40 during 1 in 50 yr ARI rainfall event in current, and 43 land parcels in future planning scenarios.<br>Deep flooding is in small 'pockets', and likely to be mostly exterior to buildings (however 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.<br>Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. | ***Manage Passively***<br>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.<br>Enhance understanding of effects of deep flooding, particularly on private property.<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised). | < 40 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event.<br>Undertake habitable floor survey and / or damage assessment of potentially flooded properties.<br>> 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. |
| Overland Flow into the South Dunedin Catchment | Overland flow is predicted to move into the South Dunedin catchment area ('the Flat') from the Shore Street catchment from the Tainui Road area during small events, and from the Lochend Street area during large rainfall events. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Investigate effects on the South Dunedin catchment, and re-prioritise issue if significant. | Assess the effects of overland flooding from Shore Street catchment on South Dunedin catchment.<br>> 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. |

**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 |
| 160 | Undertake comprehensive watercourse inspections. | $ 40 k | 3 - 6 months |
| 30 | 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 |
| 30 | Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service. | $ 0 | Ongoing |

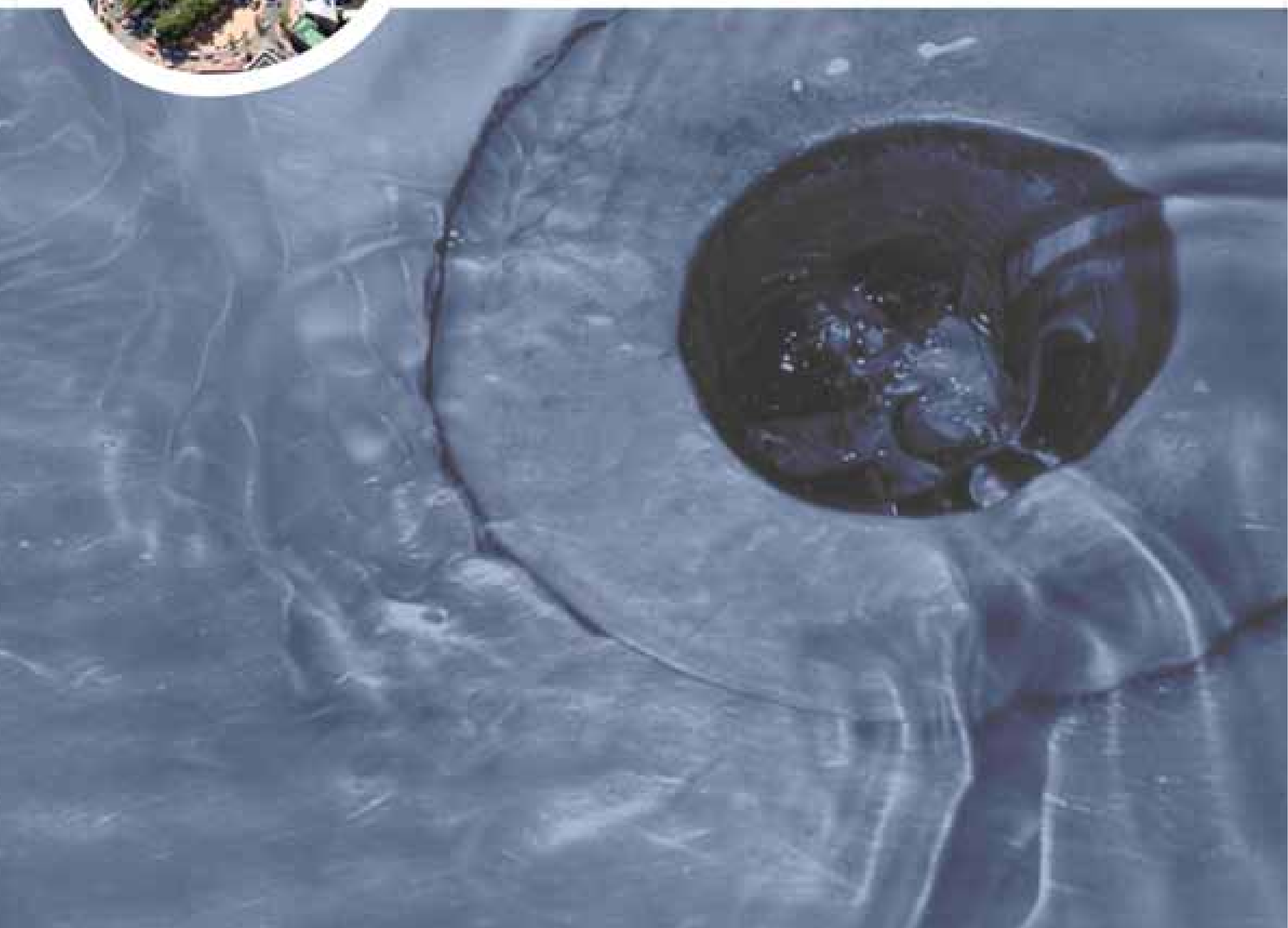
**Table ES 3: Planning and Education Recommendations**

| Risk Matrix Score | Task | Budget Cost | Work Period |
|---|---|---|---|
| 160 | Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided. | $ 0 | 3 - 6 months |
| 40 | Contribute information to a city-wide climate change adaptation plan. | $ 0 | 6 - 12 months |
| 40 | Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP. | $ 0 | 2 months |
| 30 | Review flood hazard in South Dunedin catchment, incorporating effects from the Shore Street catchment. | $ 10 - $ 20 k | 2 months |

**Table ES 4: Operation and Maintenance Recommendations**

| Risk Matrix Score | Task | Budget Cost | Work Period |
|---|---|---|---|
| 160 | Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired. | tba | Ongoing |
| 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. | $ 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 |

# 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 Shore Street Integrated Catchment Management Plan 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 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 consent granted for the Shore Street catchment (via the Shore Street outfall). This consent (Consent No. 2002.080), granted in November 2007, is for a period of five years. Condition 8 of the consent states:

> *"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 Shore Street 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 nine largest stormwater catchments was undertaken, and identified the South Dunedin catchment as the highest priority catchment in terms of stormwater issues (refer to the *'Dunedin 3 Waters Strategy, Stormwater Catchment Prioritisation Framework'*; URS, April 2008). Following the development of an ICMP for the South Dunedin catchment, 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 branch representatives 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 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, July 2009).

The Shore Street stormwater catchment ranked 5$^{th}$ out of 9 by this prioritisation, indicating that there is a moderate level of issues in the catchment. The highest scoring issue for this catchment was the sensitivity of the receiving environment – the Andersons Bay Inlet was considered to be more sensitive to stormwater inputs than the Upper Otago Harbour in general. This will be explored in more detail in the assessment of environmental effects (AEE) section of this report.

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 | Portsmouth Drive | Ravensbourne Road | St Clair |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Economic | 1A | Annual OPEX | 35 | 100 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Social | 2A | Community Pressures | - | - | - | - | - | - | - | - | - | - | - |
| Cultural | 3A | Iwi (Käi 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** | **1.77** | **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.

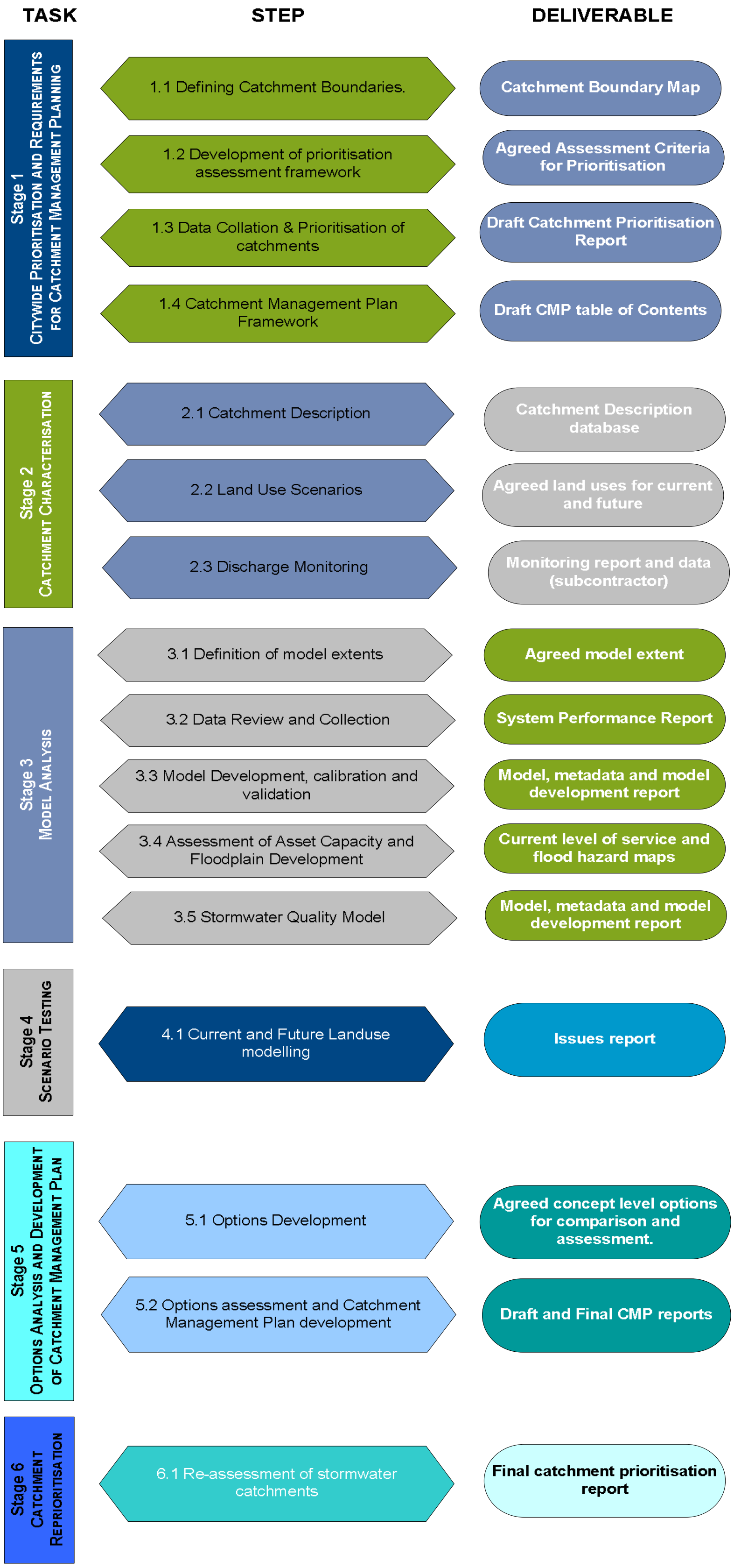



**Figure 1-1: Scope of Work**

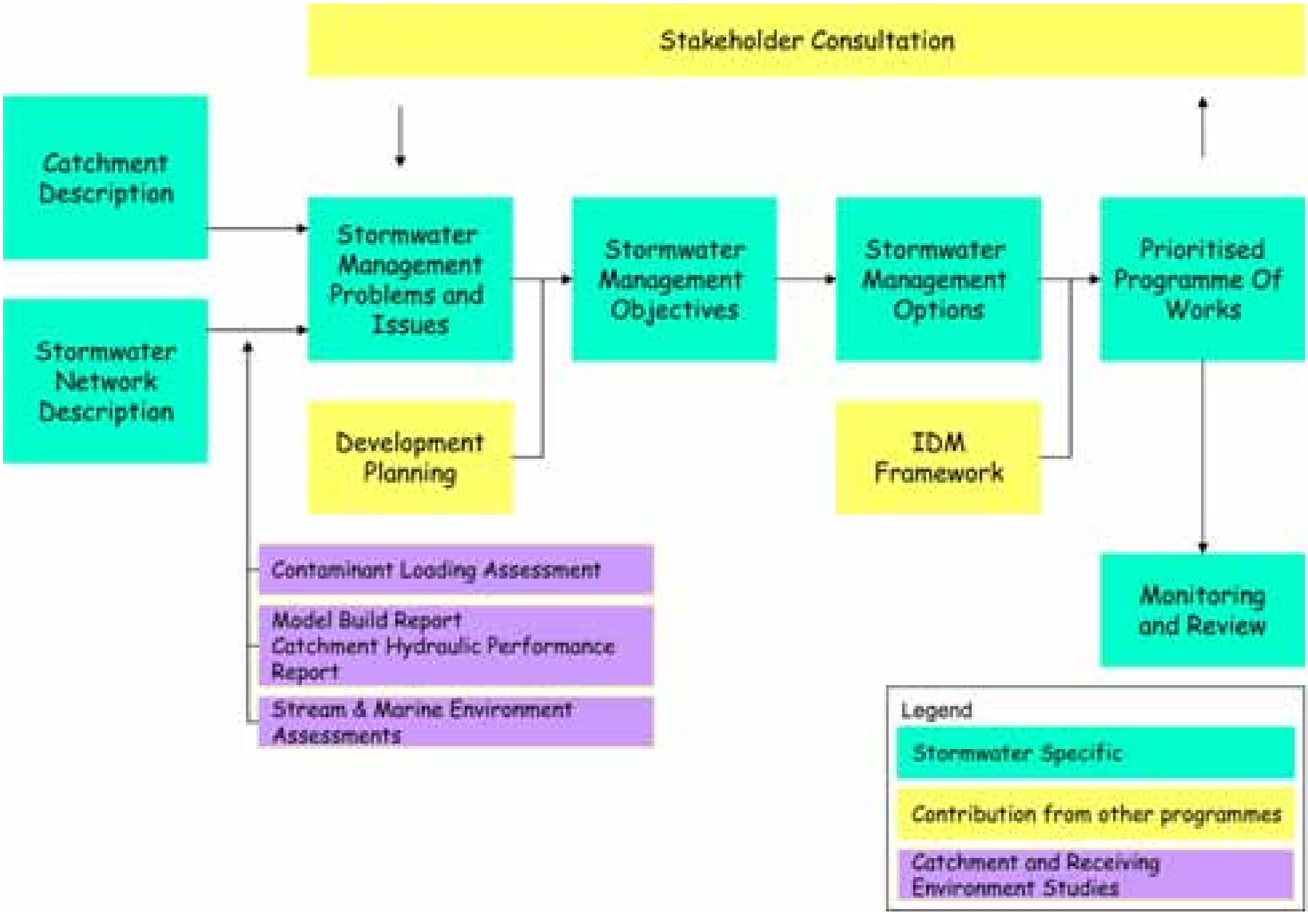



**Figure 1-2: ICMP Development Process**

# 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 central, regional and District Planning documents and key non-statutory strategic documents. Figure 2-1 below provides the hierarchies of legislative and planning documents, both statutory and non-statutory which interact with the 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 current statutory and non-statutory documents relating to stormwater management and the development of an ICMP are discussed in Sections 2.2 to 2.7. It is important to note that these documents are subject to review and change. Therefore, the ICMP needs to be sufficiently flexible to endure variations to these documents while remaining relevant. In some cases the ICMP may provide direction to these variations.

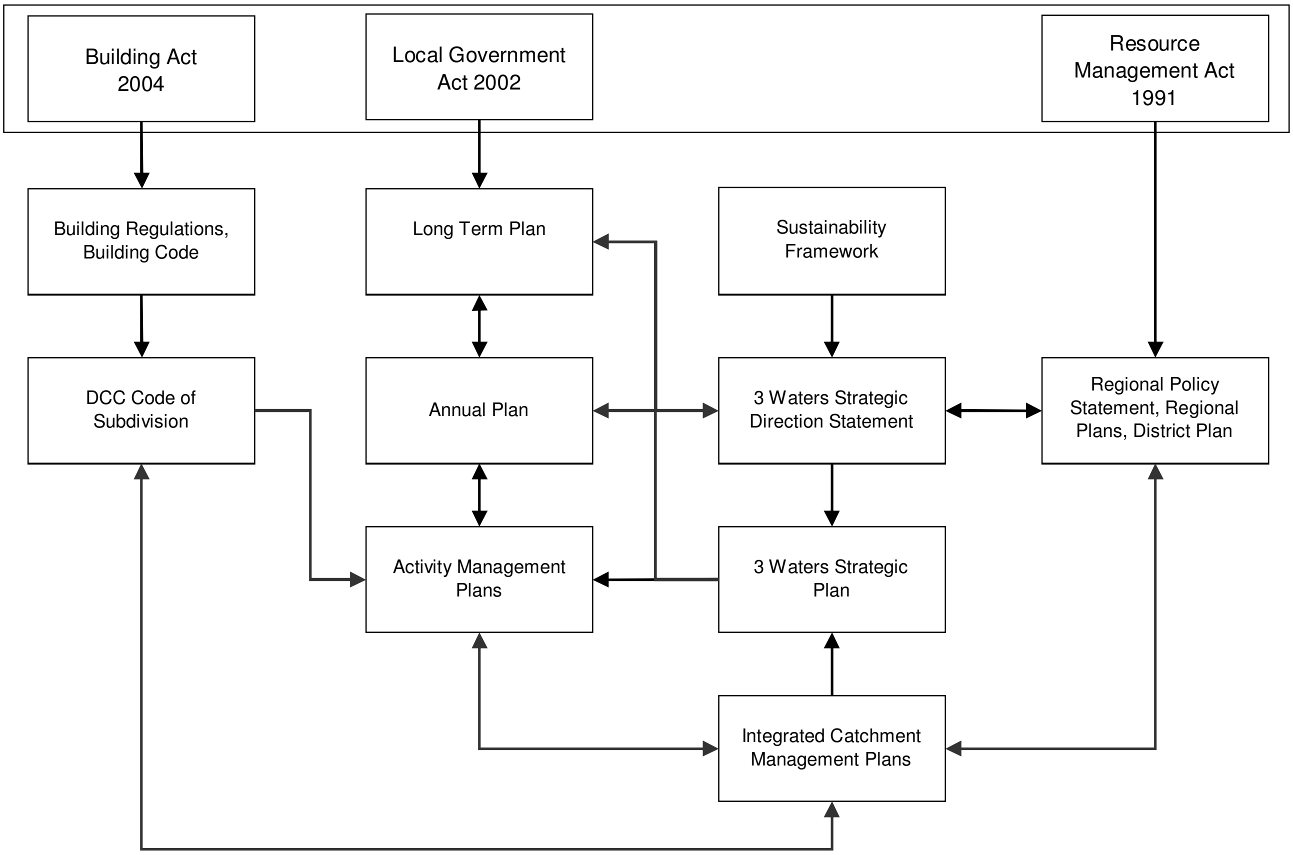



**Figure 2-1: Legislative and Planning Document Hierarchies**

## 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.

These are discussed below.

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; to 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 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; and
- 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; and

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 that 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 Shore Street catchment discharges into the Andersons Bay Inlet, part of 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 Shore 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, 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 and 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. These overarching policies may play a significant role in providing direction for the ICMP if natural hazards (such as flooding) 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 had 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 Käi 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 Käi Tahu will be treated as an affected party. Details relating to issues of particular significance are contained within the Käi 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 Shore 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 Coastal Plan 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 land use zoning as a method of regulating activities under DCC jurisdiction. These land uses will play an integral part in determining the quantity and quality of any stormwater runoff. Land Use zones in the Shore Street catchment consist predominantly of Residential 1, with small areas of Residential 2 and Local Activity 1 land use. Local Activity 1 zone is characterised by site coverage of 70 % or less, and a wide range of activities from residential to large scale retail activities are permitted. No industrial or trade activities are permitted to be undertaken in these residential or local activity zones.

Careful consideration will need to be given to these land use zones and any potential changes to the zones when looking at management options under the ICMP, as different land uses produce different stormwater quantities and quality outputs. 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 Shore 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 Käi Tahu ki Otago Natural Resource Management Plan

Käi Tahu ki Otago Natural Resource Management Plan (Käi Tahu Plan) provides a background to Käi Tahu's resource management issues in the Otago Region. The Käi Tahu Plan contains management guidelines and objectives relating to freshwater fisheries and coastal resources. Käi Tahu are particularly concerned with the destruction 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 Käi Tahu where they are not addressed by the regional or district statutory planning documents, and should ensure that Käi 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 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 in 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 the 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 (AMPs) 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 that 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 the policies and objectives of the Dunedin City District Plan as described in Section 2.3.7, by incorporating further investigations of the system and environment and monitoring any discharges that are occurring.

Most consent requirements will be addressed by the Water Plan and the Coastal Plan. The Dunedin City District Plan however, contains methods for 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 Coastal Plan 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 Shore Street catchment is unlikely to comply with the conditions of the rule due to the likelihood of contaminants having some effect on the receiving environment. 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 align as closely as possible with 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 Water Plan 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 that: the discharge does not contain any human sewage; 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.

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, floatable or suspended materials or objectionable odours.

If the conditions outlined in Rule 12.5.1 cannot be satisfied, then the discharge of drainage water 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 overleaf 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 hope 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 hoped 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 rainfall 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: Käi Tahu ki Otago Limited (KTKO Ltd.), ORC and East Otago Taiapure 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 rainfall 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 rainfall 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 Käi 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 Department of Conservation (DOC) Otago Conservancy.

### 3.2.1 Käi Tahu Cultural Impact Assessment

In October 2005, DCC commissioned 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 Käi Tahu and their descendents, 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 Käi 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 Käi 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 Käi 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 Käi 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 by Käi Tahu, as well as looking to reduce the incidence of wastewater discharge into the receiving environment.

## 3.3 Annual Plan Submissions

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 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

Figure 4-1 shows the location of the Shore Street stormwater catchment. The catchment is moderately hilly, and covers an area of approximately 100 ha. The catchment extends from the suburb of Andersons Bay towards South Dunedin and includes parts of the suburbs of Tainui and Musselburgh. The head of the catchment is located to the south west of Duckworth and Spencer Streets. The catchment contains gullies and a steep hill near the middle of the catchment, and flattens out towards the harbour in the northwest. In the west the catchment is bounded by another steep rise (Musselburgh Rise).

Land use within the catchment is predominantly residential with a small area of commercial land use. The catchment also incorporates areas of bush cover and open grass.

The stormwater network has two main branches running south to north; one along Tainui Road, picking up flow from the Musselburgh Rise area, with the second following Bayfield Road draining the balance of the catchment. These branches meet at Shore Street, continuing 200 metres towards a harbour outfall into Andersons Bay Inlet. The network is predominantly piped, but includes several lengths of open channel.

## 4.2 Topography and Geology

Figure 4-2 provides a contour map of the Shore Street catchment using 2 m contours. Figure 4-3 shows the geology of the catchment (Bishop and Turnbull, 1996).

The catchment is characterised by steep gullies at the head of the catchment in the east and the Musselburgh Rise in the west of the catchment. The head of the catchment has an elevation of approximately 86 m above mean sea level, and approximately 70 % of the catchment is located on hillside. The topography becomes flatter with low lying areas towards the harbour in the northwest. There is a large area of reclaimed land adjacent to the Andersons Bay Inlet, some of which is included in the Shore Street catchment.

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 (Md2e basalt). The volcanic deposits are very resilient to erosion and weathering, with the rock material typically providing variable infiltration capacity, depending on the extent and location of fractures in the rock. The steep terrain at the head and sides of the catchment directs surface water into one main gully which is found above and surrounding Chisholm Place. The gully then divides into two, one heading in the direction of the harbour to the north and the second towards St Kilda Beach in the south. The gradient of the catchment flattens out towards the harbour between the centre of the catchment and Musselburgh Rise.

In the vicinity of Rawhiti Street is an area of marine terrace deposits which consist of weathered sand and gravel with a cap of loess (Q5b sand). To the south of this area are stream alluvium deposits consisting of gravel, sand and peat (Q1al gravel). These deposits would be expected to have good drainage capabilities, however this would be influenced by groundwater levels in the area. Close to the harbour is an area of reclaimed seabed which is identified as geologic unit Q1an. 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 including material dredged from the harbour, most likely combined with anthropogenic materials from industrial and domestic waste. Drainage capabilities of this material will be variable, depending on the specific materials used in different areas of the reclamation.

## 4.3 Surface Water

An assessment of a number of streams in the 3 Waters Project catchments was undertaken by Ryder Consulting Ltd in 2010, one of which is located in the Shore Street catchment. The corresponding Stream Assessments Report (Ryder, 2010c) contains information on characteristics of the stream based on assessments at two sites. The following description is based on the information contained in that report together with data obtained from GIS (geographic information system) analysis of the stormwater network (see Figure 4-9 later in this report).

As identified by the geology section of this report (Section 4.2), the natural hydrology of the catchment would have resulted in two main streams, one running in a south-westerly direction from Chisholm Place (Stream 1), and the other running in a northerly direction (Stream 2). Much of Stream 2 (running along Bayfield Road) has been highly modified or piped, whereas Stream 1 (along Tahuna Road) has been modified to a lesser extent.

The Stream Assessments Report states that Stream 1 has sections of natural water channel separated by a piped section. The upstream portion of the stream flows through stormwater pipes which drain Tomahawk Road before entering the natural channel to Chisholm Place. There is also a secondary stormwater pipe that discharges into the upper reach of the natural channel. Ryder Consulting note that there are large areas of bank that have previously eroded and subsequently been reinforced by concrete blocks, bricks and rip-rap (boulders deposited along the stream-bank). The downstream reaches of the stream flow through stormwater pipes between Chisholm Place and Norman Street before entering the natural channel near Tahuna Road.

## 4.4 Groundwater

There is limited information relating to groundwater surface levels in the Shore 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, and anecdotally, the groundwater in the Shore Street area is believed to be shallow, and also believed to be influenced by tide levels and potentially lowered by drainage infrastructure in the low-lying flat areas. A discussion on a salt water intrusion study in Section 4.7.4 explains this further.

