Dunedin 3 Waters Strategy

St Clair
Integrated Catchment Management Plan

St Clair Integrated Catchment Management Plan 2010-2060

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Dunedin 3 Waters Strategy

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Executive Summary

The St Clair 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, a short term (5 year) stormwater discharge consent was granted by the Otago Regional Council (ORC) permitting stormwater discharges into the Pacific Ocean at Second Beach, pending the development of a stormwater catchment management plan. The emphasis of the plan is the effective and efficient management of stormwater to minimise contamination of stormwater. This short term consent will be replaced with a long term (35 year) consent following the completion of ICMPs. Consent will also need to be granted for discharge to St Clair beach.

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 St Clair stormwater catchment covers an area of approximately 1.6 km^2 (164 ha). The catchment extends from the southern end of the suburb of Caversham, and is bounded in the north by South Road, and in the east by Forbury Road. Forbury Hill lies to the south-west, and the coastline between Cargill Castle and St Clair Beach forms the southern boundary of the catchment. The catchment includes the suburbs of St Clair, Kew and Forbury, and parts of the suburbs of Caversham, St Clair and Corstorphine East.

Early settlement in the St Clair suburb included farming and horticulture uses. A farm occupied the centre of the catchment, and market gardens were established by draining the flat swampy land nearer the coast (mainly within the South Dunedin stormwater catchment). From the early 1900s, however, the St Clair suburb became essentially residential, and home to many of the city's wealthy residents. Currently, the St Clair catchment is almost entirely residential, with the exception of the St Clair Golf Course, located in the south west of the catchment.

There was a Māori settlement in the area close to the St Clair Esplanade in pre-European times, and artefacts have been discovered close to the western end of the Esplanade and occasionally uncovered in the dunes which lie to the east.

Overall, including roads and land parcels, the St Clair stormwater catchment is estimated to have a current imperviousness of approximately 43 %. Approximately 88 % of the catchment is zoned Residential 1, which typically has a lower site coverage than other residential zones. With the exception of possible development of vacant lots, the St Clair 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 catchment is characterised by steep gullies along the head of the catchment in the west. The topography becomes flatter with low lying areas towards the east. The head of the catchment has an elevation of approximately 154 m above mean sea level. A number of stream gullies direct stormwater from the west of the catchment towards the main stormwater collection pipe running along Forbury Road in the east. Stormwater discharges to the Pacific Ocean via three outfalls; one at Second Beach, and two at St Clair Beach. The stormwater network has been based on these natural watercourses, and many of them have significant piped sections. Three streams were identified in the St Clair catchment as still being notable watercourses.

Structures of note in the catchment include a bypass structure at the intersection of Forbury Road and Hillside Road, transferring flows between the St Clair catchment and the South Dunedin catchment, and seven watercourse intake screens located throughout the network.

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, 84 % of the pipe network in the St Clair catchment 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.

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

There are a number of ‘major environmental’ locations identified in the St Clair catchment; these are predominantly due to landslide risk, or sites of historic landslides.

There are approximately 23 km of water supply pipes within the St Clair catchment, most of which are between 20 mm and 250 mm in diameter, and constructed from cast iron, asbestos cement and PVC. Fire flows in the south of the catchment are limited due to aged cast iron mains to the north of the water supply zones.

The wastewater system within the St Clair catchment comprises approximately 19 km of wastewater pipeline, approximately 89 % of which are between 150 mm and 300 mm in diameter. 3 Waters Strategy Project wastewater investigations revealed that a number of wastewater manhole overflows occur during rainfall events within this catchment. This has been verified by customer complaints records. Recommendations from the Phase 2 wastewater investigations include further investigation of the manhole overflow problems.

A linked 1 and 2-dimensional hydrological and hydraulic model of the St Clair 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 storm event scenarios. The model was calibrated, however confidence in the model output is considered to be moderately low, due to a lack of validation with reported flooding, however recent flooding on Forbury Road (May 2011) provides some validation of model predictions at this location. The model is considered to be 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 scenarios 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 St Clair catchment.

Stormwater quality information gathered in the catchment indicates that the levels of all contaminants discharged from the St Clair outfall are typical of stormwater quality from urban residential catchments. Additionally, monitoring undertaken at both Second Beach and St Clair beach indicates that significant adverse effects are not occurring in the receiving environment due to stormwater discharge.