No information on groundwater quality is available, due to a lack of monitoring sites.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| DUNEDIN CITY COUNCIL / OPUS / URS | Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-1<br>Shore Street Catchment Location | DISCIPLINE<br>Stormwater | Drawn: KC<br>Checked: HES<br>Approved: SDH<br>Date: Sep 2011 | Status: Final<br>Scale: 1:20,000<br>Plot Date: Sep 2011<br>Job. No: 42173227<br>Map No: Figure 4-1<br>Revision: - |

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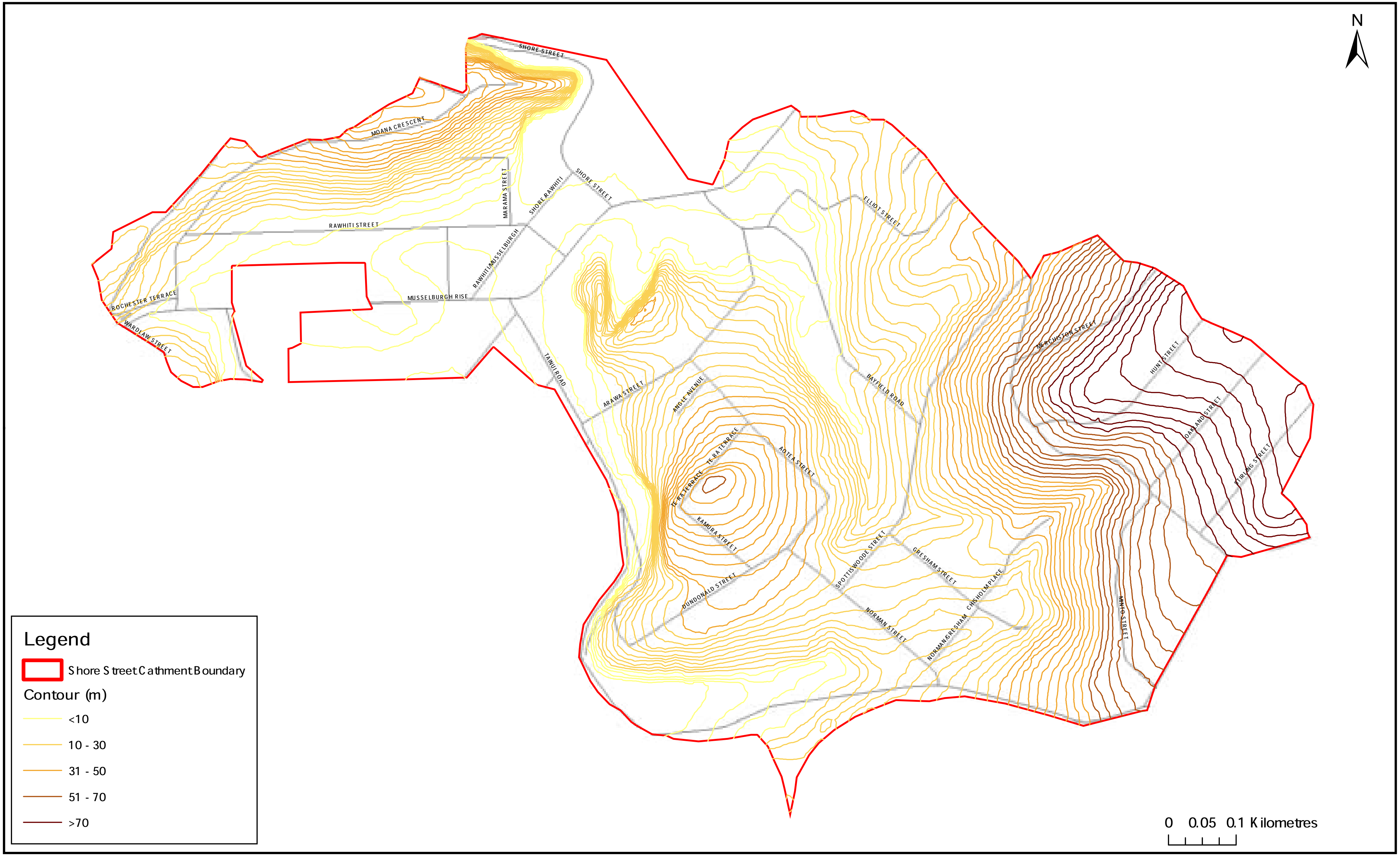


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| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-2<br>Shore Street Catchment Contour Map | DISCIPLINE<br>Stormwater |
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| Drawn: KC | Status: Final | | |
| Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 | |
| Approved: SDH | Job. No: 42173227 | Map No: Figure 4-2 | Revision: - |
| Date: Sep 2011 | | | |



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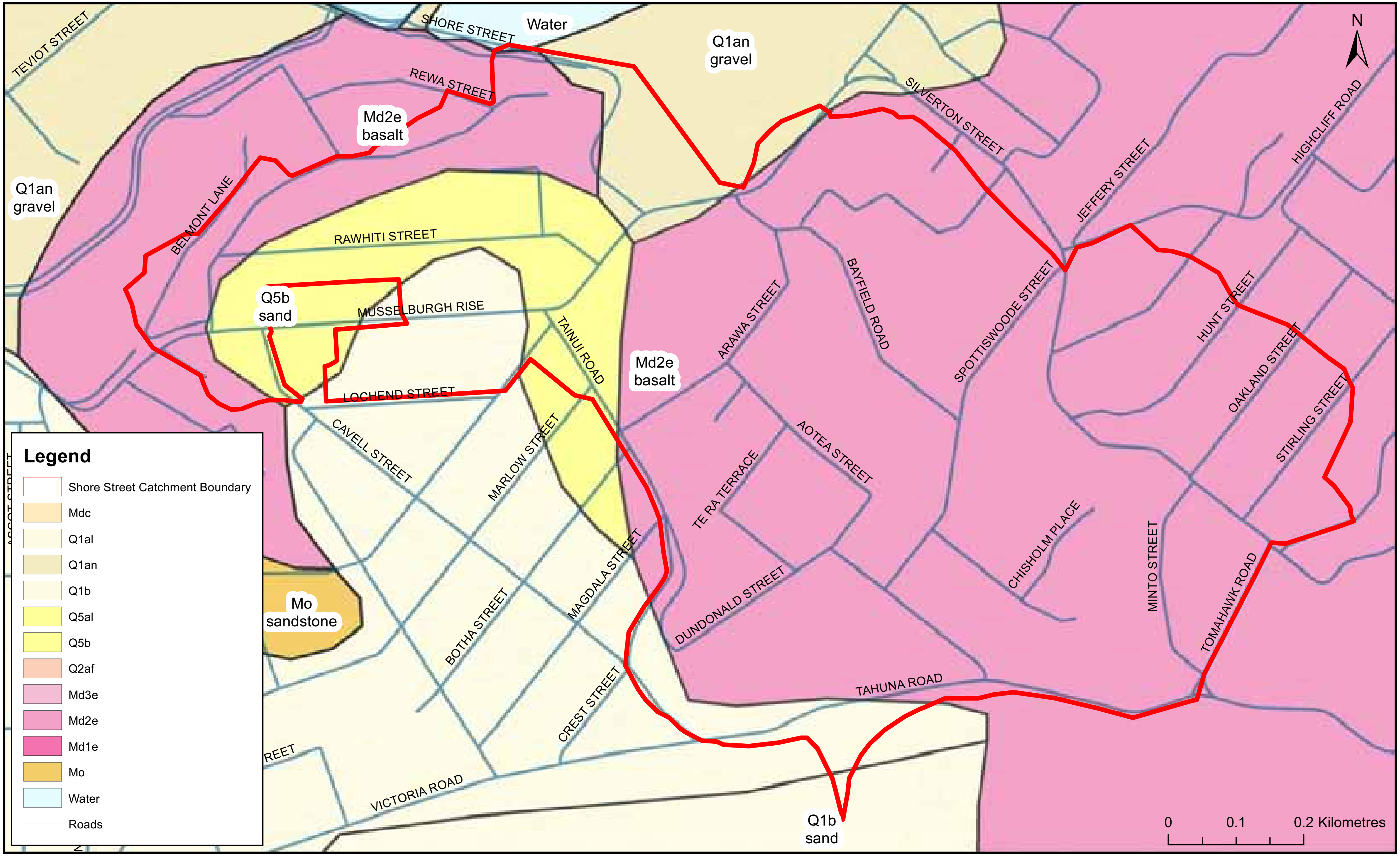


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Dunedin 3 Waters Strategy

**SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN**

**Figure 4-3**

**Shore Street Catchment Geology Map**

| DISCIPLINE | Drawn: KC | Status: Final | |
|---|---|---|---|
| Stormwater | Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 |
| | Approved: SDH | Job. No: 42173227 | Map No: Figure 4-3 / Revision: - |
| | Date: Sep 2011 | | |



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## 4.5 Land Use

### 4.5.1 Historical and Current Land Use

The Shore Street catchment encompasses parts of several suburbs including Andersons Bay, Musselburgh, and Tainui.

Given the height of Musselburgh Rise it is likely that a Māori pa was located on or near the rise as it would have provided a strategic position over the harbour and the Otago Peninsula. Today, there are several large homes along the top of Musselburgh Rise including Belmont which was built in 1860 for politician/news editor William Cutten.

Andersons Bay was named after the first European settlers in Dunedin who arrived in 1844. In the late 19th century a railway and ferry service connected the area with central Dunedin, however, neither of the transport links survived. The inlet incorporates land that was reclaimed in the 1950's to provide grounds for the Bayfield High School, which is one of Dunedin's main secondary schools. The suburb of Andersons Bay also includes Dunedin's largest cemetery.

The Shore Street catchment is currently primarily zoned for residential purposes (Residential 1 and Residential 2). Less than 1 % of the catchment is used for commercial purposes, and the commercial area is located in the suburb of Musselburgh. Table 4-1 below provides a breakdown of the land use zoning in the catchment, as depicted in Figure 4-4.

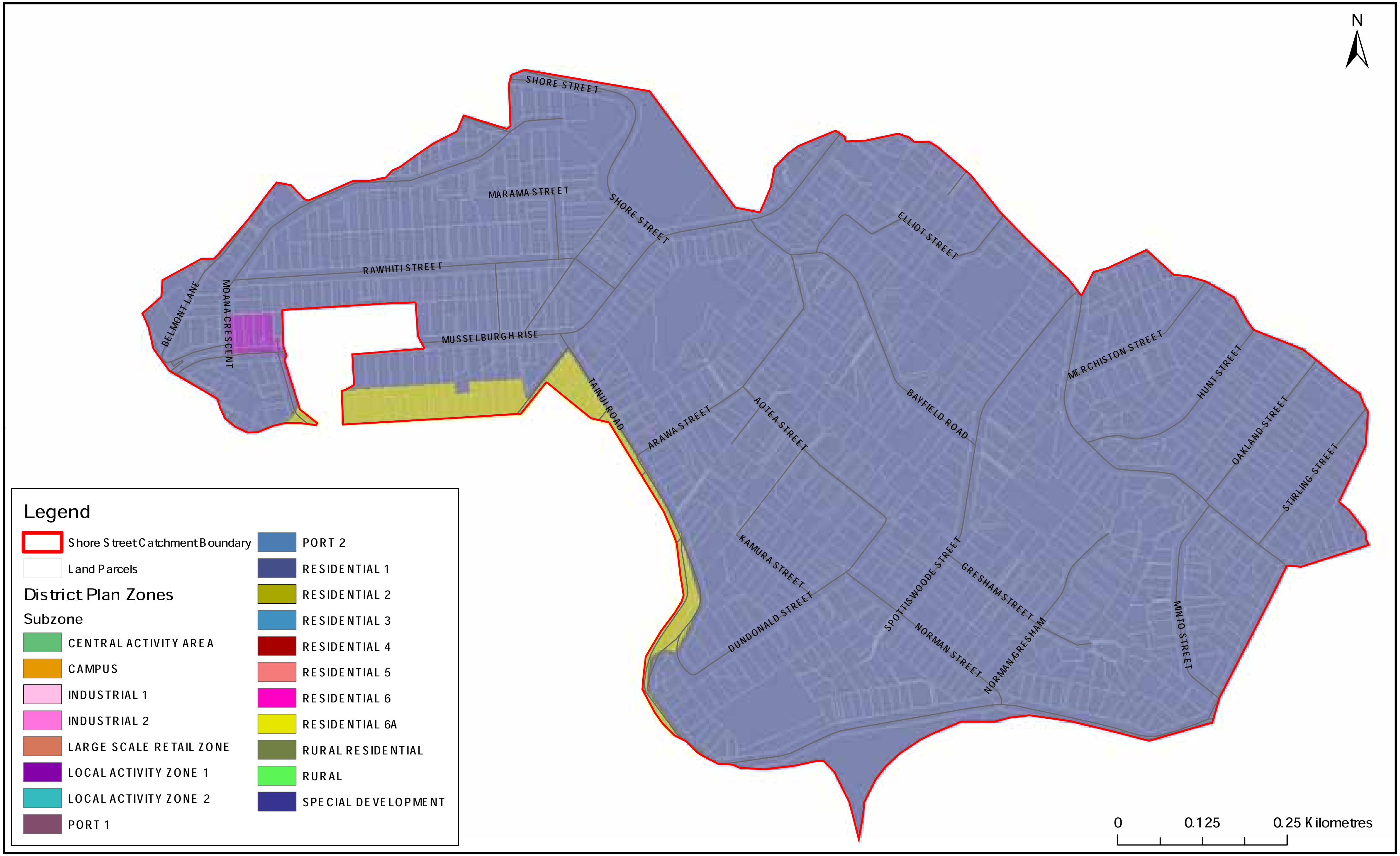
**Table 4-1: Current Land Use in the Shore Street Catchment**

| DCC Zone | Proportion of Catchment |
|---|---|
| Residential 1 | 96.5 % |
| Residential 2 | 3 % |
| Local Activity Zone 1 and 2 (commercial) | 0.5 % |

### 4.5.2 Cultural and Heritage Sites

According to DCC records of significant archaeological and heritage sites within Dunedin city, the Shore Street catchment does not contain any heritage precincts or heritage structures.

Käi Tahu have been identified as a key stakeholder. It should be noted that coastal and freshwater environments hold particularly high values for Käi Tahu. Māori cultural values, along with those of other stakeholders throughout Dunedin's community, are discussed in Section 3.

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| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-4<br>Shore Street Catchment Land Use Zones | DISCIPLINE<br>Stormwater |
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### 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 Shore Street catchment. However, there are no 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).

Three District Plan Designations exist within this catchment; all are for schooling purposes.

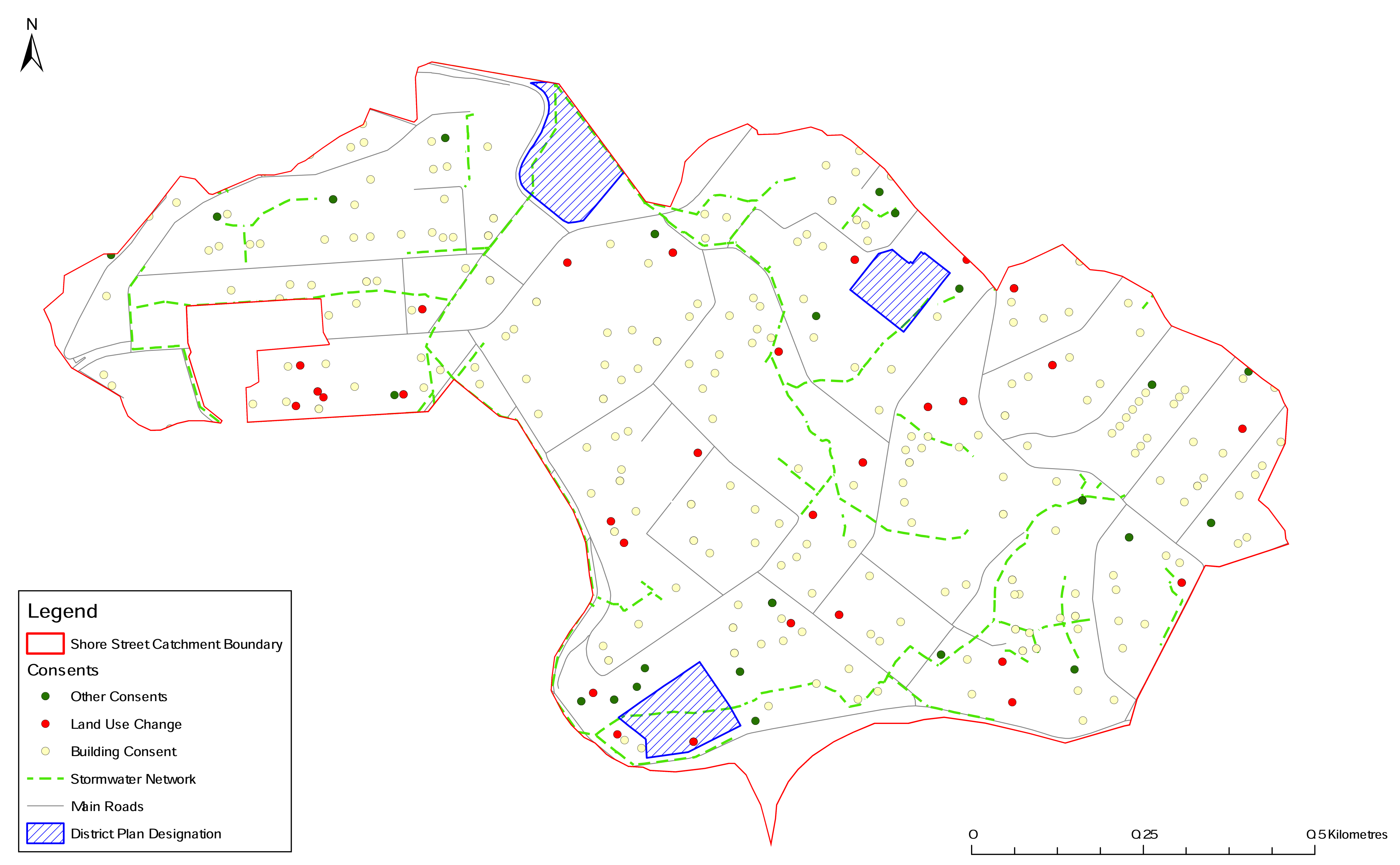
Figure 4-5 provides the location of the resource consents granted by DCC and District Plan Designations within the Shore Street catchment.

### 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.

The northern side of Shore Street, on the edge of the Andersons Bay Inlet, has been identified as a contaminated site, however no further information relating to this site was available at the time of writing this plan. A significant area of land has been reclaimed adjacent to the Andersons Bay Inlet, and reclaimed land has been used as the site of Bayfield High School on Shore Street - the materials used in the reclamation during the 1950s are unknown, but it are likely to have included domestic waste and other potentially contaminated fills. There is another reclamation site on Minto Street (which is possibly landfill, rather than reclamation), and there is also a small landfill site located on Gresham Street.

Figure 4-6 provides the location of the known contaminated land sites within the Shore Street catchment. There may be further sites around the catchment, but any information relating to these sites is not available at this time.

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| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-5<br>Shore Street Catchment Recent Consents and Designations | DISCIPLINE<br>Stormwater | Drawn: KC | Status: Final | |
| | | | Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 |
| | | | Approved: SDH | Job. No: 42173227 | Map No: Figure 4-5 / Revision: - |
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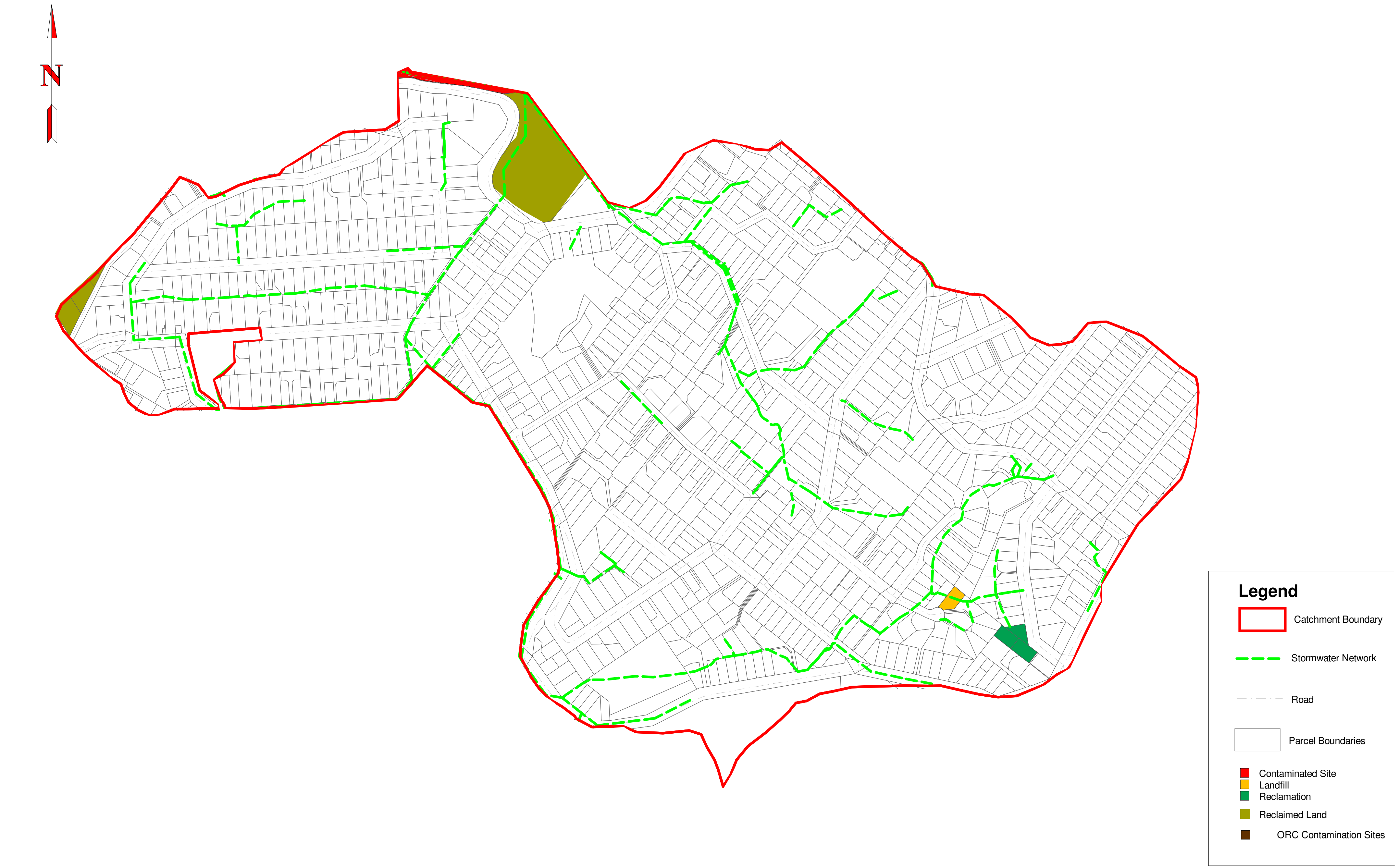


**Dunedin 3 Waters Strategy**

**SHORE ST INTEGRATED CATCHMENT MANAGEMENT PLAN**

**Figure 4-6**
**Contaminated Land Sites**

Discipline:

Stormwater

| | | | |
|---|---|---|---|
| DRAWN BY MG | STATUS Final | | |
| CHECKED LB | SCALE NTS | PLOT DATE April 11 | |
| APPROVED HS | JOB NO. 3-d1040.07 | DWG. NO. | REVISION |
| DATE April 11 | | | |

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### 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.

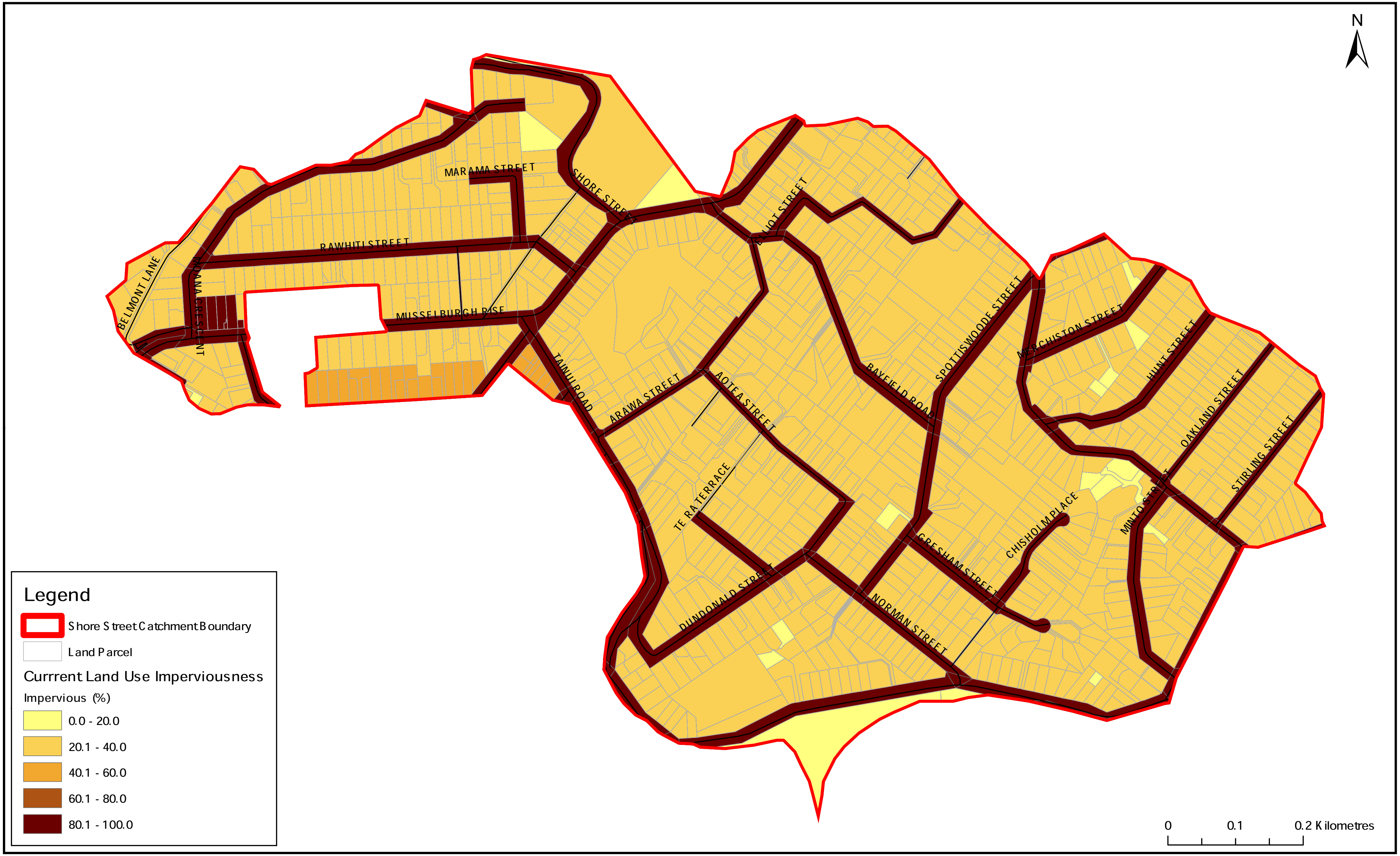
The Shore Street catchment is not expected to undergo significant changes to the existing land use practice types over the next 50 years based on the current understanding of the growth demands on the city and the existing district plan provisions.

## 4.6 Catchment Imperviousness

Figure 4-7 provides a map of current imperviousness for the Shore Street catchment (refer Appendix B for calculation methods). The land use for over 99 % of the catchment is zoned for residential purposes. The land zoned Residential 1 makes up 96.6 % (95.8 ha) of the catchment. Housing in this zone typically has lower site coverage than other residential zones, with the district plan estimating site coverage of approximately 25 %. The imperviousness study calculated that Residential 1 zones typically had a total imperviousness of approximately 39 %, of which about 23 % was estimated to be houses and driveways (with the remainder representing areas such as unconnected paving etc.). Residential 2 areas around Tainui Road and Lochend Street make up 2.5 % (2.8 ha) of the catchment, and are estimated to have a higher imperviousness (approximately 58 % total). The small area zoned as Local Activity 1 (0.5 % of catchment, 0.5 ha) is estimated to be 94 % impervious.

The maximum future imperviousness has been calculated for each land parcel, 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.

The maximum possible imperviousness of the catchment has been reviewed for 2060. In 2060, the entire area zoned Local Activity 1 (0.5 ha) may be 100 % impervious. The Residential 1 zone has a maximum allowable imperviousness of 49 %, while the Residential 2 zone could be up to 72 % impervious.

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| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-7<br>Shore Street Catchment Current Imperviousness | DISCIPLINE<br>Stormwater | Drawn: KC | Status: Final | |
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| | | | Approved: SDH | Job. No: 42173227 | Map No: Figure 4-7 / Revision: - |
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## 4.7 Stormwater Drainage Network

### 4.7.1 Network Description

The stormwater network in the Shore Street catchment has two main branches, based on historic stream gullies formed in the catchment. One runs along Tainui Road, picking up flow from the Musselburgh Rise area, with the second following Bayfield Road draining the balance of the catchment. These branches meet at Shore Street, continuing several hundred metres towards a harbour outfall into the Andersons Bay Inlet. The network is predominantly piped, but includes several lengths of open channel in the upper reaches of the Tainui Road branch, and also several private drainage discharges to roads. The longest drainage path is approximately 1.42 km.

Figure 4-8 below provides the frequency distribution of the pipes in the Shore Street catchment. As can be seen, while there are a number of smaller pipes, there is a significant length of large (900 mm diameter) pipes. A map of the stormwater network in the catchment, based on DCC GIS data, is illustrated in Figure 4-9.

Significant network features included in the hydraulic model are as follows:

- Shore Street Outfall - this outfall consists of a 1500 mm diameter pipe discharging into the Andersons Bay Inlet.
- Two Catchpits at the corner of Tomahawk Road and Highcliff Road - these two catchpits are not part of the Shore Street catchment, but if they fail to intercept the runoff from a 5.6 ha area to the east of the Shore Street catchment, then excess runoff will flow overland towards the Shore Street catchment and will be intercepted by the stormwater network along Spottiswoode Street.
- Two Screens on Tahuna Road - there are two intake screens on open channel sections of the Tahuna Road branch of the stormwater network, located in a relatively flat area.
- Close to the intersection of Tainui Road and Musselburgh Rise, there is a 900 x 900 mm concrete stormwater culvert with a 225 mm diameter PVC foul sewer installed inside it. Any damage to the foul sewer could result in contamination of stormwater, or ingress of stormwater into the wastewater system. No such damage has been observed, however.

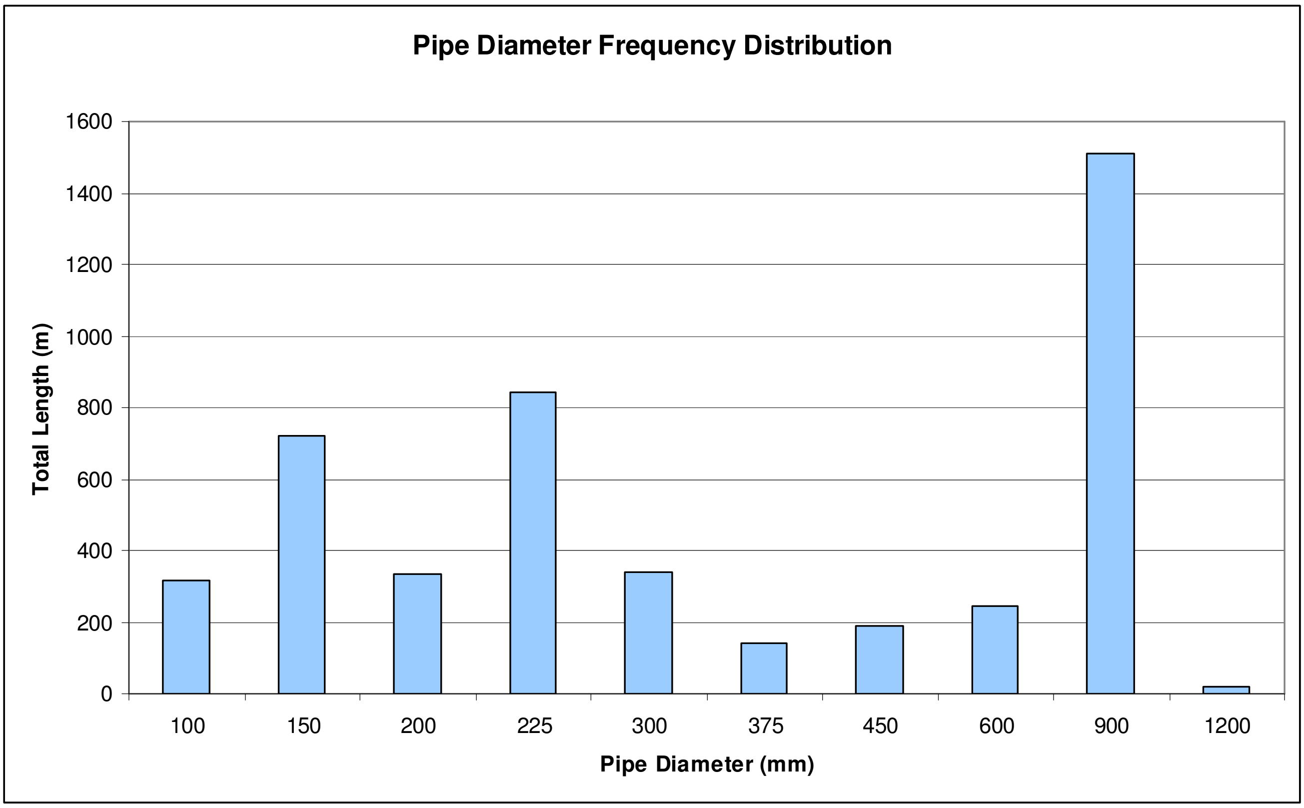
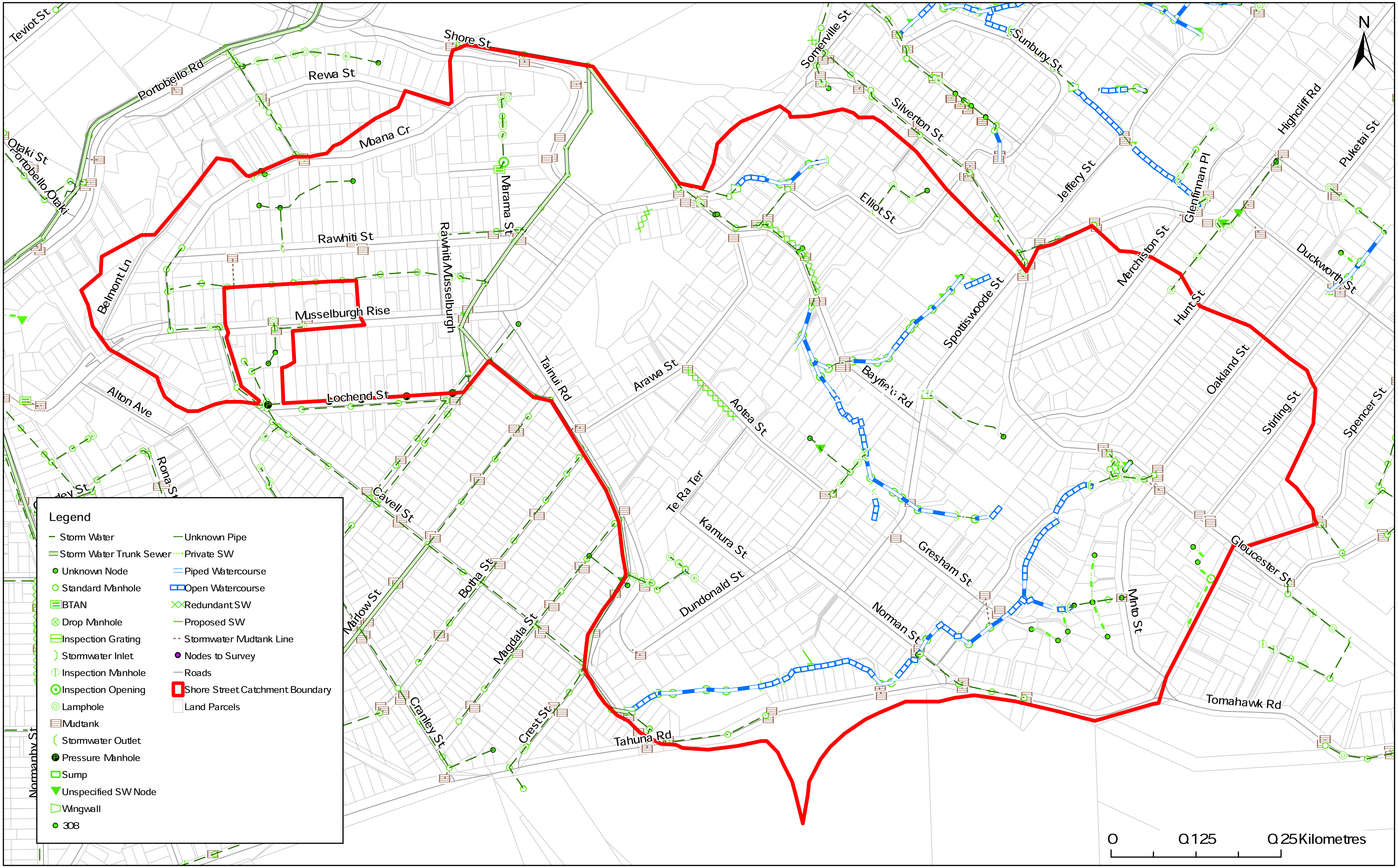



**Figure 4-8: Pipe Diameter Frequency Distribution**

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Dunedin 3 Waters Strategy

SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-9

Shore Street Catchment Stormwater Drainage Network

| DISCIPLINE | Drawn: KC | Status: Final | |
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| Stormwater | Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 |
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| | Date: Sep 2011 | | |



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### 4.7.2 Network Age

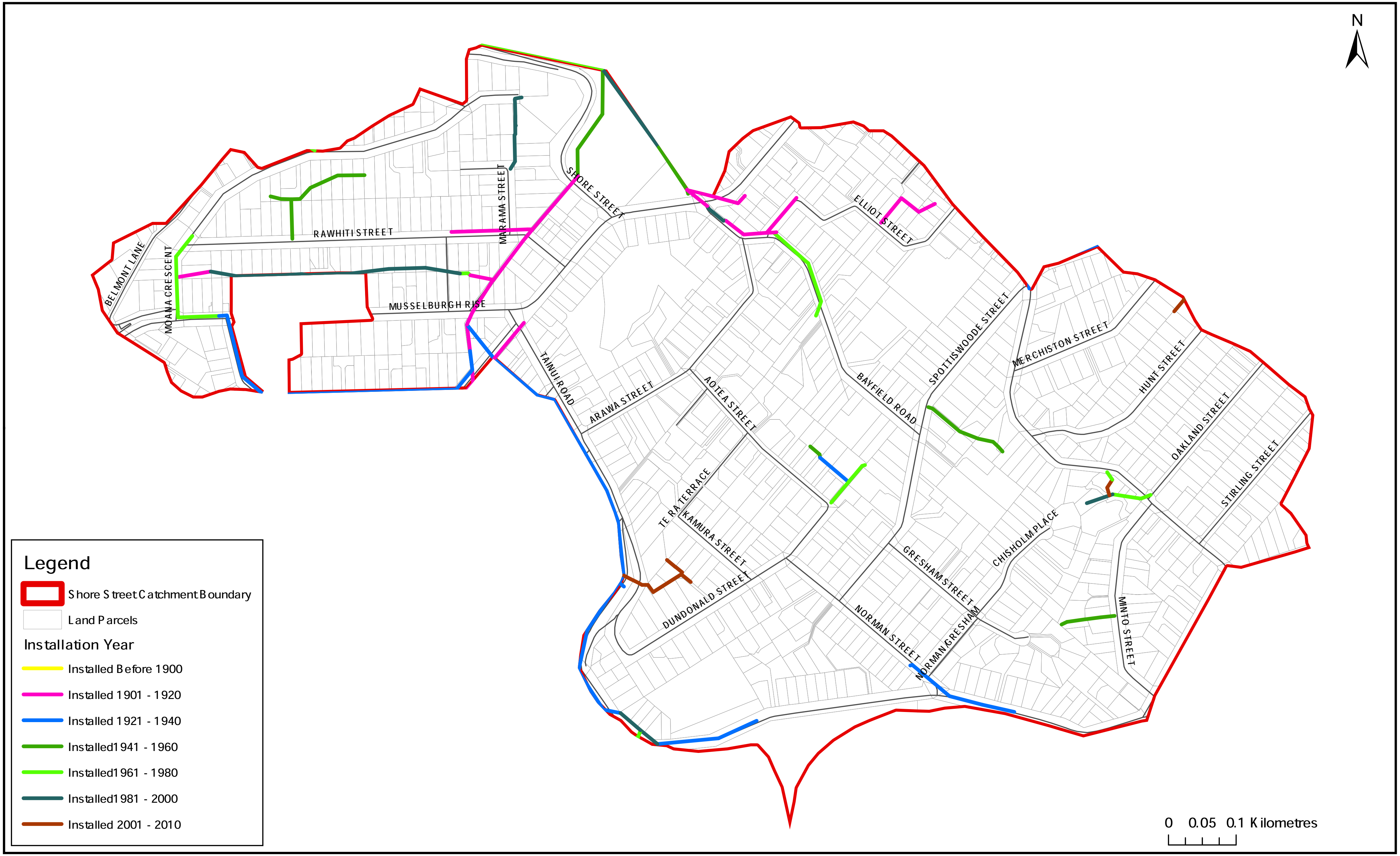
Table 4-2 below provides a breakdown of pipe age in the Shore Street catchment. Figure 4-10 provides a map of pipe age based on location.

The data shows that the majority of the pipework in the Shore Street catchment was laid in the early to mid-1900s, and as such will still be the original infrastructure.

Based on the current forecasts of theoretical asset life for stormwater mains, the majority of which have been assigned a theoretical life of 100 years, 66 % of the pipe network will be subject to inspection / condition assessment or be renewed by 2060. Remaining life forecasts will be improved based on condition assessment and related work on refining expected lives, and renewals planning adjusted accordingly.

**Table 4-2: 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 | 0 | 0 | 0 |
| Installed 1901 to 1920 | 90-110 years | 26 | 993 | 21 |
| Installed 1921 to 1940 | 70-90 years | 28 | 1397 | 30 |
| Installed 1941 to 1960 | 50-70 years | 13 | 695 | 15 |
| Installed 1961 to 1980 | 30-50 years | 22 | 526 | 11 |
| Installed 1981 to 2000 | 10-30 years | 26 | 793 | 17 |
| Installed 2001 to 2009 | < 10 years | 15 | 240 | 5 |

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Dunedin 3 Waters Strategy

SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-10

Shore Street Catchment Pipe Network Ages

DISCIPLINE

Stormwater

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| Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 | |
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### 4.7.3 Asset Condition and Criticality

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 4-3 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 wellbeings, given that the consequences of failure of an intake would be largely localised in nature due to area flooding.

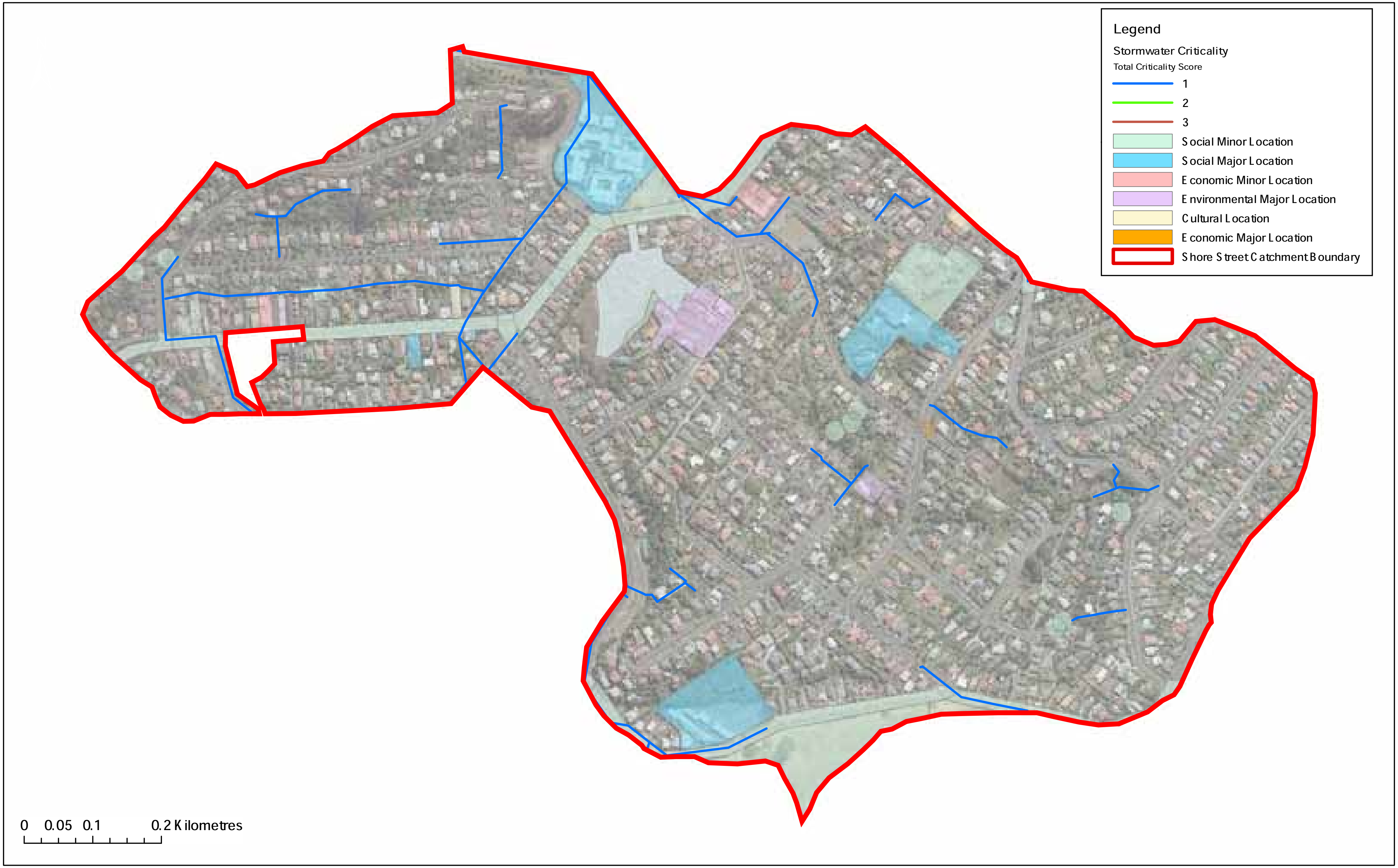
Figure 4-11 shows a map of the Shore Street catchment, with criticality and 'wellbeing' locations identified. This map shows pipe criticality only. Pipe condition assessment is currently being undertaken throughout the city on selected pipes, however to date no information is available on pipes in the Shore Street catchment.

There are a small number of 'wellbeing' locations identified in the Shore Street catchment, however all pipes in the DCC stormwater network within the Shore Street catchment are assigned a pipe criticality of 1, indicating a low criticality.

**Table 4-3: 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*




| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-11<br>Shore Street Catchment Stormwater Network Criticality | DISCIPLINE<br>Stormwater |
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### 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.

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 and Wright (2009) examined the regions adjacent to the Otago Harbour and highlighted the key locations where salt water is entering the wastewater system. Figure 4-12 from the report depicts the ‘at risk’ band segregated into seven main catchments – part of the Shore Street catchment is included in the Portobello Road catchment. The sampling at Portobello Road showed no distinct correlation between tidal movements and conductivity levels. However, the peak conductivity levels at Bayfield High School showed a relationship between tidal movements and conductivity levels. During extreme high tides the main sewer in the car park of the high school may contribute large amounts of salt water to 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. Stormwater flow monitoring in the catchment indicates some tidal influence from the outlet, and also recorded baseflows arriving at the monitoring site, however the analysis was unable to determine whether baseflows were due to saline intrusion or freshwater sources.

Tidal influence on the system via the harbour outfalls is discussed further in Section 8.

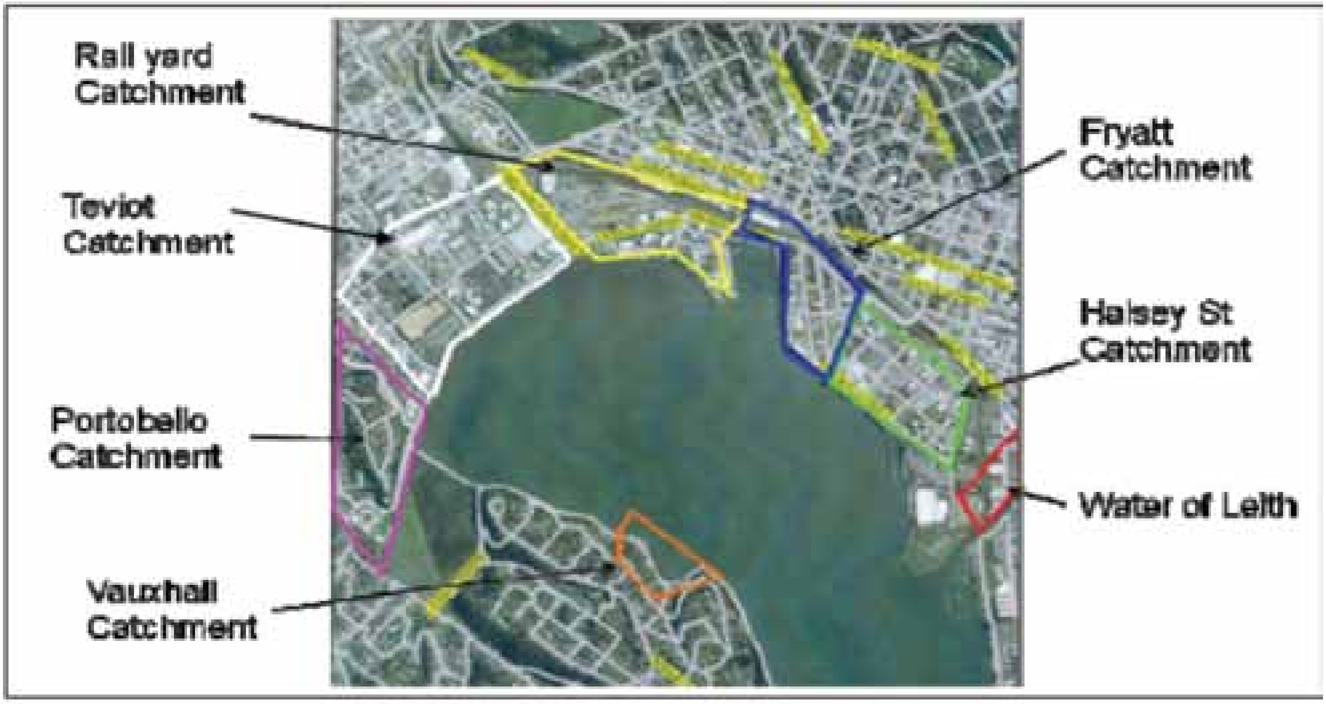



**Figure 4-12: Sampling Catchments for Salt Water Intrusion Investigated**

*Please note that catchments illustrated here are only approximate and the sewer system within each catchment is not visible.*

### 4.7.5 Operational Issues

Discussions were held with DCC operations personnel during the catchment walkover (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 staff in November 2010. Discussions highlighted the following issues:

- Blocked catchpits and stormwater culvert inlets at the top of Chisholm Place, resulting in regular nuisance flooding.
- Possible issues on Norman Street with inlet sizing.
- Tainui School stormwater inlet prone to blockage.
- Flooding at motel between Rawhiti Street and Musselburgh Rise.
- Wastewater overflows on Tainui Road.
- Flap valve at the outlet to the Andersons Bay Inlet is inspected fortnightly.

### 4.7.6 Network 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 team. It was noted by the network 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 remove silt and gravel from the catchpits can also lead to siltation and hence capacity reduction of the pipe network; siltation has been identified as an issue in some areas of Dunedin by the Network Management and Maintenance team, and this is currently being investigated as part of a city-wide CCTV (closed circuit television) programme.

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).

<u>Network Management</u>

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 m).
- 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 Highways, 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 Network Management and 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

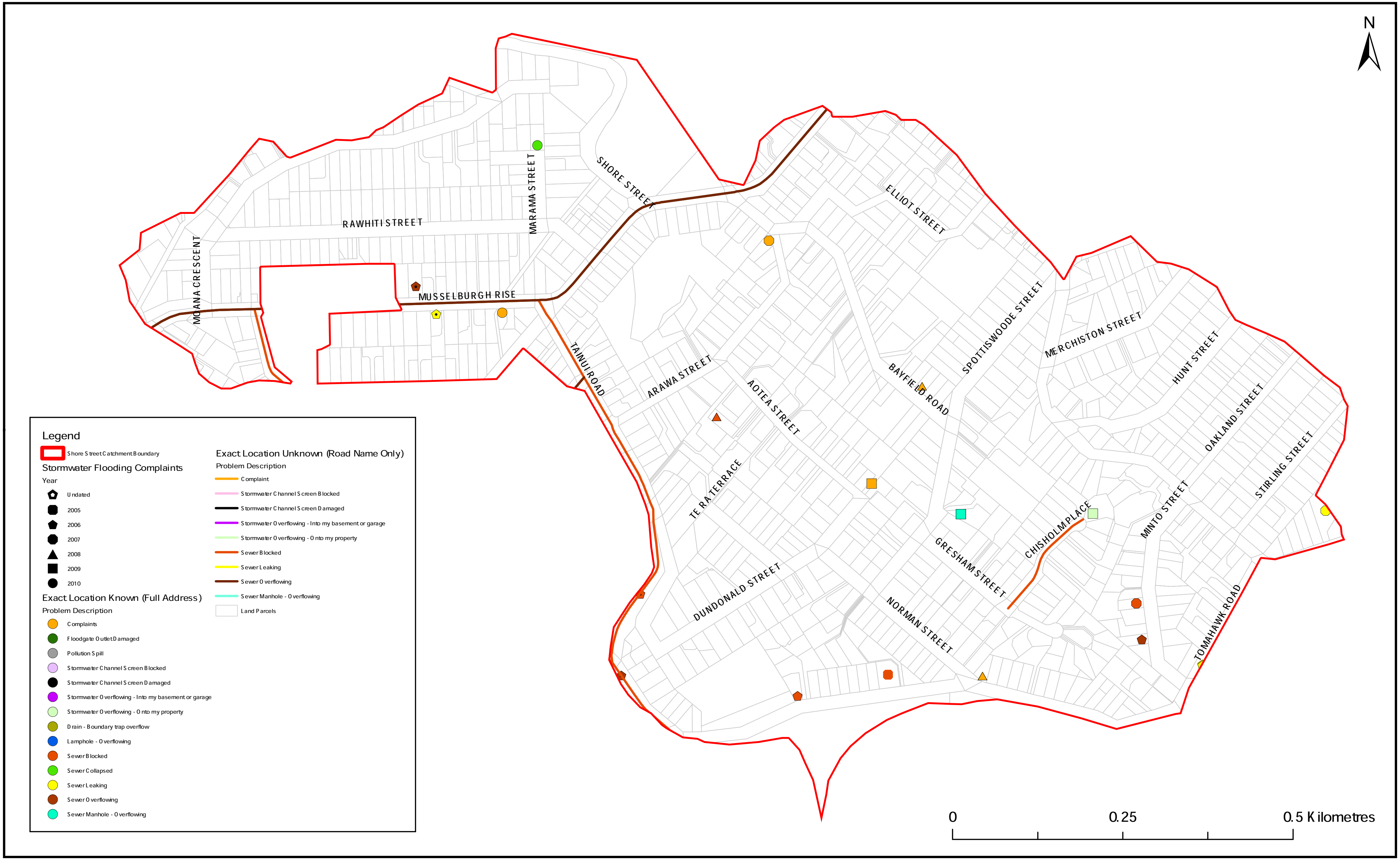
The maintenance and cleaning of stormwater structures located within parks and reserves, other than those listed under Network Management supervision, are the responsibility of CARS.

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

Based on DCC customer complaints information collated between 2005 and 2010, there were 32 stormwater flooding complaints and 39 wastewater flooding complaints in the Shore Street catchment. Figures 4-13 and 4-14 provide maps of these complaints.

There are two recorded stormwater complaints from 30 Chisholm Place and, during a catchment walkover in November 2009, a resident in the Chisholm Place cul-de-sac commented to URS staff on the frequency of flooding events at their neighbour's property (30 Chisholm Place), reporting that nuisance flooding (not threatening nearby houses) has occurred there approximately three or four times over the last seven years.

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| Created with ESRI ArcGIS | Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 4-13<br>Shore Street Catchment Reported Stormwater Flooding | DISCIPLINE<br>Stormwater | Drawn: CA<br>Checked: HES<br>Approved: SDH<br>Date: April 2011<br>Status: Draft<br>Scale: 1:5000<br>Plot Date: April 2011<br>Job. No: 42173227<br>Map No: Figure 4-13<br>Revision: - |



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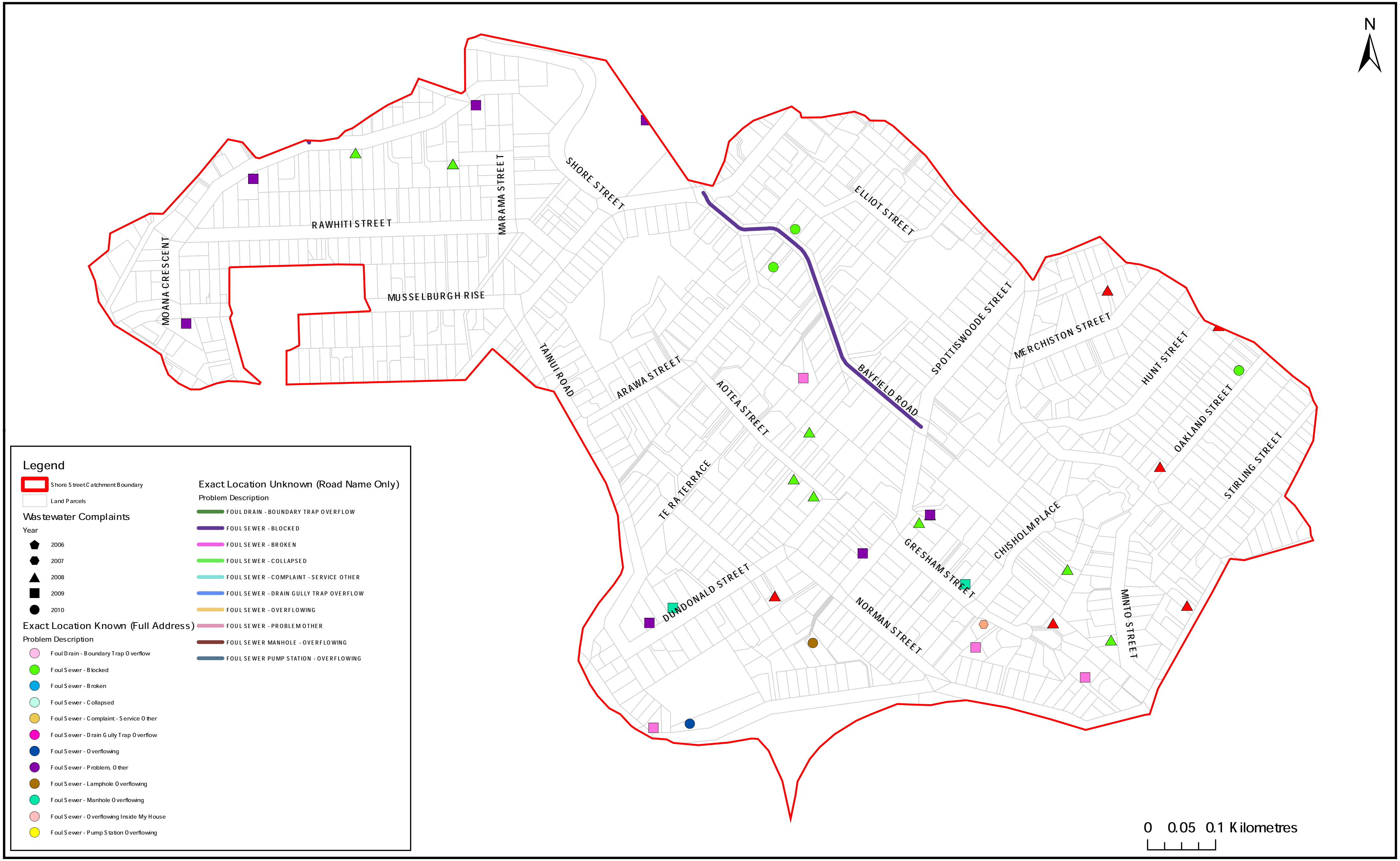


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Dunedin 3 Waters Strategy

SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-14

Shore Street Catchment Reported Wastewater Flooding

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| Stormwater | Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 |
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## 4.9 Water and Wastewater Systems

Figure 4-15 provides a layout of the three waters networks in the Shore 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 Shore 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 west of the city and the Southern WTP to the south west 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 Shore Street catchment is supplied from the Monticello reservoir, located to the east of the catchment in central Dunedin. There are approximately 13 km of water supply pipes within the Shore Street catchment, 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 Shore Street catchment is contained within the South Dunedin treated water supply zone. Leakage across the South Dunedin zone is close to the average across Dunedin. The area is known to have a lot of ageing cast iron pipe assets and a number of renewals are likely to be required in the area over the next few years.

### 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 rainfall induced inflow and infiltration (I&I). This indicated that the Dunedin City wastewater system remains at least partially combined with a clear and significant response to rainfall. 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 wastewater overflows to the natural environment have been found to operate during rainfall events within Dunedin City.

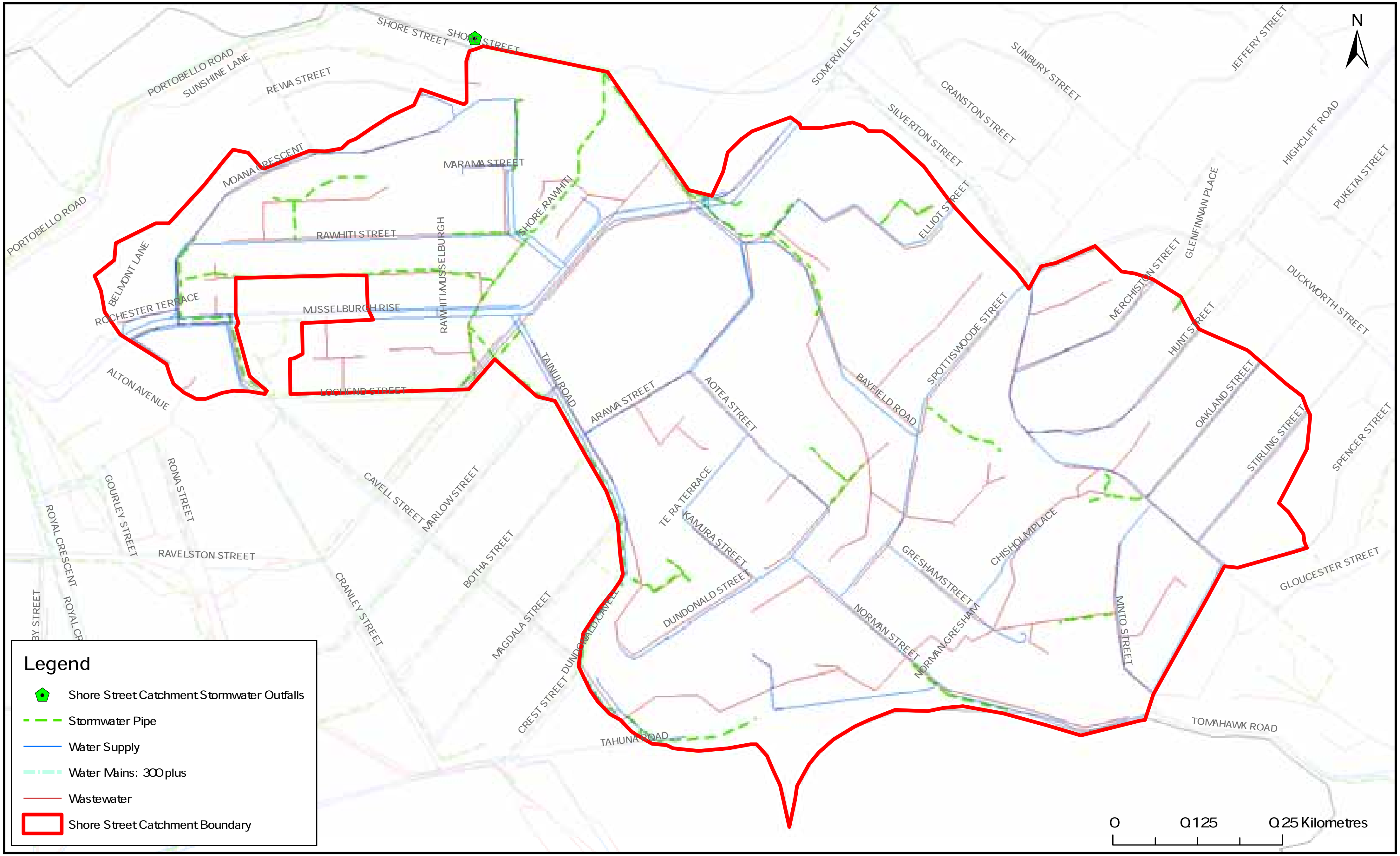
The Dunedin City wastewater system collects wastewater from commercial, industrial and residential customers in Dunedin City. It is split into three distinct schemes: the Dunedin Metropolitan Scheme, the Mosgiel Scheme and the Green Island Scheme.

The wastewater system within Shore 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 pumping station at Musselburgh 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 pumping station.

The system within the Shore Street catchment comprises approximately 13 km of wastewater pipeline, approximately 90 % of which are between 150 mm and 300 mm in diameter.

A pumping station at Ocean Grove, to the north east of the catchment, receives flows from the east and pumps to the head of the catchment. The wastewater flows from the catchment are conveyed to the Musselburgh pumping station via a trunk sewer which runs along Ravelston Street.

Flow data indicates I&I issues within the wastewater system of this catchment. The suburbs of Sunshine and Musselburgh appear to be the largest contributors of I&I. Flow survey data has also indicated tidal influence and potential saline intrusion in the trunk main upstream of the pumping station at Marne Street. Although this pumping station and its influences are outside of the Shore Street catchment boundary, when there are increased flows within the wastewater system of the pump station’s catchment, primarily during rainfall events, a pressure operated relief valve in Marne Street diverts wastewater flows to the Marne Street pumping station which then discharges directly to the Anderson’s Bay Inlet (the receiving environment that also receives stormwater from the Shore Street stormwater catchment). Solutions to reduce the use of the Marne Street pumping station have been developed, involving reduction of I&I in catchments in the area. These solutions will be assessed for implementation as part of DCC’s strategic planning process.

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Dunedin 3 Waters Strategy

SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-15

Shore Street Catchment Three Waters Networks

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| Stormwater | Checked: HES | Scale: 1:5,000 | Plot Date: Sep 2011 |
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# 5 Receiving Environment

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

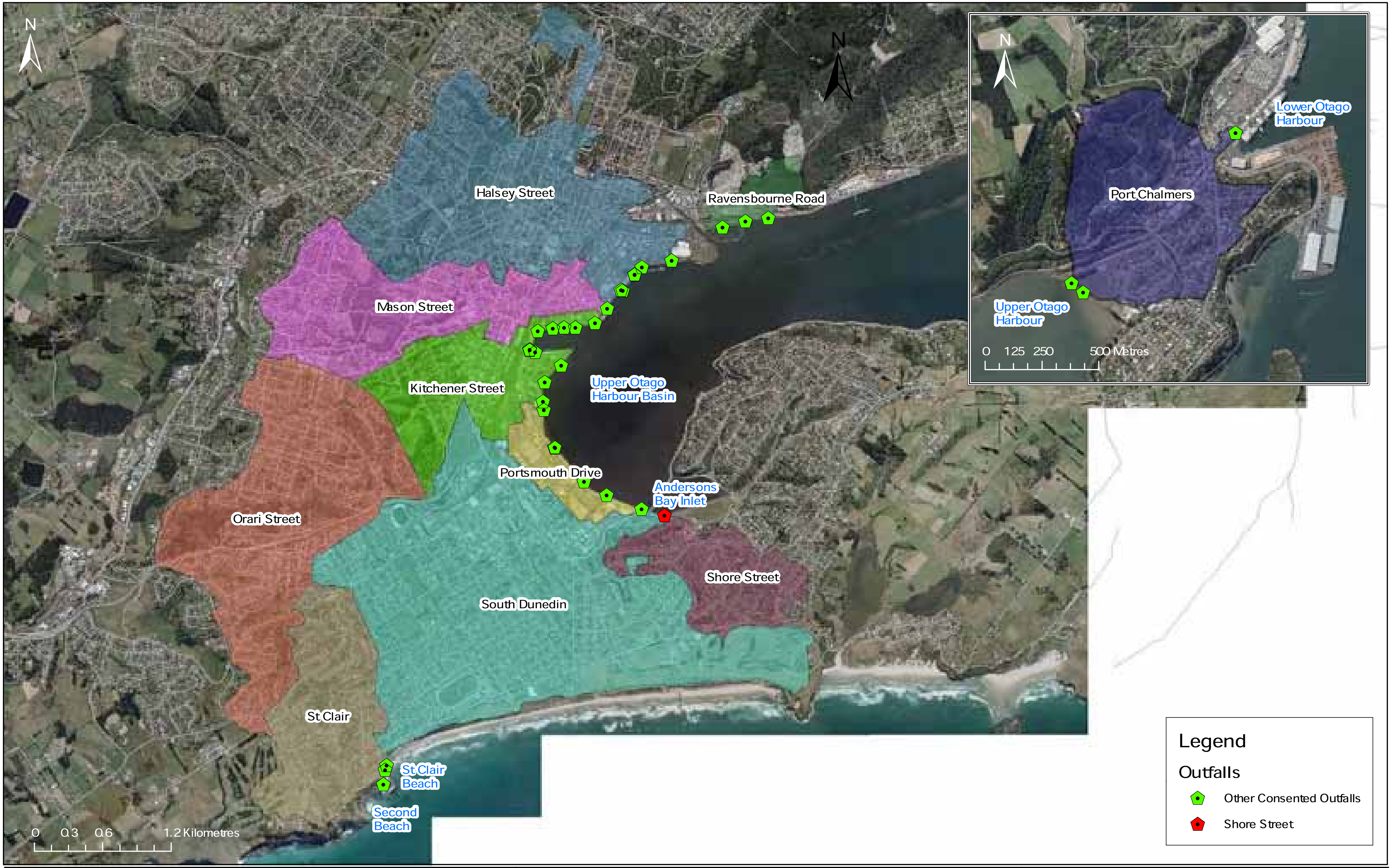
Part 3 of this report identifies and analyses the effects that specific current stormwater management practices are considered to be having on the receiving environment of the catchment. Where the effects are considered to be unacceptable, options for avoiding remedying or mitigating the effects are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

The stormwater network in the Shore Street catchment discharges directly to the marine environment in the Anderson's Bay Inlet at the south-eastern shore of the Otago harbour basin via one large outfall located on Shore Street (Figure 5-1). The inlet then discharges into the harbour beneath a bridge across the causeway (Figure 5-2). The location of the outfall, relative to other DCC stormwater outfalls and the Otago Harbour receiving environment, is shown in Figure 5-3.

There is one natural stream in the Shore Street catchment, the location of which is indicated in Figure 5-5. The stream receives discharges directly from the stormwater network as well as direct runoff from surrounding land.

**Figure 5-1: Shore Street Catchment Outfall (Andersons Bay Inlet)**

**Figure 5-2: Andersons Bay Inlet, showing Discharge to Otago Harbour beneath the Portobello Road Causeway**

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| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 5-3<br>Shore Street Catchment Marine Receiving Environment | DISCIPLINE<br>Stormwater | Drawn: MM | Status: Final | |
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### 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 in the Otago Harbour 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 1 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.

### 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 5-3.

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 (See Figure 5-4). 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. Smith and Croot also state that a low level of flushing occurs within Anderson's Bay Inlet due to the relatively long residence time of water in the inlet and low current velocities. They estimate that 2-5 days (4-10 tidal cycles) are necessary for 99 % flushing. This compares to 1-3 days for the rest of the upper harbour.

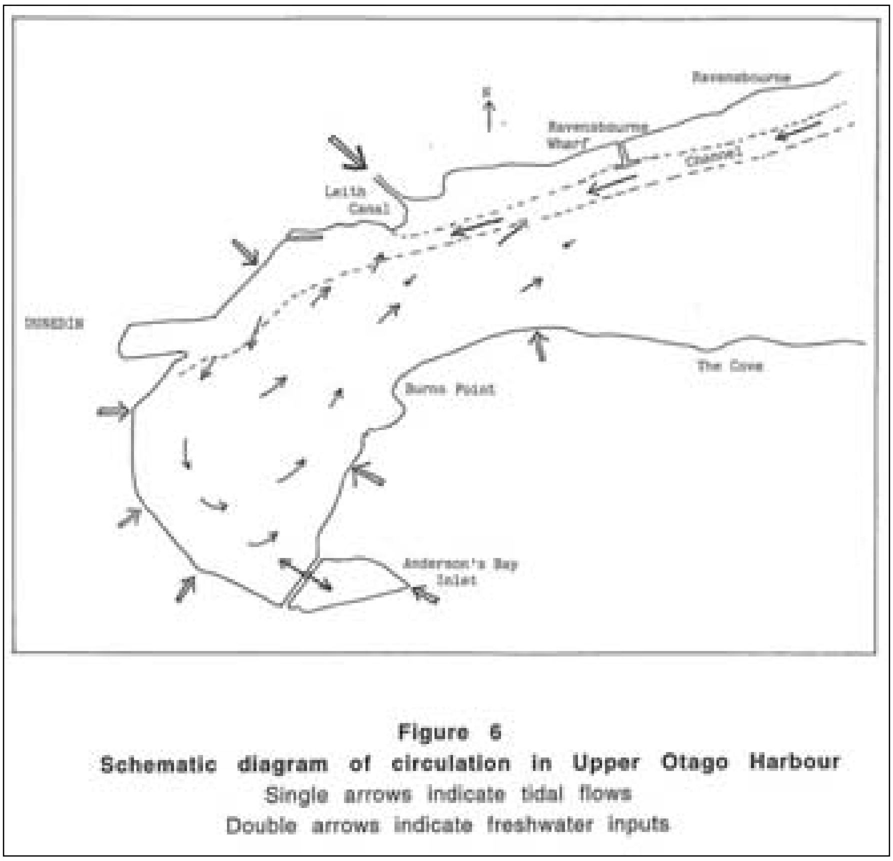


**Figure 5-4: Circulation of Water in the Upper Otago Harbour (from Smith and Croot, 1993)**

### 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 wider harbour area.

The Otago Harbour Reserves Management Plan (DCC, 2006) States that Andersons Bay Inlet is used by schools, disabled groups and other people learning how to row, canoe and kayak etc. In addition, water going from the harbour to the inlet is excellent for teaching whitewater kayaking.

A rock bird roost has recently been constructed in the Inlet, and provides a safe bird roost, as well as a bird viewing opportunity for spectators.

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 Käi Tahu have with the coastal environment. Evidence of Māori use of the harbour extends back to the Māori's 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 käi had been dramatically altered. Further consultation with Käi Tahu is discussed in Section 3 of this report.

### 5.1.3 Harbour Ecology

The resource consent associated with the outfall of the Shore Street catchment does not contain conditions requiring biological monitoring so there is a lack of temporal biological data associated with this catchment. However, the 2010 study did undertake biological monitoring of the biology in the vicinity of the Shore Street outfall. Macroflora, epifauna and infauna were investigated at sites within 20 m and at greater to 50 m from the outfall within the inlet.

The biological investigations undertaken look at the effects of the presence/absence of stormwater associated contaminants on the ecological communities of the harbour. The diversity of benthic flora and fauna is generally accepted as a reasonable indicator of environmental health. The presence of pollution tolerant species, and an absence of pollution intolerant species, can be used to indicate contamination. However, significant amounts of data are required to link the presence or absence of indicator species with 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 single data set available (2010) for this catchment is not sufficient to clearly identify the state of the ecology in the receiving environment at this location. To supplement this data, the monitoring data for the neighbouring South Dunedin (Portobello Pump Station) outfall is commented on. The South Dunedin catchment outfall is only 200 m west of the Shore Street catchment outfall and has data from 2007 to 2010, however it should be noted that the South Dunedin catchment outfall is in the harbour itself, and land use in the South Dunedin catchment, both currently and historically, is significantly different to land use in the Shore Street catchment (South Dunedin has, and continues to have a large amount of commercial and industrial land use in the catchment, whereas the Shore Street catchment is predominantly urban residential).

The results of the 2010 biological assessment for the Shore Street catchment can be summarised as follows:

- Macroalgae: There were no macroalgae visible at the Shore Street site. This is different from the nearby South Dunedin catchment outfall which showed a reasonable diversity of mainly red algae, although coverage was sparse.

- Epifauna: The results indicate that epifauna abundance was reasonably sparse, at locations less than 5 m and greater than 20 m from the outfall, with just a few mud crabs and the occasional cockle evident. The diversity of epifauna overall was found to be very low with little change in diversity with distance from the outfall.

- Infauna: Infauna in the Shore Street catchment is dominated by polychaete worms, with glyceriids, nereidids and spionids all being very common at both the less than 5 m and greater than 20 m sites. The small snail Zeacumantus subcarinatus and cockles were present in both locations, however the cockles were far less common than at other soft bottom sites. This is likely to be attributable to exposure to fresh water and longer exposure at low tide.

The reports for the 2010 study and consent monitoring conclude that, whilst not pristine, the upper harbour and the communities associated with the intertidal areas adjacent to the major stormwater outfalls appear not to be undergoing any significant further degradation as a result of the stormwater inputs during the monitoring period (2007-2010).

### 5.1.4 Harbour Sediments

The resource consents associated with the outfall in the Shore Street catchment have no sediment monitoring requirements. However, to gain a clear picture of sediment contamination within the upper harbour basin, sediment samples were collected at numerous locations, including the Shore Street outfall. 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 harbour bed at the Shore Street outfall generally consists of clean fine silt and fine to course sand with low organic content (Ryder, 2010b).

Some historic data is available regarding contamination levels within harbour sediments, including sediments near the Shore Street outfall. 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.

The sediment analysis results for consent monitoring 2007-2010, and the 2010 study, are presented in Table 5-2 alongside Australian and New Zealand Environment and Conservation Council (ANZECC, 2000) sediment quality guidelines and discussed below.

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. Contaminant concentrations below the ANZECC (2000) low trigger values therefore, are unlikely to result in the onset of adverse biological effects.

Within the 20 mm samples collected and analysed for monitoring purposes, there may 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.

Contaminant levels in much of the harbour have been found to be highly variable but are generally higher closer to the outfalls than further away. However, this is not true for all contaminants or for all outfalls in any given year (Ryder, 2010b). For example, in 2010 copper and zinc levels were found to increase with distance from the Kitchener Street outfall.

The monitoring results presented in Table 5-2 show that Enterococci and faecal coliform numbers have fluctuated over time. However they have been very low over the past two years at the near outfall sampling site. Results from the more distant sampling site also showed very low concentrations.

Lead, zinc and PAH continue to be higher than the ANZECC low trigger values. This appeared to be the case for most of the outfalls monitored.

Contaminant concentrations of arsenic, chromium, nickel and PAH are higher further from the Shore Street outfall than nearby, when the 2010 results are compared. Three other catchments also discharge into Andersons Bay Inlet. It could be the cumulative effect of the stormwater discharges into the inlet, along with the long residence time for water in the inlet and low current velocities that has resulted in the higher concentrations further from the outfall, and not necessarily the Shore Street catchment contribution. However, data is limited because samples from greater than 20 m from the outfall have only been taken once.

However, the 2010 monitoring report noted that whilst copper, lead, nickel and zinc levels were generally elevated in the sediments in previous years, overall there was a general reduction in the concentration of these contaminants in sediments at most sites monitored that year, with the exception of Wickliffe Street (Halsey Street catchment). However, ANZECC low trigger values were still found to be exceeded by lead, zinc and PAHs at the majority of the sites.

**Table 5-2: Marine Sediment Guideline Values and Measured Contaminant Levels**

| Contaminant | ANZECC Trigger Value[1] | | Shore Street Outfall | | | | | Comment |
|---|---|---|---|---|---|---|---|---|
| | | | < 20 m | | | | > 20 m | |
| | Low | High | 2007 | 2008 | 2009 | 2010 | 2010 | |
| Arsenic (As) | 20 | 70 | 9.5 | 7.1 | 6.2 | 6.0 | 9.0 | All samples below ANZECC low trigger values. |
| Cadmium (Cd) | 1.5 | 10 | 0.4 | 0.3 | 0.3 | 0.3 | 0.114 | All samples below ANZECC low trigger values. |
| Chromium (Cr) | 80 | 370 | 21.8 | 16.0 | 18.0 | 19.0 | 27.0 | All samples below ANZECC low trigger values. |
| Copper (Cu) | 65 | 270 | 51 | 44 | 41 | 35 | 27.0 | All samples below ANZECC low trigger values. |
| Nickel (Ni) | 21 | 52 | 10.7 | 9.0 | 11.0 | 10.0 | 31.0 | All samples near outfall below ANZECC low trigger values. Exceedence of low trigger value further out. |
| Lead (Pb) | 50 | 220 | 113.0 | 110 | 79 | 85 | 59 | All samples near outfall above low trigger value. Below trigger value further out. |
| Zinc (Zn) | 200 | 410 | 484 | 300 | 330 | 350 | 171 | One early exceedence of high trigger value and later exceedence of low trigger value near outfall. Below trigger values further out. |
| PAHs | 4 | 45 | 9.6 | 21.0 | 8.6 | 10.5 | 19.0 | All samples above low trigger value |
| Enterococci* | - | - | 90 | > 1600 | < 2 | 460 | 4 | Generally low numbers, within range of typical stormwater runoff. |
| Faecal coliforms* | - | - | < 2 | 540 | < 2 | 130 | < 2 | Generally low numbers, within range of typical stormwater runoff. |

1. All values in units of mg/kg dry weight, except those contaminants marked with an *, which are in MPN/g.

NB. Contaminant concentrations below low trigger values are unlikely to result in the onset of adverse biological effects and therefore are not considered significant.

**KEY:**

Exceeds Low ANZECC Trigger Value

Exceeds High ANZECC Trigger Value

## 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 watercourses. The stream in the Shore Street catchment has been receiving stormwater from urban development (both diffuse and concentrated) since the early 1900s; as a result, DCC's stormwater collection network has evolved around these natural flow corridors.

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.

One stream with a natural channel was identified as suitable for assessment in the Shore Street catchment. A total of two sites were assessed in June 2010. The locations of the streams and assessment sites are shown in Figure 5-5.

Two assessment sites were established at the upstream and downstream ends of Shore Street 1.

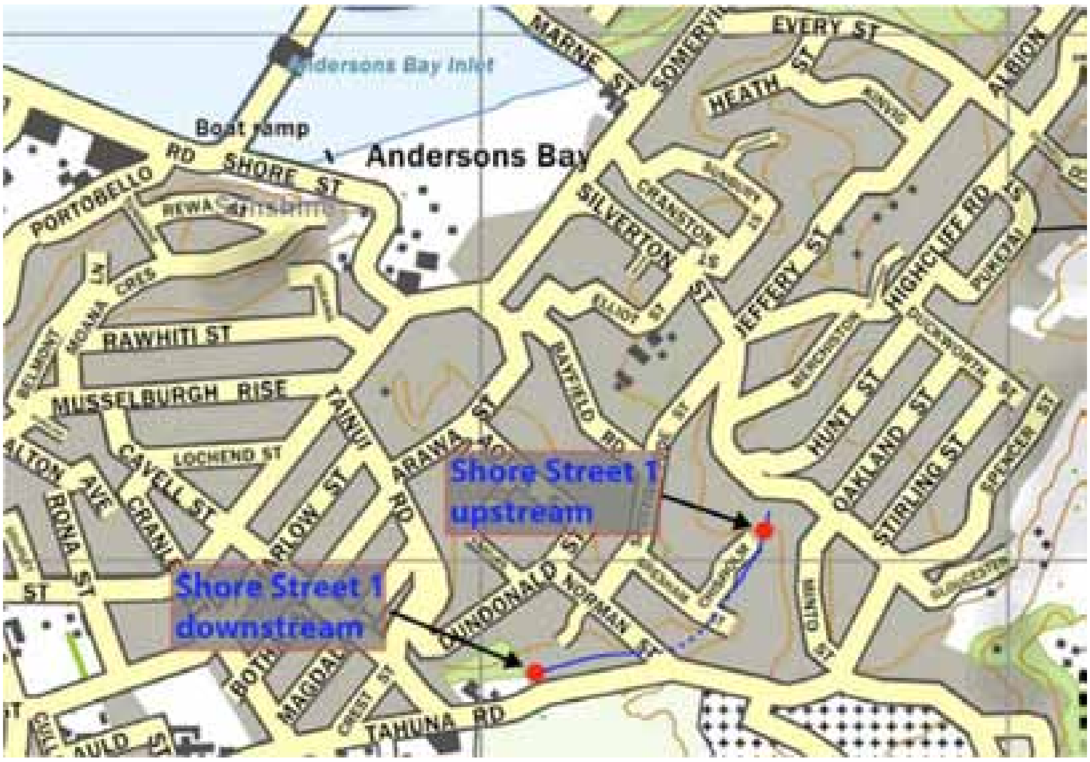


**Figure 5-5: Freshwater Receiving Environment**

### 5.2.1 Habitat Characteristics

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

**Table 5-3: Assessment Site Characteristics**

| Characteristic | Shore Street 1 - Upstream | Shore Street 1 - Downstream |
|---|---|---|
| Length | 50 m | 20 m |
| Channel width | 0.5 - 1.0 m | 2.0 m |
| Channel depth | 3 - 40 cm | 1 - 10 cm |
| Bank height | 1.5 - 0.2 m | 0.4 - 1.5 m |
| Bank stability | Moderately stable with some reinforcing | Stable |
| Wetted width | 0.02 – 0.3 m | 0.3 - 0.5 m |
| Dominant riparian vegetation | Grass, shrubs, some bamboo | Grass, shrubs, fruit trees |
| In-stream characteristics | Shallow riffles and drops - upstream end. Runs and small pools - downstream end | Shallow runs with small riffle sections |
| Bed substrate | Gravels and cobbles with large areas of concrete | Fine sediments, with small areas of gravels and occasional cobbles |
| Other | Woody debris, leave and moss - occasional | Woody debris and moss - absent. Some leaves |

Shore Street 1 Upstream

The upper reaches of this stream flows through stormwater pipes draining Tomahawk Road, then through a relatively steep natural channel to Chisholm Place. Land use in the catchment is urban.

Amenity values are limited to viewing from Chisholm Place due to the location on private land and dense vegetation in some areas. Refer Figure 5-6.

Shore Street 1 Downstream

The lower reaches of this stream flow through stormwater pipes between Chisholm Place and Norman Street before entering a low gradient natural channel. Refer Figure 5-6. The sampling site was located between a culvert beneath a private driveway and where it enters stormwater pipes. Land use is mainly urban, with a small area draining a golf course.

The stream does not support any public amenity values because it is entirely contained with the grounds of a primary school and is only visible from the school grounds and a private driveway.


**Figure 5-6: Shore Street 1 Stream Assessment Sites – (a) Upstream; (b) Downstream; and (c) Entrance to Stormwater Pipes near Downstream Site**

### 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 relatively high upstream and were considerably higher at the downstream site. High conductivity indicates 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 relatively low at both sites, only marginally above the minimum standard.

### 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 can be summarized 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 were not observed at the downstream site, but several patches of brown algae mats and short filaments were seen upstream.
- Aquatic Plants: Macrophytes were not seen at the upstream site. However, the downstream site contained high cover levels of aquatic plants including, sweetgrass, starwort, watercress and monkey musk.
- Macroinvertebrates: A total of 15 different taxa were observed within the Shore Street catchment. 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).
- Macroinvertebrate communities were dominated by oligochaete worms and orthoclad midge larvae, with the downstream site dominated by oligochaete worms, snails, pea clams, and Talitridae amphipods.
- Macroinvertebrate community health index scores were very low, with average MCI and SQMCI scores at both sites indicative of ‘poor’ quality habitat, using narrative terminology of Stark and Maxted 2004.
- Fish: No fish were caught or observed in the Shore Street stream at the time of assessment. However, subsequent to the assessment, a landowner caught a fish in vicinity of the Shore

Street 1 upstream site. Ryder Consulting identified the fish as a banded kokopu. Anecdotal evidence from the landowner also revealed that several smaller fish had been sighted in the stream. These are likely to be juvenile banded kokopu.

### 5.2.4 Summary

Further to the use of national classification systems, the different habitat and ecosystem features have been interpreted relative to each other and the other streams in the Dunedin stormwater catchments assessed as part of this study. This is shown in Table 5-4 below.

The aquatic ecosystems within the Shore Street 1 downstream site were generally of poor quality, with poor habitat, water quality and ecology.

The Shore Street 1 upstream site was found to be of slightly better quality with some 'good' habitat features and water quality. Whilst invertebrate communities were found to be poor, the fish community was found to be 'excellent'.

There are currently no relevant National Policy Statements or National Environment Standards relating to freshwater systems. There is a Proposed National Environmental Standard on Ecological Flows and Water Levels however the focus of this is on setting ecological flows and water levels in relation to water abstraction.

Whilst the stream quality is not good when compared to a pristine, wilderness environment, the quality of the stream in the Shore Street catchment is in general as to be expected for modified urban streams with the upstream reach being a good quality for a modified urban stream.

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

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

# 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 Shore 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 Shore Street catchment has been included in this sampling regime.

The resource consent for stormwater discharge from this catchment requires that the water quality sampling shall be undertaken: following one rainfall 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 grab sample was taken from the stormwater outfall within 1 hour of the commencement of a rainfall event to attempt to ensure that the first flush, and therefore worst case scenario, is captured.

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 Shore Street outfall, which is undertaken via a grab-sampling technique, providing a 'snapshot' of stormwater quality during a rainfall event.

Table 6-2 shows the results of the time-proportional sampling in Dunedin. The 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.

For zinc, suspended solids and lead, the results of the 2010 monitoring indicate a decreasing trend in contaminant levels. For other contaminants such as arsenic, cadmium, chromium, nickel and oil and grease, contaminant levels have remained below detectable levels.

Suspended solids, lead, copper and zinc remain within the typical range for urban stormwater (see Tables 6-2 and 6-3).

E.coli has decreased from the 2009 result and remains at levels within the contaminant ranges monitored for South Dunedin (Table 6-2). Faecal coliforms have also decreased from the 2009 result and remains at levels with the ranges monitored for South Dunedin and Port Chalmers (Table 6-2). Faecal coliform results are also within the typical range for urban stormwater (1,000 – 21,000 MPN/100 ml) according to Metcalf and Eddy (1991).

Considerable variability must be expected from the grab-sampling employed, due to factors influencing the results 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 (flushing) 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. Furthermore, the intensity of the rainfall event, particularly in the first few minutes, can significantly affect the dilution (and therefore contaminant concentration) of the first flush. The intensity of the rainfall events is not recorded during the stormwater monitoring.

The presence of FWAs within stormwater can be an indication of human waste contamination within the stormwater. FWA concentrations in the stormwater have increased over the years at the outfall, however E.coli and Faecal coliform levels have not, indicating that the increase in FWAs is not due to wastewater contamination.

**Table 6-1: Stormwater Quality Consent Monitoring Results – Shore 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 | 7.9 | 0.04 | BDL | BDL | 0.01 | 0.01 | 0.003 | 0.02 | 41 | BDL | 0.081 | 300 | 300 |
| 2008 | 7.2 | BDL | BDL | BDL | 0.014 | BDL | 0.0085 | 0.44 | 24 | BDL | 0.031 | 5100 | 5100 |
| 2009 | 7.3 | BDL | BDL | BDL | 0.02 | BDL | 0.0069 | 0.21 | 20 | BDL | 0.142 | 16000 | 16000 |
| 2010 | 7.4 | BDL | BDL | BDL | 0.012 | BDL | BDL | 0.115 | 9.5 | BDL | 0.98 | 7000 | 9400 |

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 Shore Street 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] | Shore Street 2010 |
|---|---|---|---|---|---|---|---|---|
| | Residential / Industrial | Christchurch | Industrial | Residential | Australian sites | Highway | Urban | Residential |
| TSS | 8 - 330 | 33 - 200 | 124 | 5 - 49 | 164 | 142 | - | 9.5 |
| Zinc | 0.05 - 2.50 | 0.40 | 2.80 | 0.003 - 0.260 | 0.910 | 0.329 | 0.09 – 0.80 | 0.115 |
| Copper | BDL - 0.23 | 0.05 | 0.08 | 0.002 - 0.031 | 0.08 | 0.054 | 0.015 – 0.110 | 0.012 |
| Lead | BDL - 0.087 | 0.075 | 0.23 | 0.003 - 0.007 | 0.25 | 0.4 | 0.06 – 0.19 | BDL |

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 Shore 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 '*Shore Street Model Build Report'* (URS, 2011a), and the *'Shore Street Catchment Hydraulic Performance Report'* (URS, 2011b), 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; 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 year ARI applied to 2060 extreme climate change).
- Five design rainfall events; 1 in 2 year, 1 in 5 year, 1 in 10 year, 1 in 50 year and 1 in 100 year 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 relied in the most part on DCC GIS and Hansen (database) information regarding network configuration and detail. Site visit information, operational knowledge and LiDAR (light detecting and ranging) survey data were also incorporated into the model. Catchment hydrological (runoff) parameters were initially estimated based on the calibrated model built for the adjacent catchment, South Dunedin, and then adjusted during calibration.

Confidence in the model output is considered to be moderate. The model output is not absolute, however it is an adequate tool for the purposes of indicating areas with a potential to flood, and allowing the comparative effects of the different rainstorms and climate change to be assessed.

## 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 overleaf 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 issues 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.

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: Shore 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 | 7.0 |
| | 1 in 5 yr | 15.5 |
| | 1 in 10 yr | 24.0 |
| Number of land parcels with flood depth potentially >= 300 mm[2] | 1 in 2[1] yr | 0 |
| | 1 in 5 yr | 2 |
| | 1 in 10 yr | 21 |
| | 1 in 50 yr | 40 |
| | 1 in 100 yr | 43 |
| Estimated flood extent (% of catchment area with flood depth >= 50 mm)[3] | 1 in 2[1] yr | 0.24 |
| | 1 in 5 yr | 0.57 |
| | 1 in 10 yr | 1.06 |
| | 1 in 50 yr | 1.84 |
| | 1 in 100 yr | 2.30 |
| Modelled percentage (by number) of pipes surcharging | 1 in 2[1] yr | 66.4 |
| | 1 in 5 yr | 81.5 |
| | 1 in 10 yr | 87.0 |
| Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover) | 1 in 2[1] yr | 11.6 |
| | 1 in 5 yr | 18.6 |
| | 1 in 10 yr | 20.9 |

[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

[3] Includes areas flooded outside the catchment boundary

**Table 7-2: Shore 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 | 24.8 | 26.4 | 27.1 | 27.9 | 33.3 |
| Number of land parcels with flood depth potentially >= 300 mm[1] | 1 in 10 yr | 21 | 22 | 24 | 24 | 35 |
| | 1 in 50 yr | | 43 | | 43 | |
| | 1 in 100 yr | | | | | 64 |
| Estimated Flood Extent (% of catchment area with flood depth >= 50 mm)[2] | 1 in 10 yr | 1.1 | 1.4 | 1.6 | 1.6 | 2.0 |
| | 1 in 50 yr | | 2.1 | | 2.4 | |
| | 1 in 100 yr | | | | | 3.33 |
| Modelled percentage (by number) of pipes surcharging | 1 in 10 yr | 87.0 | 87.7 | 88.4 | 88.4 | 93.2 |
| Percentage of manholes with free water level within 300 mm of cover | 1 in 10 yr | 21.7 | 24.0 | 25.6 | 25.6 | 25.6 |

[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


| | | | | | | |
|---|---|---|---|---|---|---|
| Dunedin 3 Waters Strategy | SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN<br>Figure 7-1<br>Model Extent | DISCIPLINE<br>Stormwater | Drawn: CA | Status: Draft | | |
| | | | Checked: AB | Scale: 1:5,000 | Plot Date: April 2011 | |
| | | | Approved: AB | Job. No: 42173227 | Map No: - | Revision: A |
| | | | Date: April 2011 | | | |

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# 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 car parks, 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 above, 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. Minimal model adjustment was required to achieve a calibrated model at the single flow monitor location near the outfall of the Shore Street catchment. All of the events meet the WaPUG criteria for peak flow, with two of the three meeting the criteria for depth, and one meeting the criteria for volume. A good level of calibration was achieved which provides a moderate to good level of confidence in the model's ability to broadly estimate the catchment response to extreme rainfall events.

The effects of stormwater quantity on the network within the Shore Street catchment are discussed in the following section. 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 modelling results indicate that approximately 76 % of the modelled manholes in the Shore Street catchment stormwater network can accommodate flows from a 1 in 10 yr ARI rainfall event without overflowing; although these pipes may be surcharged, manhole overflow is not predicted.

Overall, the current level of service of the stormwater network in the Shore Street catchment is variable; 93 % of the catchment manholes (120 out of 129 manholes) are able to contain a 1 in 2 yr ARI rainfall event; and 84.5 % a 1 in 5 yr ARI rainfall event.

The hydraulic capacity of the pipe network in Shore Street catchment is related not only to the pipe sizes and grades, but also to the tidal influence originating from the Andersons Bay outfall.

Analysis of tidal influence on the system indicates that during a 1 in 10 yr ARI rainfall event, a MHWS tide influences the network capacity in the flatter and low lying areas of the catchment and in particular, has an influence over the predicted flooding in the Ravelston Street and Lochend Street corner. The effect in other areas such as Bayfield Road, Musselburgh Rise and Tainui Road is considered minimal.

Figure 8-1 illustrates the parts of the network influenced by the tide and the resulting changes in flood depth with and without the MHWS boundary.


**Figure 8-1: Extent of Tidal Influence during a 1 in 10 yr ARI Rainfall Event**

The influence of climate change on predicted system performance indicates that the number of manholes predicted to overflow in a 1 in 10 yr ARI rainfall event increases from 24 % at present to 33 % when the 2060 extreme climate change rainfall and tide levels are taken into account. Analysis for growth effects results in an increase in manhole overflows of 0.8 %, with no change in the number of properties predicted to be susceptible to deep flooding during the 1 in 10 yr ARI rainfall event.

Similarly, due to climate change effects the amount of catchment surface predicted to flood increases from approximately 1 % to 2 % during the 1 in 10 yr ARI rainfall event.

### 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 rainfall events, current and future land use scenarios and climate change projections, generally modelled with a MHWS 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, customer complaints, and observations made on the catchment walkovers.

The accuracy of the flood hazard maps cannot be fully relied on to depict secondary flow paths and flooding extent due to possible inaccuracies within the data. The flooding indicated should therefore be considered as indicative with respect to the exact extent of the flooding, with a higher level of confidence in the location of surcharging manholes and volume of stormwater leaving the pipe network.

Predicted flooding in the Shore Street catchment appears to be confined to small areas in the flatter parts of the catchment, or associated with watercourse intakes; overflows in the southwest of the catchment are predicted to cross over into the South Dunedin catchment during large rainfall events. This has been confirmed by DCC Network Management and Maintenance staff.

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.

The two areas most affected by shallow flooding during small events (with a recurrence interval of less than 1 in 10 yrs) are Lochend Street and Tainui Road. These are discussed in Table 8-1 below. Figure 8-2 shows the surcharging manholes and surface flooding in these areas. It is noted that a number of manholes in these areas have been sealed to reduce nuisance flooding in the low lying area. Figure 8-3 illustrates the extent of surcharging in the Lochend Street stormwater line during a 1 in 2 yr ARI rainfall event.

**Table 8-1: Predicted Nuisance Flooding (50 mm – 300 mm deep) – up to a 1 in 10 yr ARI Rainfall Event**

| Location | Description | Predicted Cause | Minimum Rainfall Event (ARI yr) |
|---|---|---|---|
| Lochend Street | Low to moderate flooding in properties at the eastern end of Lochend Street and on Musselburgh Rise. Extends into South Dunedin catchment during large events. | Inadequate capacity and tidal influence on network, resulting in overflows on Musselburgh Rise, Rawhiti Street and Ravelston Street, and overland flow to gully in Lochend Street. | 1 in 2 |
| Tainui Road | Low to moderate flooding in the South Dunedin catchment due to overland flow from Tainui Road stormwater system. | Surcharging of the main network resulting in overflow from a steep lateral. | 1 in 2 |

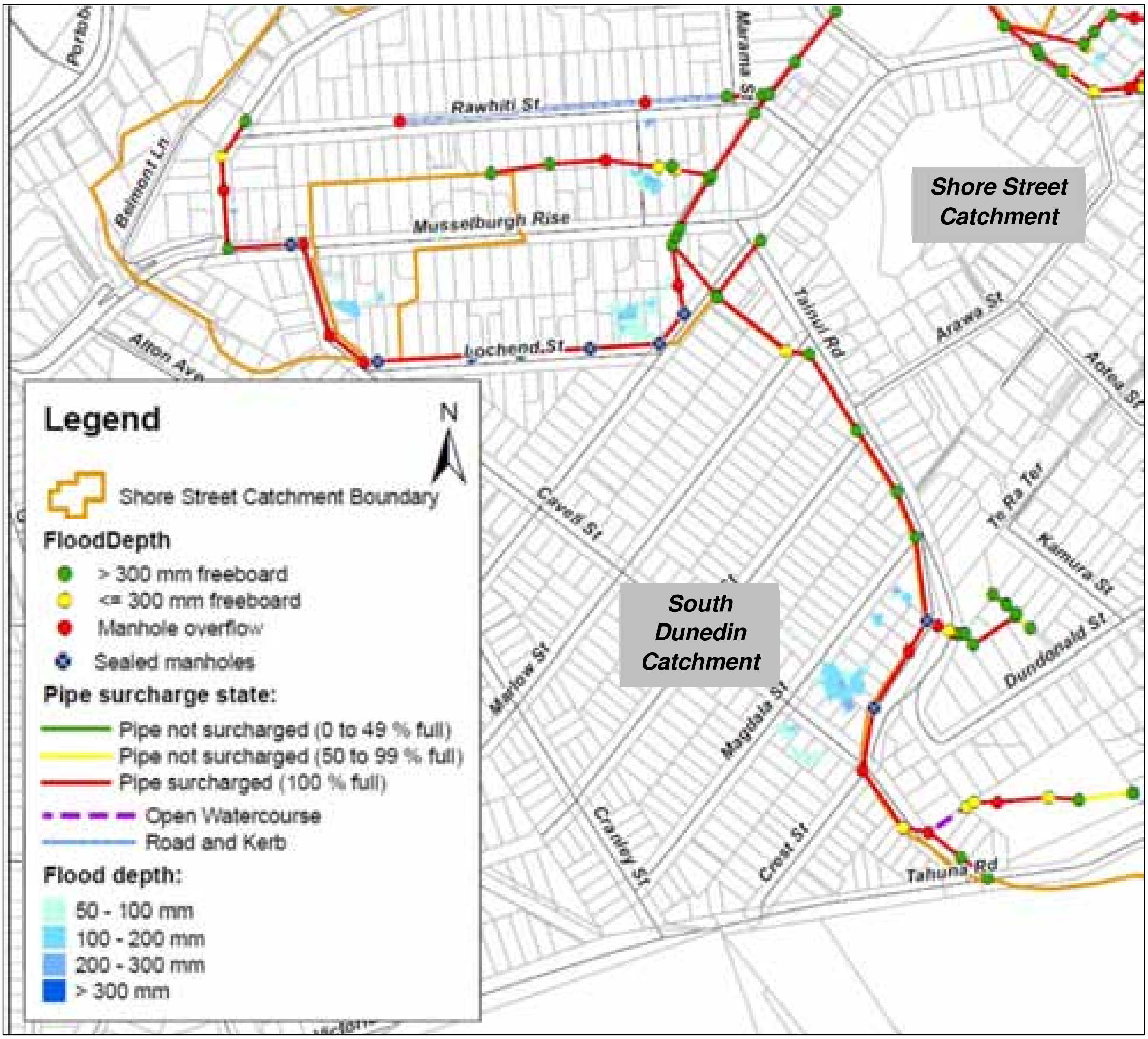



**Figure 8-2: Surcharging Pipes and Manholes causing Nuisance Flooding on Lochend Street and in the South Dunedin Catchment during a 1 in 5 yr ARI Rainfall Event**


**Figure 8-3: Longitudinal Profile along Lochend Street showing a Surcharged Network (1 in 2 yr ARI Rainfall Event)**

#### 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.

During the 1 in 50 yr ARI events modelled, 40 properties are predicted to experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the maximum land use increased the number of properties affected to 43; whereas under the 2060 land use the same number of properties experienced flood risk. It should be noted, however, that it is uncertain whether this flooding is likely to enter habitable floors, as no floor level survey has been undertaken, and a number of parcels are only predicted to experience flooding on part of the parcel.

Flood depths exceeding 300 mm are predicted on 21 parcels during a 1 in 10 yr ARI rainfall event, and on 2 properties during a 1 in 5 yr ARI rainfall event. No properties are predicted to be at risk during a 1 in 2 yr ARI rainfall event.

The three areas predicted to experience deep flooding are as follows:

**Lochend Street** / **Musselburgh Rise** - Deep surface water flooding is predicted to occur during the 1 in 10 yr ARI flood event to a depth > 300mm on a small number of parcels in this area This increases to eight parcels in a 1 in 50 yr ARI rainfall event (current land use, no climate change) at both the western and eastern ends of Lochend Street (Figure 8-4), and on Musselburgh Rise. This area has been the subject of flooding issues in the past, resulting in the sealing of manholes in the area. While this may have reduced the frequency of the flooding somewhat, it is still predicted to occur during large events.

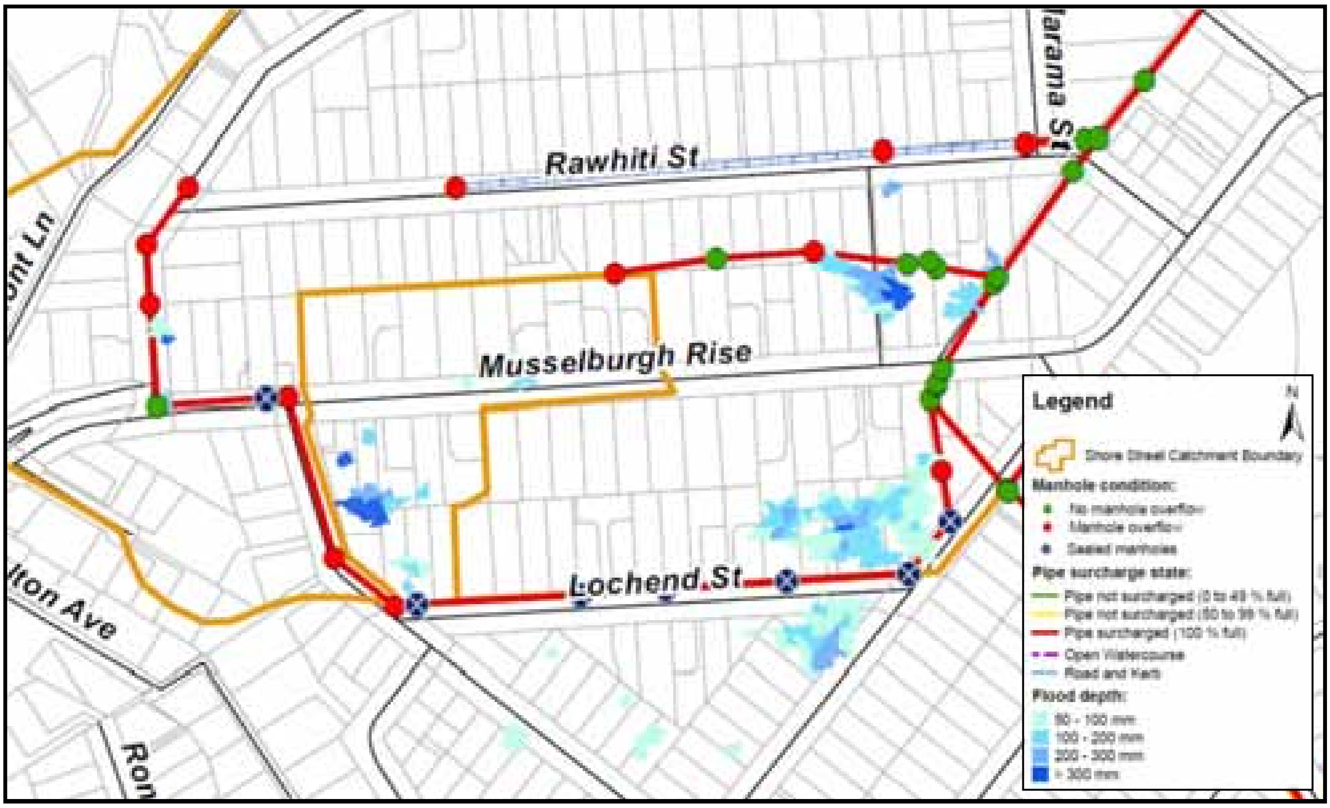



**Figure 8-4: 2010 Predicted Level of Service (1 in 50 yr ARI) – Lochend Street and Musselburgh Rise**

**Bayfield Road -** Deep surface water flooding is predicted to first occur during the 1 in 10 yr ARI flood event to a depth > 300 mm on two properties, increasing slightly during the 1 in 50 yr ARI rainfall event (Figure 8-5). Flooding is predicted due to capacity restrictions in the local network. DCC Network Management and Maintenance staff indicate that there is a motel in this vicinity, and that they are unaware of flooding being an issue in this location. Similarly, no flood complaints have been recorded in this area.

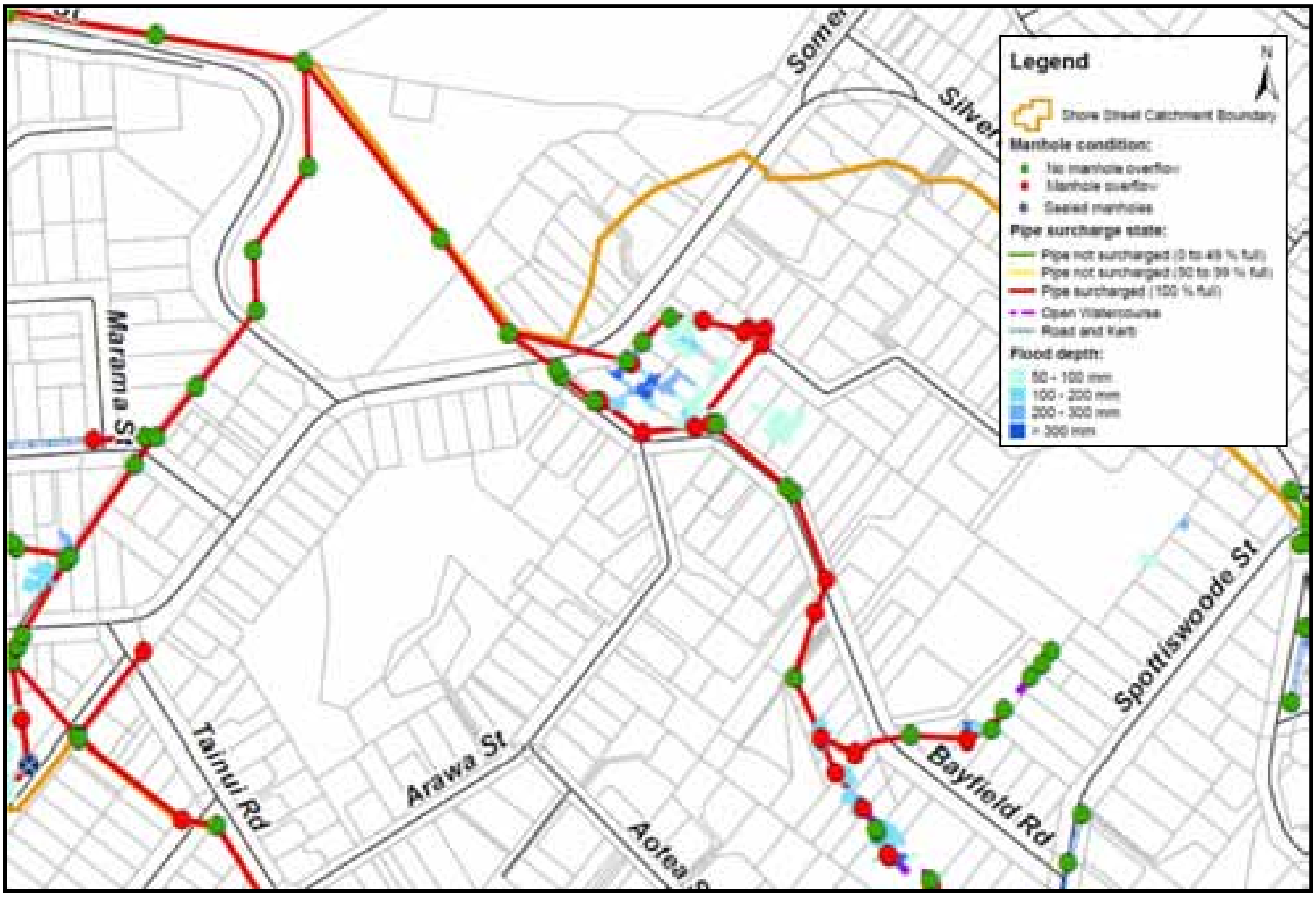



**Figure 8-5: 2010 Predicted Level of Service (1 in 50 yr ARI) – Bayfield Road and Somerville Street**

**Norman Street / Gresham Street** - Deep surface water flooding is predicted to occur during events as small as the 1 in 5 yr ARI rainfall event in locations around Gresham Street and Norman Street (Figure 8-6). DCC Network Management and Maintenance staff report that catchpits regularly block at the top of Chisholm Place and Minto Street, and that the pipe network in the Norman Street vicinity is not in good condition, and that flooding may indeed be an issue. Pipe surcharge maps indicate that this area has a lower capacity than the open watercourse / pipe network downstream of Norman Street. Reports of flooding have been noted along Tahuna Road also, which are potentially due to intake screen blocking; DCC staff also confirm that the intake within the Tainui School grounds on Tahuna Road is prone to blockage.

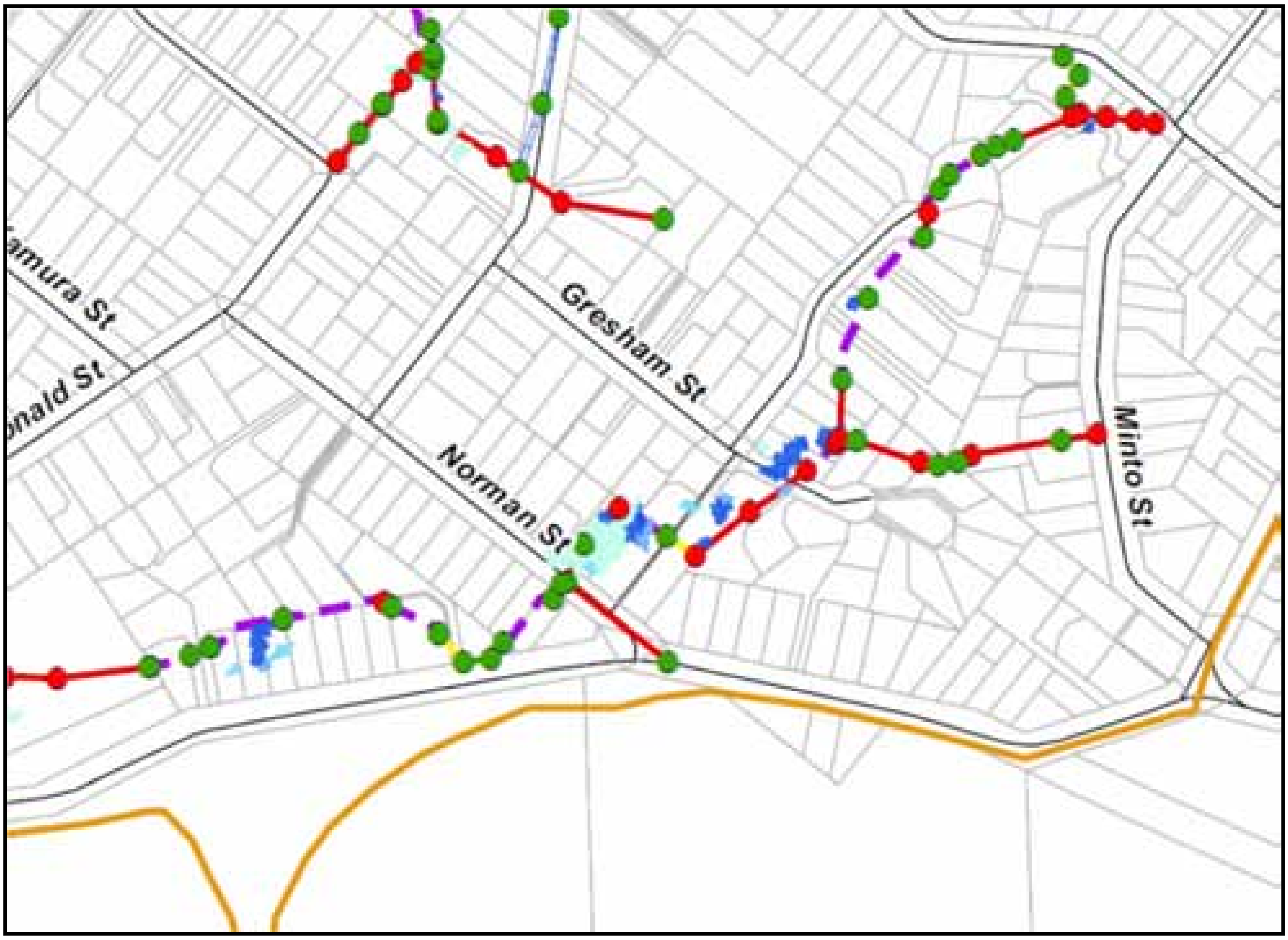



**Figure 8-6: 2010 Predicted Level of Service (1 in 50 yr ARI) – Gresham Street and Norman Street**

#### 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 8-2 below.

**Table 8-2: 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 emergency planning scenario modelling indicates that there is flood hazard risk to areas on the flat (Lochend Street and Cavell Street, and Bayfield Road / Musselburgh Rise), and along the watercourse channels (Gresham Street / Norman Street, Tahuna Road, and Bayfield Road).

Figure 8-7 shows the 2060 predicted flood hazard due to a 1 in 100 yr ARI rainfall and 1 in 20 yr ARI tide level (an extreme climate change event).

The flood hazard mapping shows that the areas of 'significant' flood hazard are very localised, and occur in locations also at risk of flooding during smaller events. As discussed above, the Lochend Street and Gresham Street areas are known flooding locations, whereas the area near the Bayfield Road / Musselburgh Rise intersection is unconfirmed.

During a future 1 in 100 yr ARI rainfall event when the extreme planning scenario is applied, it is likely that the area close to the Andersons Bay Inlet may become inundated directly due to sea level rise. Based on catchment topography, this is not expected to extend a long way into the catchment, however. It is beyond the scope of this management plan to detail the effects of sea change, however the effects of tide on the network have been assessed, and the model predicts that there is very little difference between the extent and predicted severity of flood hazard due to the stormwater network between the current and future scenarios.

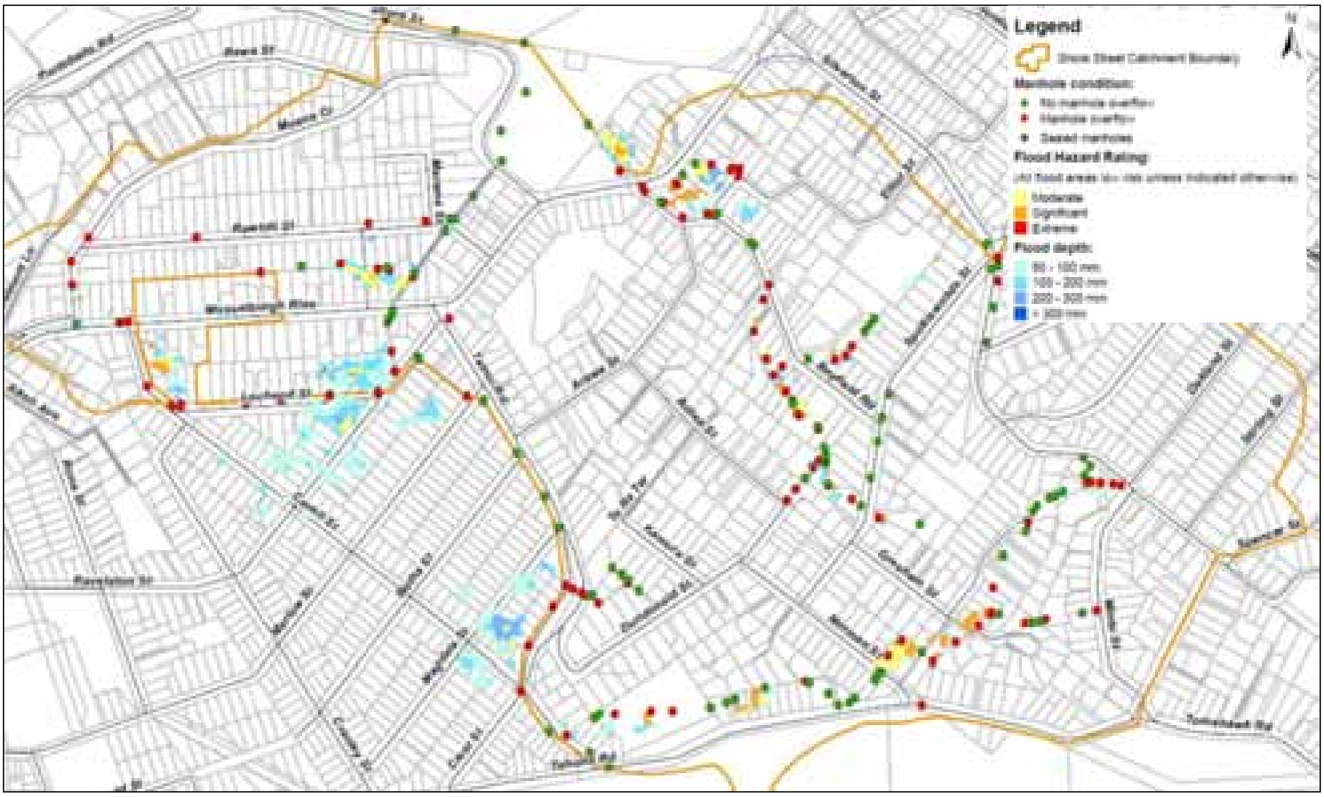



**Figure 8-7: 2060 Predicted Flood Hazard, 1 in 100 yr ARI Rainfall and 1 in 20 yr ARI Tide Level - Extreme Climate Change Event**

### 8.1.5 Network Age, Operation and Maintenance

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 Maintenance and Management staff as a potential issue during walkovers and workshops.

The main and possibly the key asset of this particular catchment is the flap valve at the outfall. Flow monitoring indicated that the flap valve may not be operating effectively, and is allowing negative flows into the network. DCC Network Management and Maintenance staff advise however, that this flap valve is inspected fortnightly. Baseflows from catchment streams sometimes also accumulate behind the flap valve; these flows are only released when the hydraulic head behind the valve is sufficient for it to open.

Watercourse intakes (some of them privately owned) at Chisholm Place, Normans Road and along Tahuna Road may be subject to blockage; these may benefit from inspection and improved maintenance regimes.

### 8.1.6 Culture and Amenity

There are no significant cultural or recreation sites predicted to be adversely affected by stormwater quantity within the catchment.

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

### 8.1.7 Summary of Effects of Stormwater Quantity

- The current level of service for the network in this catchment varies across the catchment but is generally between a 1 in 5 and 1 in 10 yr ARI rainfall event.
- The level of service of the stormwater network is significantly influenced by tide level, particularly in the lower flatter parts of the catchment towards the outfall.
- Flooding has been predicted and confirmed in Lochend Street and Tainui Road areas due to tidal influence and system capacity restrictions in the lower catchment.
- Flows from Lochend Street and Tainui Road are predicted to enter the South Dunedin catchment during large events.
- Flooding duration in the catchment is expected to be short given the proximity of predicted flooding to catchpits and the relatively short distance to the outfall. However, the relatively flat gradient at the lower end of the catchment could prolong the surface water flooding in the lower catchment areas
- Flooding in the Bayfield Road / Musselburgh Rise area has been predicted by the model but not confirmed by DCC Staff or customer complaints.
- Flooding in the Norman Street / Gresham Street area has been predicted and confirmed; this is potentially related to localised system capacity issues. Pipe condition may also be an issue in this area.
- Monitoring indicates that the flap gate at the outfall is not operating as it was originally designed. The flap valve appears not to be sealing properly when influenced under tidal conditions.
- Potential blockage of catchpits and stormwater inlet screens within the catchment are likely to contribute to flood duration and extent.
- Flood depths exceeding 300 mm are predicted on two properties during a 1 in 5 yr ARI rainfall event and 21 properties in a 1 in 10 yr ARI rainfall event.
- During the 1 in 50 yr ARI rainfall events modelled, up to 40 properties are predicted to experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the 2060 land use during a 1 in 50 yr ARI event could result in 43 properties experiencing deep flooding.
- During a current 1 in 100 yr ARI rainfall event, predicted maximum flood hazard rating for the catchment is ‘moderate / significant’. Risk to habitable floors / useful floor space during that

event occurs to a depth of up to 750 mm in the Tahuna Street, Musselburgh Rise, Cavell Street and Lochend Street areas.

- During a 1 in 100 yr ARI, the flood extents and depths predicted may render part of Lochend Street, Magdala Street and Norman Street impassable to traffic. However, these appear to be minor roads and not strategic routes. This flooding, therefore, is unlikely to cause significant traffic disruptions.

## 8.2 Stormwater Quality

Stormwater quality is discussed in detail in Section 6. Annual monitoring of the quality of the stormwater discharged from the Shore 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).

- For zinc, suspended solids and lead, the results of the 2010 monitoring indicate a decreasing trend in contaminant levels, since 2008.
- For other contaminants such as arsenic, cadmium, chromium, nickel and oil and grease, contaminant levels have remained below detectable levels for all years sampled.
- Suspended solids, lead, copper and zinc remain within the typical range for urban stormwater and are now at the lower end of that range.
- E.coli has decreased from the 2009 result and remains at levels within the contaminant ranges monitored for the South Dunedin catchment.
- FWA concentrations in the stormwater have increased over the years at the outfall, however E.coli and faecal coliforms have not, indicating that the increase in FWAs is not due to wastewater contamination.

In summary, no contaminants of concern have been identified through the stormwater sampling programme. However, it should be noted that the monitoring results do not include PAHs.

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 rainfall event, the concentration of contaminants within the stormwater varies depending on the time since the start of the event. This is indicated in Figure 8-8 below.

The time, during the rainfall 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 rainfall 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.

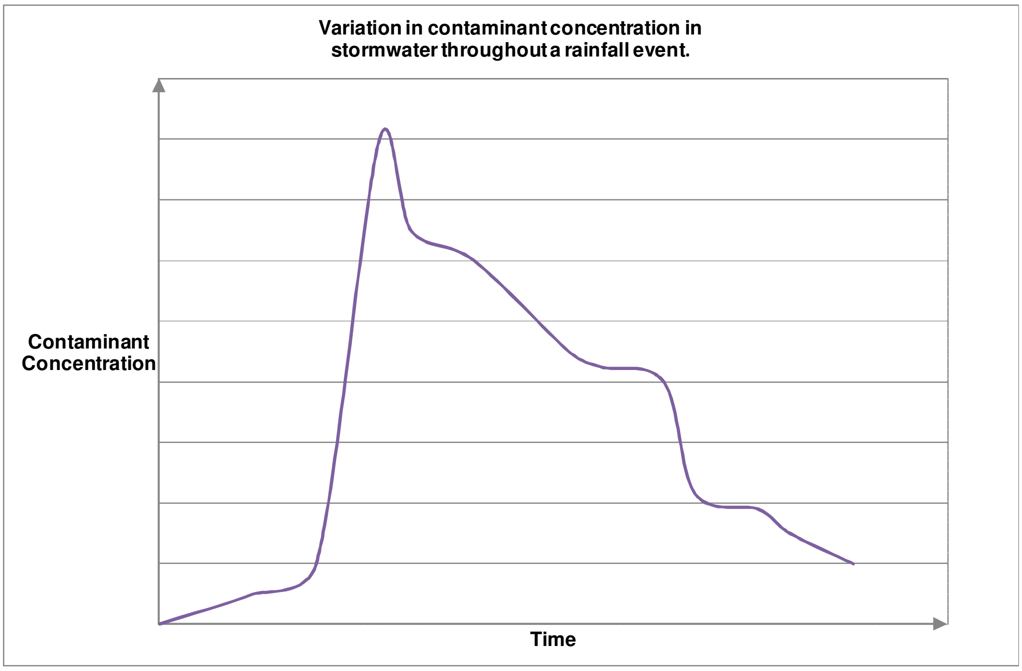



**Figure 8-8: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event**
(Based on time-proportional sampling carried out in Dunedin)

Flow data from the Wastewater study undertaken as part of the 3 Waters Strategy project indicates I&I issues within the wastewater system of this and the adjacent catchments. The suburbs of Sunshine and Musselburgh appear to be the largest contributors of I&I. When there are increased flows within the wastewater system of this catchment, primarily during rainfall events, a pressure operated relief valve in Marne Street diverts wastewater flows to the Marne Street pumping station which then discharges directly to Anderson's Bay. While not inside this catchment, the effects on the Andersons Bay Inlet may be influencing the receiving environment. Additionally, DCC Network Management and Maintenance staff noted a suspected wastewater overflow on Tainui Street within the Shore Street catchment.

Stormwater monitoring has not indicated the presence of wastewater in the discharge from the catchment, however harbour sediment monitoring has shown slightly elevated wastewater related contaminants in sediments throughout the sampling period (annually from 2007 to 2010). This could, however, be related to the Marne Street pumping station - at the time of writing this report, solutions to reduce the use of the Marne Street pumping station are being investigated.

### 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 outfalls and the quality of the water in the harbour.

While no national or international guidelines are available for stormwater discharge quality, ANZECC (2000) guidelines 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 water quality in 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 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. This is 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 for adverse effects, any exceedence of the guidelines therefore, indicates only a potential for adverse effects.

ANZECC sediment quality guidelines (ANZECC, 2000) 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 Shore Street Catchment

The contaminant levels within the Shore Street catchment receiving environment (The Andersons Bay Inlet) are discussed in detail in Section 5. To summarise, the levels of contaminants in the marine sediments in the Inlet, sampled in the in 2010 were generally low, although, lead, zinc and PAH exceeded the ANZECC (2000) low trigger values for the near outfall sampling site (as well as the more distant sampling site in the case of PAH). In general, the levels of contaminants were similar to those observed in previous monitoring years.

The elevated level of lead in sediments near the outfall was observed in all years from 2007-2010, but not at the site further from the outfall. Lead was not elevated in any of the 2007-2010 stormwater monitoring results. So, while the higher concentration of lead near the outfall compared with further away does suggest that the outfall and associated stormwater is responsible, the lack of data and the lack of observed lead in the stormwater samples put considerable uncertainty in this conclusion.

Zinc was also above the ANZECC (2000) trigger values at the near outfall site for all years monitored, but not above the trigger values at the more distant site. Stormwater results from this outfall have shown concentrations of zinc in the 2008-2010 samples at levels greater than the ANZECC (2000) trigger values. Therefore, there is some likelihood that the stormwater discharging from this outfall is responsible for the sediment contamination.

Levels of nickel and PAH that were sampled further from the outfall also exceeded the ANZECC (2000) low trigger values. These contaminant concentrations were higher than those observed closer to the outfall.

The elevated level of nickel within the sediments was observed in samples at a distance of greater than 20 m from the outfall only. Samples from this location have not been analysed in previous monitoring years. At a distance of less than 20 m from the outfall, nickel levels were not elevated above guideline trigger levels during any monitoring year (2007 to 2010). Furthermore, nickel was not elevated in any of the 2007-2010 stormwater monitoring results. It is difficult therefore to attribute the elevated nickel levels in the samples from greater than 20 m from the outfall with the quality of the stormwater discharges from this catchment.

While it is possible, and in some cases likely, that the contaminants measured in the sediments outside of the Shore Street outfall are a result of the stormwater discharging from the outfall there are other possible sources of contamination. These include historic contamination, ongoing contamination from sources outside of the catchment (such as discharges from other catchments), or factors unrelated to stormwater discharges (such as boating within the harbour). The fill used in the reclamation in this area is also likely to have contained waste materials, so it is possible that contaminants are leaching from the reclaimed area adjacent to the Inlet. Circulation patterns in the harbour may also result in contaminated harbour water and sediments entering the Inlet, and becoming trapped.

#### 8.2.2.2 Harbour-Wide

Harbour-wide, trends in the levels of contaminants in the sediment throughout 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 stormwater discharges from this catchment does not require any biological monitoring. However, investigations were undertaken in 2010. Therefore, there is a lack of temporal biological data for the Shore Street catchment with just 1 year of monitoring results. The 2010 investigations indicated that the marine benthic and infaunal communities in the vicinity of the outfalls in the catchment are of reasonably poor diversity with sparse abundance.

Historical data and the results of biological monitoring carried out for 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 lack of diversity may be attributable to anthropogenic influences, including stormwater quality, but other factors may also be contributing to the ecological health observed. For marine ecology in the vicinity of the Shore Street outfall low diversity and abundance are likely to be attributable to exposure to fresh water and longer exposure at high tide.

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. However, as the quality of stormwater and level of contamination in the sediments in the vicinity of the outfalls of this catchment were found to be reasonable it is likely that the poor ecology observed is as a result of other factors such as substrate composition or exposure at low tide.

### 8.2.4 Freshwater Habitat Quality

There is a single stream in the Shore Street catchment. The stream habitat, assessed in 2010, was generally found to be of poor quality with high conductivity levels, particularly at the downstream sampling site, with poor invertebrate communities and the absence of fish.

Stormwater inputs in the upper reaches of the stream have resulted in an increase in velocity and volumes of water in the upper reaches of the stream. This may have resulted in the stream flowing out of its channel in places, and has resulted in considerable bank erosion as well as increased levels of debris, wood and rubbish in the channel.

The stream is located within the urban area. It runs through private land and alternates between natural channel and stormwater pipes. Most of the catchment upstream of the open channel is developed, so water entering the stream from the piped network will consist of urban stormwater runoff. Stormwater discharging from the outfall displayed elevated levels of some contaminants. As such, the stream habitat quality is poor.

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 catchment to the streams assessed in the Shore Street catchment are urban residential and have an imperviousness of approximately 60 %. This suggests that the quality of the stream assessed in the Shore Street catchment is as to be expected. 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 can work acceptably in rural areas, in the urban context, private property owners often lack the 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 paths is vital to the flood protection provided by the stormwater network.

### 8.2.5 Freshwater Ecology

The aquatic ecology within the stream in this catchment was found to be variable with the upstream reach being of better quality than downstream.

Given that habitat quality and water quality at the downstream site surveyed was also found to be poor, it is likely that the poor ecology can be attributed to these factors.

The upstream site had several habitat features of ‘good’ quality, water quality was also found to be ‘good’. The presence of banded kokopu at this location (including juveniles) suggests that the fish population is successfully recruiting and there are no barriers to fish passage downstream in the catchment. However, invertebrate communities were found to be 'poor'

In general the stream and its ecology are likely to be limited by the small size of the stream catchment and the alternation between natural stream bed and the piped sections.

No benthic algae were observed in the downstream section of this site, although some was observed further upstream. Benthic algae is a primary producer, a reduction in the primary producers within a stream can have a detrimental impact on the food chain and aquatic ecosystem as a whole.

To summarise, the variable ecology, found in some instances to be poor, in the stream in the Shore Street catchment is likely to be as a result of the urban character of the environment feeding the stream, and possibly poor management of some sections of the stream, where it passes through private sections.

### 8.2.6 Culture and Amenity

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

The harbour has been used historically by Käi Tahu and their descendents and the discharge of stormwater and associated contaminants has the potential to significantly impact Käi Tahu values and beliefs. The historic decline of harbour quality has been noted by Käi Tahu.

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 Shore 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:

- Stormwater contaminant levels appear to be within the typical range for urban stormwater and some are showing decreasing trends. However, the results show high variability between years and contaminant levels were not significantly elevated during any sampling year.

- Harbour water quality is not currently monitored. Monitoring would allow comparison with ANZECC (2000) marine water quality guidelines and allow a link to be established between stormwater discharge quality and harbour water quality.

- Most sediment contaminants levels sampled near the Shore Street outfall are below the ANZECC (2000) sediment guideline trigger values, except for lead, zinc and PAH.

- Lead in sediments near the outfall has been elevated all years sampled, near the outfall, but not further away. Lead was not elevated in any of the stormwater monitoring results. So there is uncertainty as to whether stormwater from the outfall is responsible.

- Zinc in sediments was elevated at the near outfall site for all years monitored, but not above the trigger values at the more distant site. Stormwater results from this outfall have shown moderate concentrations of zinc. Therefore, there is some likelihood that the stormwater sourced from activities including general tyre wear, exhausts, galvanised building material and paints within the catchment may contribute to the sediment contamination.

- In general, 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 poor marine ecology in the vicinity of the Shore Street outfall 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. There is also a lack of temporal biological data for this catchment. Further rounds of monitoring would provide a clearer understanding of the health of the marine ecology in this catchment.

- Freshwater ecology within the catchment was found to be variable and in some cases poor. This is likely to be as a result of the urban character of the environment feeding the stream, as well as the influence of stormwater inputs, stream piping and potentially poor management in some areas, where the stream passes through private sections.

- The presence of fish, in the upstream reaches of the stream, indicates that there are no barriers to fish passage downstream in the catchment.

- Andersons Bay Inlet has important cultural (amenity) values. The results of investigations do not indicate that the inlet quality is deteriorating as a result of the quality of stormwater from this catchment.

# 9 Catchment Problems and Issues Summary

Following the AEE, and identification of catchment specific targets for stormwater management, a number of key problems and issues can be identified in the Shore Street catchment, and prioritised for action. These are discussed below. Section 10 following 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 Shore Street catchment.

## 9.1 Stormwater Quantity Issues

### 9.1.1 Low Level of Service

The level of service of the stormwater system is close to a 1 in 5 yr ARI, which is slightly below the current design standard for stormwater networks. The network renewals programme will drive the rate at which stormwater assets are renewed, at which time allowances for climate change effects will be made.

### 9.1.2 Significant Tidal Influence on Network

Tidal influence on the stormwater network in the Shore Street catchment has been reducing the level of service of the network for some time; sealing of manholes along Ravelston Street and Tainui Road has been undertaken in the past to reduce flooding during high tide / rainfall events.

### 9.1.3 Nuisance Flooding

Nuisance flooding is predicted and confirmed in two locations; in the Lochend street / Musselburgh Rise area, and adjacent to Tainui Road. This flooding becomes deeper and more extensive during larger rain events.

### 9.1.4 Deep Flooding

Flood depths exceeding 300 mm are predicted on two properties during a 1 in 5 yr ARI rainfall event and 21 properties in a 1 in 10 yr ARI rainfall event. During these events, the extent of deep flooding predicted is minor – small 'pockets' of deep flooding are predicted in a number of different areas. Visual assessment of the flood maps indicates that many of these areas of deep flooding are likely to be within watercourse channels, and are not posing a significant threat to habitable floors.

During the 1 in 50 yr ARI rainfall events modelled, up to 40 properties are predicted to experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the 2060 land use during a 1 in 50 yr ARI event could result in 43 properties experiencing deep flooding. Again, much of this deep flooding is in 'pockets' across the catchment, with the exception of the deep flooding predicted in the Norman Street / Gresham Street area.

Lower system capacity on Ravelston Street, Bayfield Road / Somerville Street, Tainui Road, and in the Norman Street vicinity appears to be the primary cause of flooding in this catchment. As discussed above, tidal influence is thought to be a major contributing factor in the lower catchment, however network configuration and stormwater asset maintenance may be an issue in the Norman Street area.

### 9.1.5 Overland Flow into the South Dunedin Catchment

Overland flow into the South Dunedin catchment is predicted to occur from the Tainui Road area during rainfall events as small as a 1 in 2 yr ARI rainfall event. Overland flow also leaves the catchment in the Lochend Street area during larger events (1 in 50 yr ARI and larger).

### 9.1.6 Blocking / Maintenance of Intake Structures

DCC Network Management and Maintenance staff have indicated that a number of catchpits and intake structures in the Chisholm Place and Tahuna Road area are prone to blockage. Maintenance of these structures is critical to the optimal operation of the hydraulic network. Negative flow observed during monitoring indicates that the flap valve at the Shore Street outfall is not fully closed. This is not expected to cause a significant issue during large rain events.

### 9.1.7 Flood Hazard – Current and Future 1 in 100 yr ARI

Pockets of flood hazard are predicted in the areas of the catchment prone to flooding, with the most significant hazard predicted in the Norman Street and Gresham Street area.

### 9.1.8 Network 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. This has the potential to exacerbate or transfer flooding.

## 9.2 Stormwater Quality Issues

It is clear that there is sediment contamination in the Andersons Bay Inlet; likely to be from a combination of the stormwater outfall and other sources. Although there is potential for ongoing contamination of the sediment from stormwater, the results are ambiguous and it has not been possible to establish a causal link from available data.

Elevated levels of lead, zinc and PAH have been measured in sediments adjacent to the outfall, however they do not correlate with stormwater quality sampling undertaken, and are potentially due to sources other than stormwater. The Andersons Bay Inlet is poorly flushed, and as such may be particularly sensitive to contaminant inputs, regardless of the source.

Stormwater quality could also be contributing to poor stream health in the stream surveyed. The management and maintenance of the stream physical environment is thought to be contributing to poor stream health at the lower catchment site in particular.

### 9.2.1 High Variability of Stormwater Quality Results

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

Monitoring indicates, however, that there are no major contaminants of concern in the Shore Street catchment stormwater.

### 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.

There appear to be limited contaminants of concern in the stormwater discharged from the Shore Street catchment, however there is evidence of elevated zinc, lead and PAH in the harbour sediments adjacent to the outfall. More confidence is needed in information relating to the state of the receiving environment, before links can be made between discharge quality and receiving environment health.

### 9.2.3 Ongoing Stormwater Discharge

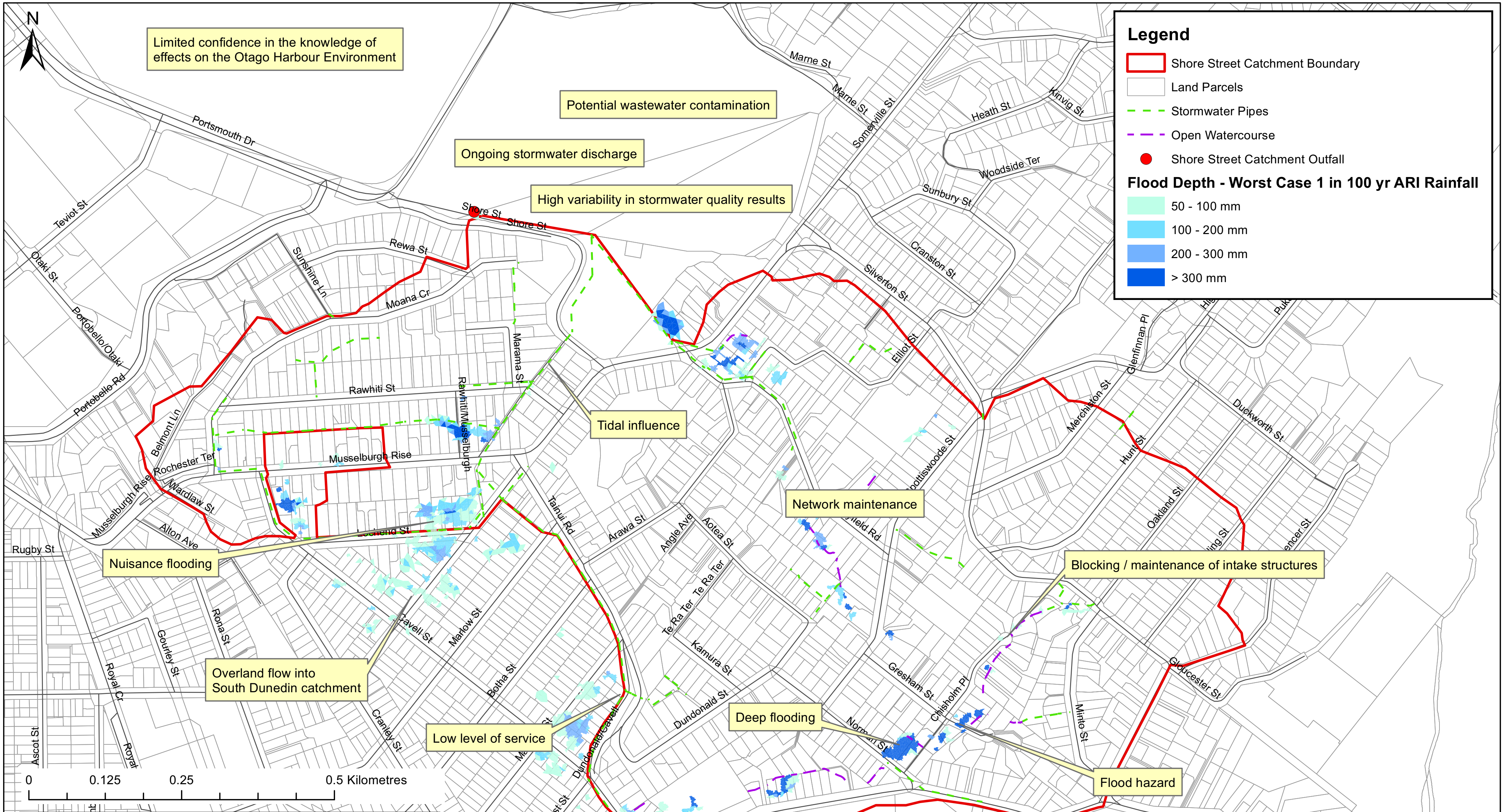
Stormwater quality monitoring indicates that the stormwater quality discharged from the Shore Street catchment appears to be typical for a catchment with residential land use. There are indications, however, that the sediments adjacent to the outfall are contaminated, however as discussed above, there is insufficient information available to enable the identification of the source(s) of this contamination, and further data is required to develop any conclusions.

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.

Further study outlined above will provide more information relating to the likely effects of the current stormwater discharge on the Andersons Bay Inlet.

### 9.2.4 Potential Wastewater Contamination

Potential wastewater overflows have been identified in this catchment. No strong evidence of this has been found, however, in catchment stormwater monitoring or sediment monitoring.




DISCLAIMER: Whilst we have attempted to produce mapping that is as reliable as possible, Dunedin City Council and its consultants (Opus / URS) accept no responsibility for the accuracy of the mapping, nor any decisions made based on it. The mapping was prepared for strategic planning purposes only. It indicates the predicted likelihood of flooding from stormwater reticulation for defined areas, based on the best available information at the time of preparation and is subject to uncertainty. The mapping is not sufficiently detailed to account for individual properties, as individual properties may be subject to local factors not considered in the modelling.

Created with ESRI ArcGIS

**Dunedin 3 Waters Strategy**

**SHORE STREET INTEGRATED CATCHMENT MANAGEMENT PLAN**

**Figure 9-1**

**Shore Street Catchment Issues**

| DISCIPLINE | Drawn: JMH | Status: Final | |
|---|---|---|---|
| Stormwater | Checked: HS | Scale: 1:6,000 | Plot Date: Sep 2011 |
| | Approved: HS | Job. No: 42173227 | Map No: Fig 9-1 / Revision: A |
| | Date: Sep 2011 | | |



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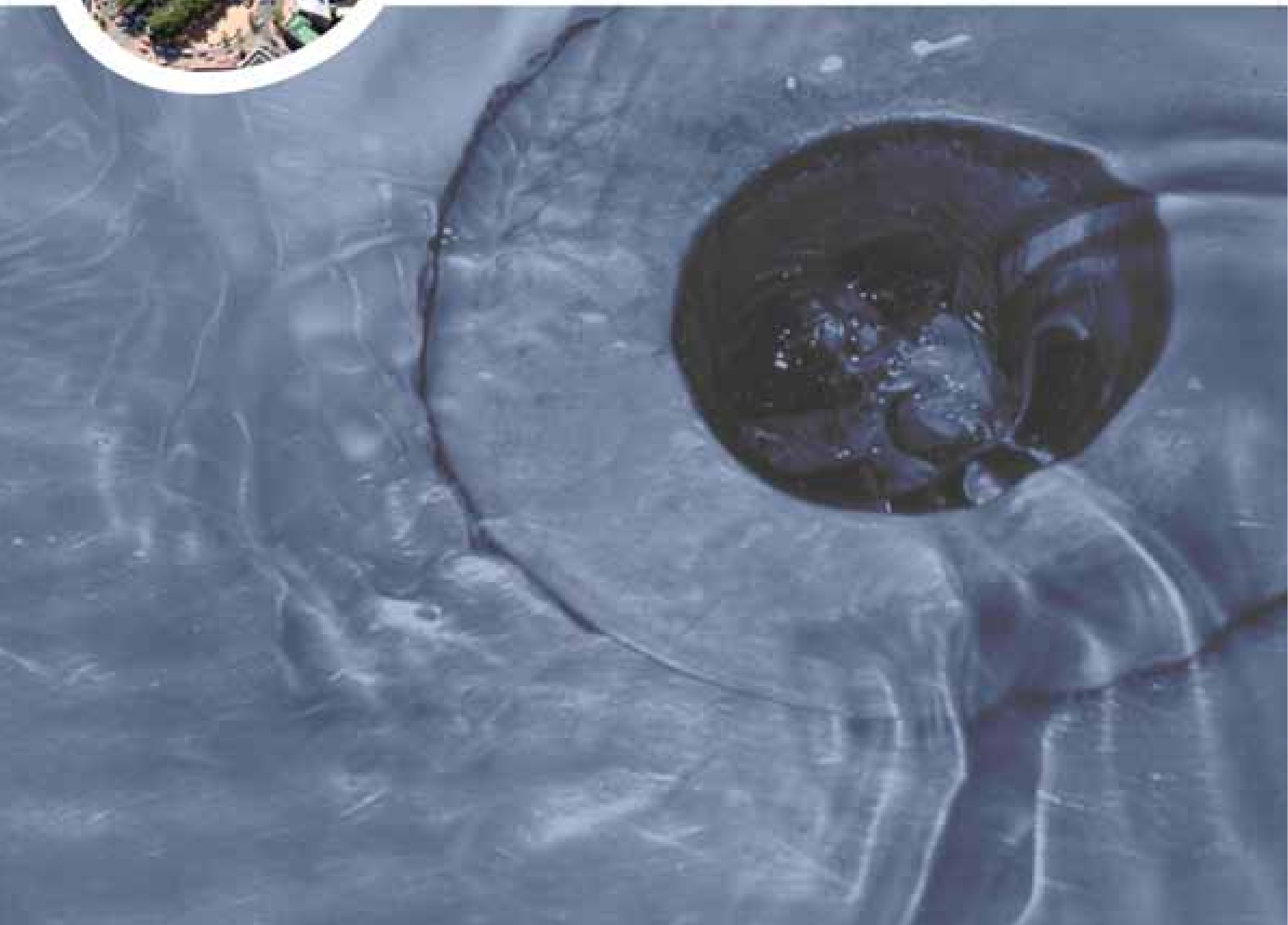
Original Size: A3

# 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 below provides a list of the main issues identified for the Shore 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 | CONSEQUENCE | | | | |
|---|---|---|---|---|---|
| LIKELIHOOD | 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: Issues Prioritisation**

| Issue | Consequence Rating | Likelihood Rating | Discussion | Risk Matrix Score | Management Approach |
|---|---|---|---|---|---|
| Blocking / Maintenance of Intake Structures | 40 | 4 | Blocking and maintenance of structures in parts of the catchment are contributing to nuisance and/or deep flooding in the upper catchment. The outfall valve may not be sealing during high tides, and allowing flow back into the network. The effects of this in terms of system capacity and flooding are not thought to be significant. | 160 | Manage Actively |
| 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.<br>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 |
| Potential Wastewater Contamination | 40 | 4 | There is an indication that wastewater may occasionally discharge into the stormwater system, however without better knowledge it is difficult to establish a source and significance of the threat. Major Stakeholder Issue. | 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.<br>Discharges from the Shore Street stormwater catchment, however, have contained moderately low levels of contaminants over the four year sampling period. | 120 | Manage Actively |
| 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 |
| 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 land use. | 40 | Manage Passively |

| Issue | Consequence Rating | Likelihood Rating | Discussion | Risk Matrix Score | Management Approach |
|---|---|---|---|---|---|
| Tidal Influence on Network | 10 | 4 | Tidal influence on the network reduces system capacity and results in flooding in isolated locations. The extent of deep flooding is minor, and it is likely that flooding is confined to the exterior of properties. | 40 | Manage Passively |
| Nuisance Flooding | 10 | 4 | Flooding predicted in a small number of locations, and flowing into adjacent catchment during some events. Not predicted to affect transport corridors, and likely to remain exterior to buildings. Effects likely to increase with climate change. | 40 | Manage Passively |
| Flood Hazard – Current and Future 1 in 100 yr ARI | 40 | 1 | Pockets of flood hazard in areas already subject to deep flooding. Not predicted to be widespread. | 40 | Manage Passively |
| Low Level of Service | 10 | 3 | Catchment level of service estimated to generally be between a 1 in 5 and a 1 in 10 yr ARI; specific areas appear to have hydraulic bottlenecks, and tidal influence affects system capacity. | 30 | Manage Passively |
| Deep Flooding | 10 | 3 | Deep flooding predicted in 'pockets' on a number of properties, but predominantly only in large events (40 predicted for the current 1 in 50 yr ARI, 20 during a 1 in 10 yr ARI rainfall event). Suspected to be mostly exterior to buildings, however limited knowledge of the threat (no surveyed floor levels). | 30 | Manage Passively |
| Overland Flow into the South Dunedin Catchment | 10 | 3 | Overland flow into the South Dunedin catchment is predicted to occur from two locations; from Tainui Road during small events, and from Lochend Street during large events. Additional contributions to the South Dunedin catchment from such flows could exacerbate existing issues with the stormwater and wastewater systems. | 30 | Manage Passively |

# 11 Catchment Specific Targets and Approaches for Stormwater Management

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

The information presented in the assessment AEE section of this report has been used to identify the key stormwater management issues for the Shore 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.

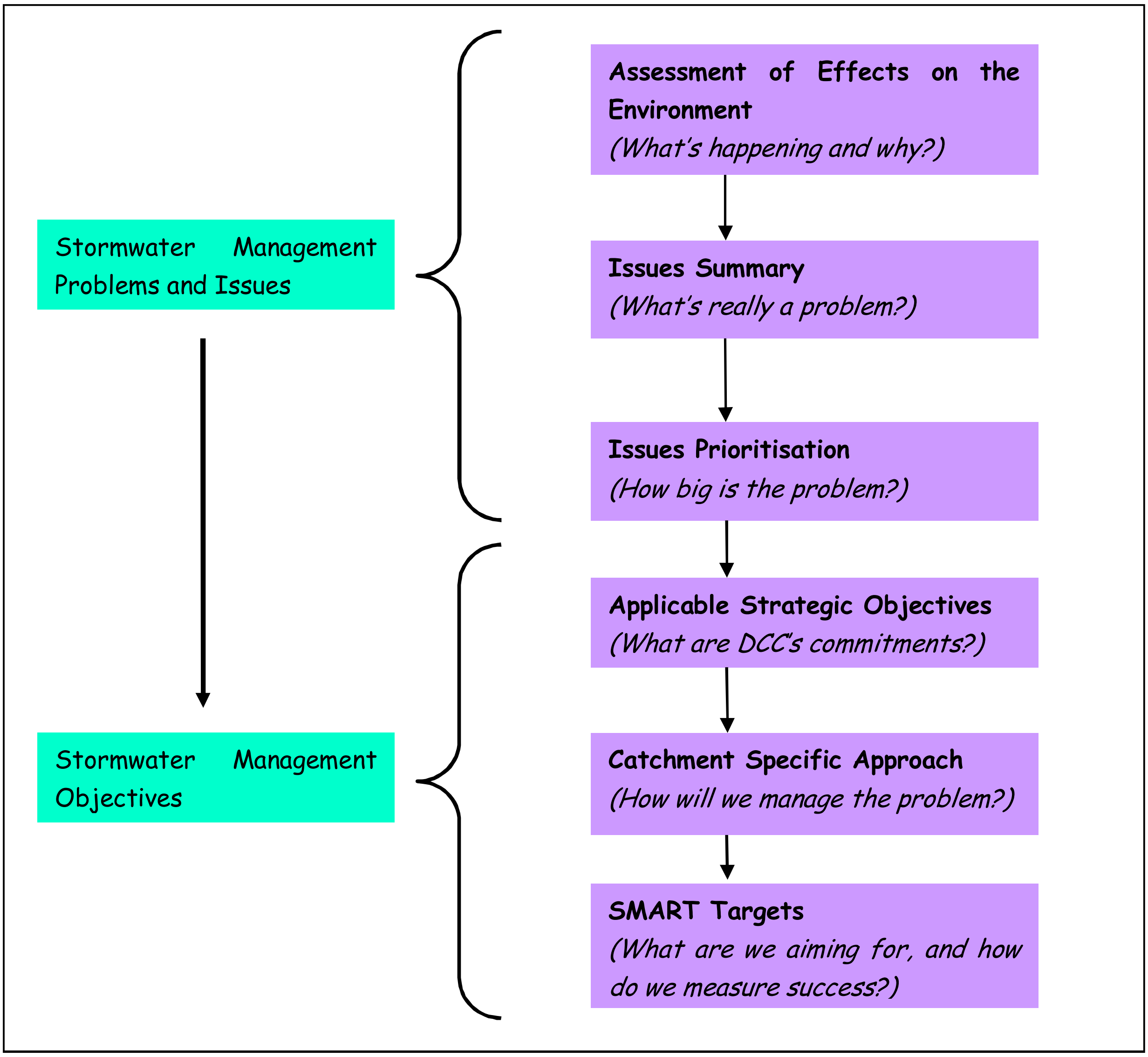



**Figure 11-1: Target Development Process**

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:

- **S**pecific – well defined and clear targets, able to be understood;
- **M**easurable – to provide feedback to continually improve performance;
- **A**chievable – to ensure success;
- **R**ealistic – within available resources, knowledge and time; and
- **T**ime-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 below outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the Shore Street catchment.

## 11.1 Stormwater Quantity Targets and Approaches

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

### 11.1.1 Blocking / Maintenance of Intake Structures

The blocking and poor maintenance of the watercourse running from Chisholm Place through to Tainui Road is likely to be exacerbating flooding in the area.

City-wide network maintenance is discussed as a separate issue, however a number of the approaches will be common to this issue; establishing criteria for screen cleaning and intake inspection is vital, as is identifying and advising those responsible for the maintenance.

In the Shore Street catchment, this issue has been prioritised due to the effects on catchment flooding; DCC may need to take a more active role in ensuring that intake structures and screens on privately owned watercourses are of a required standard, and well maintained. Initially, inspections of the drainage channels in the catchment should be undertaken to identify critical structures. Following this, options for structure improvement / optimisation can be considered along with options for improving the management and maintenance of the watercourse.

### 11.1.2 Network Maintenance

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 in Dunedin city is split between three DCC departments, and one national authority. Contracts for maintenance of catchpits and inlet structures have some differences in terms of performance criteria. Additionally, there would be benefit in identifying key assets 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.

### 11.1.3 Tidal Influence on Network

The tidal influence on the network in the Shore Street catchment is reducing the system capacity, and results in flooding in isolated locations. This issue will be addressed during solutions investigated for nuisance flooding and deep flooding, however it will make the design of solutions for relatively minor flooding difficult.

In terms of targets and approaches, this issue has been identified in order to highlight the significance of the tidal influence on network performance.

### 11.1.4 Nuisance Flooding

Nuisance flooding is predicted and confirmed in a number of areas in the catchment. This flooding is not predicted to affect transport corridors, however may be causing an issue on private properties. The resolution of the ground model, however, means that the exact location of the flooding is not confirmed.

Options pursued to resolve deep flooding in these areas, along with network renewals over time, are expected to resolve the majority of the nuisance flooding issues in the catchment. However, as identified above, the tidal effects on the network may result in continuing nuisance flooding in some areas.

### 11.1.5 Flood Hazard – Current and Future 1 in 100 yr ARI

Flood hazard issues in this catchment are considered to be fairly minor, with hazard being mainly restricted to areas already predicted to have deep flooding during a number of events. The majority of these locations are near or within watercourses in the upper catchment.

As such, the approach to this issue is one of passive management; ensuring that there is no increase in flooding due to development. There is a relatively small difference between predicted hazard in the current and future scenarios.

Additionally the area of direct inundation due to sea level rise is relatively small and confined to the area close to the inlet - it is unlikely that this catchment would be of high priority to the climate change adaptation group in terms of system performance, however it should be noted, as should the impacts of sea level rise on the tidal influence to the lower stormwater network.

### 11.1.6 Low Level of Service

Approximately 15 % of catchment manholes are predicted to overflow in a 1 in 5 yr ARI rainfall event, rising to approximately 22 % in a 1 in 10 yr ARI event. 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.

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 DCC's Code of Subdivision and Development, and also with the Building Act. Based on the age of the network, the pipes in the Shore Street catchment will be prioritised for assessment under the DCC pipe renewals programme. By 2060, 66 % of the pipes in the network (including those already at the desired level of service) will have been inspected and dependent on condition and performance, potentially replaced (with new pipes designed to convey the 1 in 10 yr ARI rainfall event).

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. 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 Shore Street catchment is partly within the South Dunedin group of this survey.

### 11.1.7 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. The modelling predicts that currently, up to 40 land parcels may experience flood depths greater than 300 mm during a current 1 in 50 yr ARI event. During a 1 in 10 yr ARI rainfall event, 21 properties are estimated to be at risk, however it is not considered that many of these properties have habitable floor risk from this flooding; deep flooding areas are small, and often remain within watercourse boundaries.

Targets for this flood hazard seek to avoid habitable floor flooding under both current and future land use and climate change scenarios, for all events smaller than and including the 1 in 50 yr ARI rainfall event. It is also desirable to avoid any increases in surface flooding of private properties during this event.

Because the modelled flood extents indicate that in many cases, flooding may not actually enter buildings, parcels identified as potentially being subject to deep flooding during rainfall 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, prior to detailed design of options.

'Land parcels' and 'properties' are both used to provide information in this context, however model results only provide information in terms of 'land parcels'. DCC's targets are focussed on avoiding habitable floor, or significant private property flooding, therefore actual numbers of properties / premises at risk is likely to be less than the number of land parcels reported.

The network renewals programme will review approximately 66 % of the Shore Street catchment network prior to 2060. Currently, however, approximately 76 % of the network can accept flows from the 1 in 10 yr ARI rainfall event without overflowing. Hence, the target is to maintain or improve the current level of service offered by the stormwater network in this catchment under climate change conditions.

#### 11.1.8 Overland Flow into the South Dunedin Catchment

Overland flow is predicted to move into the South Dunedin catchment area ('the Flat') from the Shore Street catchment during large rainfall events. To some extent, any proposed upgrades and renewals of the network in the catchment will reduce this overland flow, however the risk still remains during large events.

An assessment of the South Dunedin catchment hydraulic model results, alongside the Shore Street catchment hydraulic model results, may be required in order to consider how significant the impact of the overland flow is on the South Dunedin catchment (an area with known flooding issues).

**Table 11-1: Shore Street Catchment Management Targets: Stormwater Quantity**

| Issue (Problem Description) | Effects Summary | Strategic Objectives and Targets | Catchment Specific Approach | SMART Targets |
|---|---|---|---|---|
| Blocking / Maintenance of Intake Structures | A number of catchpits and intake structures in the Chisholm Place and Tahuna Road area are prone to blockage, resulting in small areas of deep flooding in these areas. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Actively***<br>Undertake an inspection of all open channel sections, to record status of intake structures.<br>Ensure damaged screens are replaced / fixed.<br>Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.<br>Work with property owners to ensure screens and intakes 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.<br>Develop list of key intake structures in Shore Street catchment requiring additional cleaning and maintenance checks by 2013.<br>Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013.<br>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 |
|---|---|---|---|---|
| Network Maintenance | Flooding extents and durations in the Shore Street catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen cleaning and maintenance.<br>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.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Ensure consistency city-wide of stormwater structure cleaning and maintenance.<br>Ensure cleaning and maintenance schedules and contracts are sufficiently robust.<br>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.<br>Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013.<br>Develop list of key stormwater assets in Shore Street catchment requiring additional cleaning and maintenance checks by 2013. |
| Tidal Influence on Network | Tidal influence on the network results in reduced capacity in lower network.<br>May be exacerbating nuisance flooding issues in some locations.<br>Will be affected by climate change, resulting in increased extent of flooding in lower catchment. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Develop a better understanding of the likely effects and magnitude of climate change. | > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.<br>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 |
|---|---|---|---|---|
| Nuisance Flooding | Nuisance flooding is predicted and confirmed in two areas in the catchment – in the vicinity of Lochend Street in the lower catchment, and from Tainui Road, causing flooding into the South Dunedin catchment.<br>Flooding is affected by tidal influence, and may be causing an issue on private properties. The resolution of the ground model, however, means that the exact location of the flooding is not confirmed. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Monitor customer complaints and / or undertake site visits to confirm locations of flooding. | > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. |
| Flood Hazard –<br>Current and Future 1 in 100 yr ARI | Flood hazard issues in this catchment are considered to be fairly minor, with hazard being identified in areas predicted to have deep flooding during a number of events. The majority of these locations are near or within watercourses in the upper catchment.<br>Transport routes are not predicted to be severely affected – inundation across roads is predicted to be shallow.<br>Small parts of lower catchment at risk of direct tidal inundation. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. | ***Manage Passively***<br>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.<br>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.<br>Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances). | 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 |
|---|---|---|---|---|
| Low Level of Service | 15 % of network manholes overflow during a 1 in 5 yr ARI rainfall event.<br>Low level of service in some locations contributing to nuisance (and deep) flooding. | Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.<br>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.<br>95 % of customer emergency response times met.<br>> 60 % residents' satisfaction with the stormwater collection service. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Use customer complaints and ROS to gauge satisfaction with the stormwater system performance. | > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.<br>> 60 % residents' satisfaction with the stormwater collection service (ongoing). |

| Issue (Problem Description) | Effects Summary | Strategic Objectives and Targets | Catchment Specific Approach | SMART Targets |
|---|---|---|---|---|
| Deep Flooding | Model results indicate 21 parcels affected by deep flooding during 1 in 10 yr ARI rainfall event; rises to 40 during 1 in 50 yr ARI rainfall event in current, and 43 land parcels in future planning scenarios.<br>Deep flooding is in small 'pockets', and likely to be mostly exterior to buildings (however 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.<br>Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. | ***Manage Passively***<br>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.<br>Enhance understanding of effects of deep flooding, particularly on private property.<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised). | < 40 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event.<br>Undertake habitable floor survey and / or damage assessment of potentially flooded properties.<br>> 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. |
| Overland Flow into the South Dunedin Catchment | Overland flow is predicted to move into the South Dunedin catchment area ('the Flat') from the Shore Street catchment from the Tainui Road area during small events, and from the Lochend Street area during large rainfall events. | Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.<br>Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. | ***Manage Passively***<br>Maintain or improve existing level of service in network.<br>Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances).<br>Undertake pipe renewals programme as scheduled (with older pipes prioritised).<br>Investigate effects on the South Dunedin catchment, and re-prioritise issue if significant. | Assess the effects of overland flooding from Shore Street catchment on South Dunedin catchment.<br>> 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. |

## 11.2 Stormwater Quality Targets and Approaches

A summary of key stormwater quality effects, and catchment specific approaches and targets set for the Shore 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 Shore Street catchment is adversely affecting the marine environment, targets and approaches 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 Potential Wastewater Contamination

DCC Network Management and Maintenance staff have suggested there may be an overflow on Tainui Street. This could affect the water quality in the receiving environment, or contribute wastewater into the stormwater system. No strong evidence of the overflow on Tainui Street has been found, however, in catchment stormwater monitoring or sediment monitoring. The improved stormwater monitoring programme can be used to confirm (or otherwise) the existence of an overflow on Tainui Street.

Discharges from the Marne Street pumping station into the Andersons Bay Inlet are known to occur, however, and are highly undesirable to DCC – outcomes from the wastewater component of the 3 Waters Strategy Project recommend capital works to reduce the use of the pumping station – the target is to have no overflows during a 1 in 10 yr ARI rainfall event. Monitoring is undertaken by DCC to measure the frequency at which it discharges.

### 11.2.2 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.

Samples taken from the Shore Street catchment discharge have, however, only contained moderate or low levels of residential land use associated contaminants, despite the variability in results.

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 – some sediment samples taken adjacent to the Shore Street catchment outfall have shown relatively high levels of contaminants, particularly heavy metals. 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 discharges.

Only one round of biological monitoring has been undertaken for the Shore Street catchment receiving environment; the results of this indicated poor marine ecology, however this data cannot be used to identify any particular trends or contributors to 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 harbour wide, the data does not appear to be showing any trends. With 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 defendable 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.

### 11.2.3 Ongoing Stormwater Discharge

The monitoring data at present does not indicate that the levels of contaminants in stormwater from the Shore Street catchment stormwater are significantly high. 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. Elevated levels of contaminants have been found in the marine sediments adjacent to the outfall, and the Andersons Bay Inlet is a ‘low energy’ environment, which appears to have been affected by historical land uses and activities in the area (and possibly in adjacent catchments). 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 receiving 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.

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

**Table 11-2: Shore Street Catchment Management Targets: Stormwater Quality**

| Issue (Problem Description) | Effects Summary | Strategic Objectives and Targets | Catchment Specific Approach | SMART Targets |
|---|---|---|---|---|
| Potential Wastewater Contamination | Known emergency discharge into the Andersons Bay Inlet from Marne Street pumping station.<br>Suspected overflow in Tainui Street area, although no evidence in stormwater sampling to date. | Improve the quality of stormwater discharges to minimise the impact on the environment.<br>Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.<br>> 75 % compliance with stormwater discharge consents.<br>Ensure stormwater discharge quality does not deteriorate. | ***Manage Actively***<br>Use improved monitoring programme to enable better understanding of potential catchment contamination. | No discharges from the Marne Street pumping station during 1 in 10 yr ARI rainfall event or less.<br>Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012.<br>Implement management options to remediate problem where necessary. |

| 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, however results to date indicate moderately low contaminant concentrations in stormwater discharge.<br>Poor information on actual effects of stormwater on harbour environment.<br>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.<br>Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.<br>No recorded breaches of the RMA.<br>Ensure stormwater discharge quality does not deteriorate. | ***Manage Actively***<br>Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework.<br>Develop method for determining linkages between stormwater management and harbour environment.<br>Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable.<br>Require source control of stormwater contaminants in new development of high-contaminant generating land uses.<br>Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.<br>Undertake monitoring to ensure stormwater quality does not deteriorate over time.<br>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.<br>Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013.<br>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 |
|---|---|---|---|---|
| Ongoing Stormwater Discharge | Could exacerbate historical contaminant issues in the harbour. Extent to which this is likely to occur is unconfirmed.<br>Key stakeholder issue.<br>Based on available data, consequence currently believed to be minor. | Improve the quality of stormwater discharges to minimise the impact on the environment.<br>Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges.<br>> 75 % compliance with stormwater discharge consents.<br>Ensure stormwater discharge quality does not deteriorate. | ***Manage Passively***<br>Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable.<br>Require source control of stormwater contaminants in new development of high-contaminant generating land uses.<br>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.<br>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 Shore 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.
- 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 subsequently evaluated against the QBL evaluation criteria outlined in Section 14, with the most favourable stormwater management option identified.

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 Shore 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 Shore Street 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 may be considered for further evaluation in Section 14, if more than one potential solution is available.

### 12.2.1 Blocking / Maintenance of Intake Structures – Manage Actively

Blocking of intake structures has been identified as a key issue in the Shore Street catchment. Observations during catchment walkovers, community comment, DCC Network Management and Maintenance comments, and model results all indicate that flooding in the catchment in the Norman Street and Gresham Street area is in either caused or exacerbated by blocked structures in the roads (catchpits) or watercourse (culverts).

The options to be considered at each site in order to reduce the risk of flooding (locally and at key flood locations) will be site dependent, and could include localised detention, watercourse piping, or a more rigorous maintenance regime. Therefore, the following approach has been recommended for this issue:

- Undertake an inspection of all open channel sections, to record status of intake structures.
- Ensure damaged screens are replaced or repaired.
- Identify areas in catchment where more regular cleaning and maintenance could reduce flooding risk.
- Work with property owners to ensure screens and intakes are properly maintained.

Additionally, ownership of each stormwater asset will need to be clarified. It is proposed, therefore, that further investigation, in the form of stream inspections and asset inventories, would be the first step in this process. Following from this, the criticality of each location would be assessed, and an appropriate management approach designed.

### 12.2.2 Network Maintenance – Manage Passively

Flooding extents and durations in Shore Street catchment could potentially be exacerbated should critical catchpits 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 Shore Street catchment, the following structures would be included:

- Catchpits at the top of Chisholm Place.
- Intake structures on Chisholm Place.
- Intake structures in Tainui School grounds.

As also discussed in Section 12.2.1 above, where these structures are in privately owned properties, DCC should review the current maintenance regime, and, if necessary contact the property owners to ensure that they have the appropriate advice regarding adequate maintenance of intake structures.

### 12.2.3 Tidal Influence on Network – Manage Passively

The influence of the tide on the lower network in the Shore Street catchment reduces the level of service provided by the network in that part of the catchment. Because the level of flooding generated by the current network configuration is not extreme, the approaches and targets for this issue rely on the pipe renewals process to ensure that in the future, the network has improved level of service in this area, and is designed to accommodate climate change impacts.

Further, some of the options investigated to reduce deep flooding in the catchment will also address this issue during design.

The main pipeline section of the network extending from the Shore Street outfall up to Tainui Road was all installed before 1960, with most of it installed between 1901 and 1940. This will ensure that the tidally influenced sections of pipeline are reviewed before 2060.

### 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.

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 and conveyance up to a 1 in 10 yr ARI rainfall event (as outlined in Table 12-1). It is likely that this, along with planned pipe renewals, will somewhat relieve the frequent nuisance flooding in the catchment over time. Additionally, the main areas experiencing nuisance flooding are being addressed actively under 'deep flooding' issues – nuisance flooding will therefore also abate as capital works or flood management options are implemented.

### 12.2.5 Flood Hazard (Current and Future) – Manage Passively

As the flood hazard in this catchment is predominantly related to deep flooding, reduction in the flood hazard is likely to occur during current and future events due to options employed to reduce deep flooding in the catchment. The catchment specific approaches identified for this issue are as follows:

- Ensure new development does not increase the number of properties predicted to flood due to the 1 in 100 yr ARI rainfall event.
- Avoid development of vulnerable sites / critical infrastructure in flood prone areas.

- Design new pipes with capacity to convey a 1 in 10 yr rainfall event (including climate change allowances).

- 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 above to a discussion on this regarding nuisance flooding).

The approach with respect to enhancing the understanding of climate change leads to the provision of information to DCC's climate change adaptation group, so that the information about the Shore Street catchment can be considered as part of the city-wide climate change adaptation plan.

### 12.2.6 Low Level of Service – Manage Passively

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 below 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.

Low level of service in the upper catchment will be addressed over time via pipe renewals; 66 % of the stormwater pipes in the Shore Street catchment are due for renewal within the timeframe of this document. The renewals 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. However where capacity is an issue, and level of service is compromised, renewals will be necessary.

The ROS can also be used to gauge satisfaction with the stormwater system performance. The suburbs of Musselburgh and Andersons Bay, part of the Shore Street catchment, have been considered by the survey as part of the 'South Dunedin' group; in 2010, 63 % of the respondents in this area were either satisfied or very satisfied with the stormwater collection service. 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 |

### 12.2.7 Deep Flooding – Manage Passively

DCC's target with respect to this flooding is to ensure that the risk is not increased in the future, as development occurs and climate change is taken into account. Additionally, planned pipe renewals will increase system capacity and potentially reduce potential floor flooding.

In order to fully understand the risk of habitable / useful space floor flooding, properties identified as being at risk will require building footprint confirmation and floor level survey to determine whether flood depths of 300 mm or greater would in fact enter the building. This is a particularly important step in the Shore Street catchment, where the deep flooding is often close to watercourses, and in 'pockets' across the catchment, rather than in large areas. Once the threat to habitable floors is confirmed (or otherwise), options can be explored further.

### 12.2.8 Overland Flow into the South Dunedin Catchment – Manage Passively

Modelling in the Shore Street catchment indicates that flooding from the Tainui Road area may flow overland into the South Dunedin catchment.

Upgrades in the Shore Street catchment, either as a direct result of options investigated to resolve flooding, or as part of the pipe renewal process, should reduce the extent of overland flow, however it will possibly still occur in large events.

It is critical to establish an understanding of the effects of this overland flow on the South Dunedin catchment. Network analysis undertaken in the South Dunedin ICMP (URS, 2010) indicated surcharging manholes in the Magdala Street area during a 1 in 10 yr ARI rainfall event, where flood flows are also predicted to travel from Tainui Road, indicating that there is not sufficient network capacity in the South Dunedin catchment to accept additional stormwater. Complaints have also been received in this area.

It is recommended that following outcomes of this ICMP, the flood hazard in the South Dunedin catchment is reviewed with respect to this information; additional modelling, in the form of combination of part of the Shore Street catchment model with the South Dunedin catchment model, may be necessary to quantify the risk.

### 12.2.9 Potential Wastewater Contamination – Actively

As discussed in Section 11 above, the wastewater programme has set a target of eliminating discharge from the Marne Street pumping station into Andersons Bay Inlet in events up to a 1 in 10 yr ARI. Work is underway to reduce wastewater overflows from the Marne Street pump station as part of the investigation and capital works programme being implemented for wastewater.

As the presence of another overflow has only been mentioned anecdotally, this issue has been prioritised as manage actively due to the high level of uncertainty regarding the wastewater overflow, along with the fact that wastewater discharge to the environment is a key stakeholder issue, and DCC are committed to avoiding such discharges. It is proposed that the monitoring programme be used to confirm (or otherwise) the presence of a wastewater discharge from other parts of the catchment.

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

Inconsistencies between the stormwater quality data collected from the Shore Street catchment and the sediment quality data collected adjacent to the outfall, combined with a lack of ecological data in the near receiving environment indicate that 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 Shore 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 defendable information on current stormwater discharge quality and the effects thereof. Following this, it is expected that the stormwater management approaches will be reviewed and adjusted where necessary to reflect DCC's strategic objectives.

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, as described below.

**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 sediment 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.

### 12.2.11 Ongoing Stormwater Discharge – Manage Passively

The monitoring data at present indicates that the levels of contaminants in stormwater from the Shore Street catchment are not significantly high. 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 residential nature 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 (predominantly residential in this catchment) 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.

# 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 capacity shortfalls.

### 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 success 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.

Issues in the Shore Street and adjacent catchments involve high I&I, and the consequent use of the Marne Street pumping station (outside of the Shore Street catchment) to discharge wastewater into the Andersons Bay Inlet during large rainfall events. As discussed in Section 4.9, preferred solutions have been developed to reduce wastewater discharge into the inlet, and will be assessed as part of DCC's asset planning programming.

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 have 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 an additional two risk categories, Implementation Risk and Effectiveness (risk reduction) separated from the core QBL by DCC and given significant weighting; the first to ensure that operationally, capital works installed will work, and the second to highlight the benefits of each option in terms of reduction of current risk and levels of service. The scoring framework is presented in Table 14-1 below. Weighting for each of the criteria has been assigned by DCC.

## 14.2 Options Comparison

For the Shore Street catchment there are a number of 'passive management' issues and only single options identified for higher priority issues and as such options comparison has not been necessary at the ICMP level. Comparison of recommendations for this catchment alongside other catchments will be undertaken as part of the 3 Waters Strategic Plan.

**Table 14-1: Option Assessment Criteria and Scoring System**

| QBL (weighting) | 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 (weighting) | 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 (weighting) | 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. |

# 15 Option Selection

## 15.1 Approaches for Active Management

The issues that have been prioritised in the Shore Street catchment as requiring 'active management' are identified below. As comparison of alternative options was not undertaken for the Shore Street catchment, all options presented in this ICMP have been recommended.

- Blocking / Maintenance of Intake Structures;
- Deep Flooding;
- Limited Confidence in Knowledge of Effects on the Otago Harbour Environment;
- High Variability of Stormwater Quality Results;

The following options have been recommended:

- Undertake watercourse inspections, to record status of watercourse environment, and current maintenance levels, and create an inventory of stormwater structures (including identification of ownership). Assess watercourses for opportunities to provide both stormwater quantity and quality benefits, and to provide enhanced amenity values.
- Ensure damaged screens on watercourses are replaced or repaired (where not imposing a threat to stream health).
- Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.
- Undertake ground and habitable floor level survey of 40 properties in areas with predicted deep flooding (up to a 1 in 50 yr ARI rainfall event). Following this, a re-assessment of the risk profile regarding deep flooding in the catchment should be undertaken.
- Redesign and implement the city-wide framework for stormwater quality and harbour environment monitoring.

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.

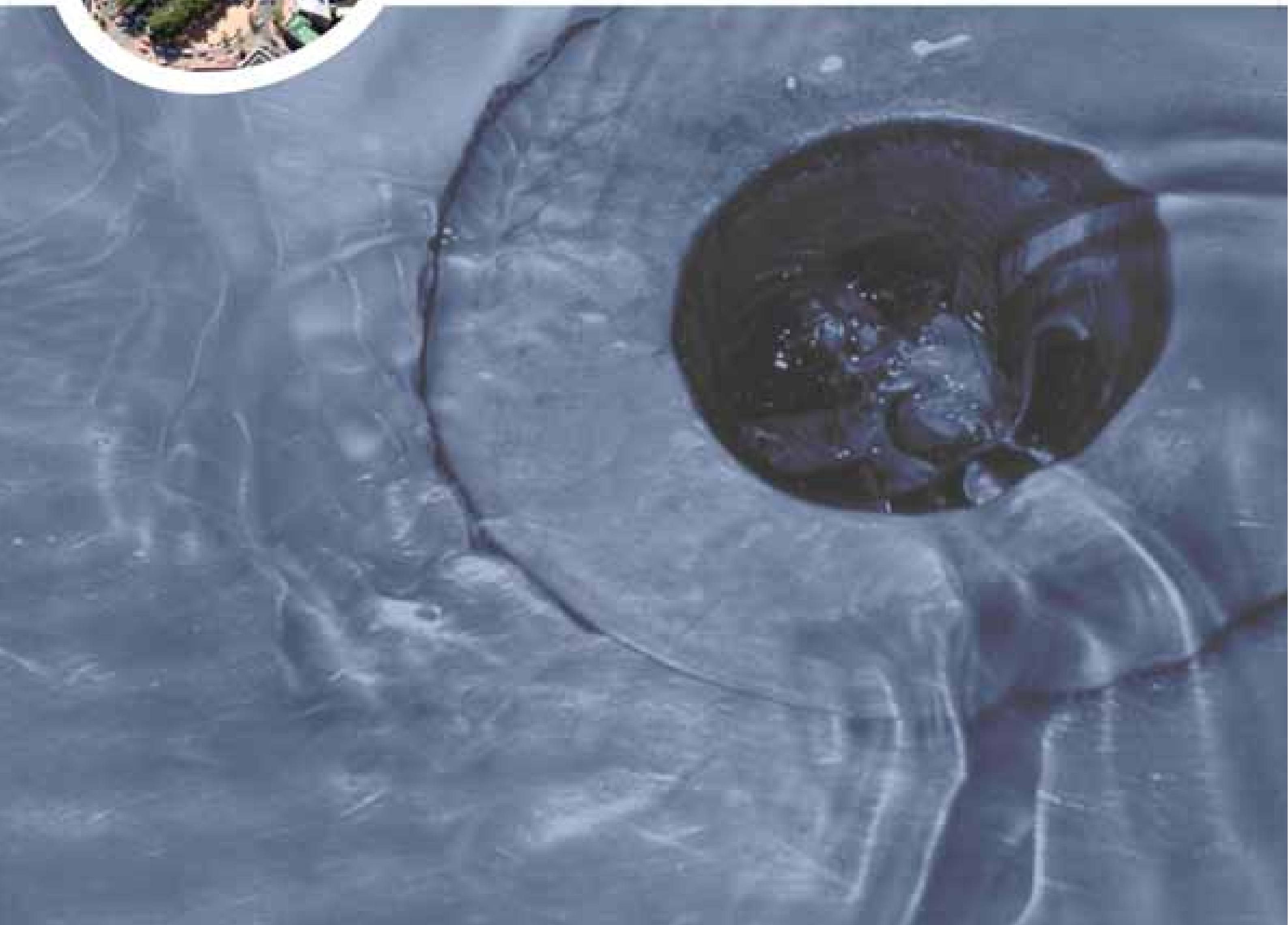
## 15.2 Approaches for Passive Management

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:

- Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.
- Develop list of key stormwater structures for more regular cleaning as part of existing and/or future maintenance contracts, incorporating Chisholm Place catchpits and watercourse inlets.

- Utilise ROS information to continuously gauge customer satisfaction with the stormwater service.
- Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.
- Provide information regarding predicted future flooding to the climate change adaptation team.
- Review flood hazard in South Dunedin catchment, incorporating effects from the Shore Street catchment.

# Part 6
Way Forward



# 16 Recommendations

The following tables provide a list of recommendations relating to stormwater management in the Shore 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, and operation and maintenance tasks. No capital works tasks have been recommended in this catchment. 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 |
| 160 | Undertake comprehensive watercourse inspections. | $ 40 k | 3 - 6 months |
| 30 | 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 |
| 30 | Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service. | $ 0 | Ongoing |

**Table 16-2: Planning and Education Recommendations**

| Risk Matrix Score | Task | Budget Cost | Work Period |
|---|---|---|---|
| 160 | Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided. | $ 0 | 3 - 6 months |
| 40 | Contribute information to a city-wide climate change adaptation plan. | $ 0 | 6 - 12 months |
| 40 | Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP. | $ 0 | 2 months |
| 30 | Review flood hazard in South Dunedin catchment, incorporating effects from the Shore Street catchment. | $ 10 - $ 20 k | 2 months |

**Table 16-3: Operation and Maintenance Recommendations**

| Risk Matrix Score | Task | Budget Cost | Work Period |
|---|---|---|---|
| 160 | Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired. | tba | Ongoing |
| 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. | $ 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 |

# 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 subsequently 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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