Stormwater issues were prioritised, and management targets and catchment specific approaches were developed for the St Clair 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 St Clair 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-5 below outline the recommendations, split into further studies, planning and education, operation and maintenance, and capital works tasks. The further studies recommended will assist in improving certainty around catchment management targets, or provide further information in order to develop options. Note that where a recommendation is to be resourced internally at DCC, a cost of $ 0 has been assigned.

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

Table ES 1: St Clair Catchment Issues, Approach and Targets Summary

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Potential Wastewater Contamination	Single stormwater measurement in 2010 indicating potential wastewater contamination. Possibility of manhole overflows from the wastewater system supported by 3 Waters Wastewater Study and stream assessments.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Actively*** Support further investigation into overflows in catchment. Use improved monitoring programme to enable better understanding of potential catchment contamination.	Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012. Implement management options to remediate problem where necessary.
Cross Connection with the South Dunedin Stormwater Network	Limited knowledge of the effects of the cross connection due to independent modelling of catchments. Stormwater exchange between the South Dunedin and St Clair networks may be reducing the available capacity of the receiving network during extreme events.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	***Manage Actively*** Quantify and investigate effects of overflows through the bypass structure between the two networks.	Quantify and assess the effects of overflows from St Clair on South Dunedin, and / or vice versa by 2013. > 66 % of pipes to convey a 1 in 10 yr Average Recurrence Interval (ARI) rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Low Level of Service in Lower Catchment	While network capacity in the upper catchment is in excess of the 1 in 10 yr ARI rainfall event, the capacity of the Forbury Road interceptor stormwater line (leading to the outfalls) is insufficient to convey the flows from the catchment.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. 95 % of customer emergency response times met. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and residents' opinion survey (ROS) to gauge satisfaction with the stormwater system performance.	> 84 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in St Clair are potentially exacerbated by variations in the frequency and standards of catchpit and watercourse inlet screen cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Work with property owners to ensure screens and intakes are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Develop list of key stormwater assets in St Clair catchment requiring additional cleaning and maintenance checks by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Nuisance Flooding	Nuisance flooding is predicted and confirmed during small events in two main areas: along Forbury Road, from Wilson Avenue to approximately 80 m north of Macandrew Road; and surrounding an intake screen at 30 Middleton Road Not expected to inundate roads or be experienced for long periods of time.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Undertake an inspection of all open channel sections, to record status of intake structures. Monitor customer complaints and / or undertake site visits to confirm locations of flooding.	> 84 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. 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
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 identified in areas predicted to have deep flooding during a number of events. Transport routes are not predicted to be severely affected – inundation across roads is predicted to be shallow or confined to the sides of the road.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Design new pipes with capacity to convey a 1 in 10 yr ARI 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.
Ongoing Stormwater Discharge	Stormwater discharged contains relatively low levels of stormwater contaminants; no measurable adverse effects on the receiving environment. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Overland Flow into the South Dunedin Catchment	Overland flow is predicted to move into the South Dunedin catchment from the St Clair catchment, along Forbury Road during small events, as well as Beach Street during large storm events.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	***Manage Passively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Investigate effects on South Dunedin catchment, and re-prioritise issue if significant.	Assess the effects of overland flooding from St Clair catchment on South Dunedin catchment. > 84 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.
Deep Flooding	Model results indicate 2 parcels affected by deep flooding during a current 1 in 10 yr ARI rainfall event; rises to 5 during a current 1 in 50 yr ARI rainfall event in current, and 7 land parcels in the mean climate change future planning scenarios.	Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** 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. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 16 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event. Undertake habitable floor survey and / or damage assessment of potentially flooded properties. > 84 % 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
120	Combine the South Dunedin and St Clair 1-D and 2-D stormwater models.	$ 20 k	3 months
120	Undertake further stormwater monitoring to investigate the extent of potential wastewater contamination and likely sources within the catchment.	$ 10 k	Ongoing
50	Undertake comprehensive watercourse inspections.	$ 50 k	3 - 6 months
50	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	$ 0	Ongoing
20	Identify and undertake floor level survey and damage assessment of properties potentially internally affected by deep flooding (up to a 1 in 50 yr ARI).	$ 20 k	3 - 6 months

Table ES 3: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
50	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 months
50	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
30	Review flood hazard in South Dunedin catchment, incorporating effects from the St Clair catchment.	$ 10 - $ 20 k	2 months

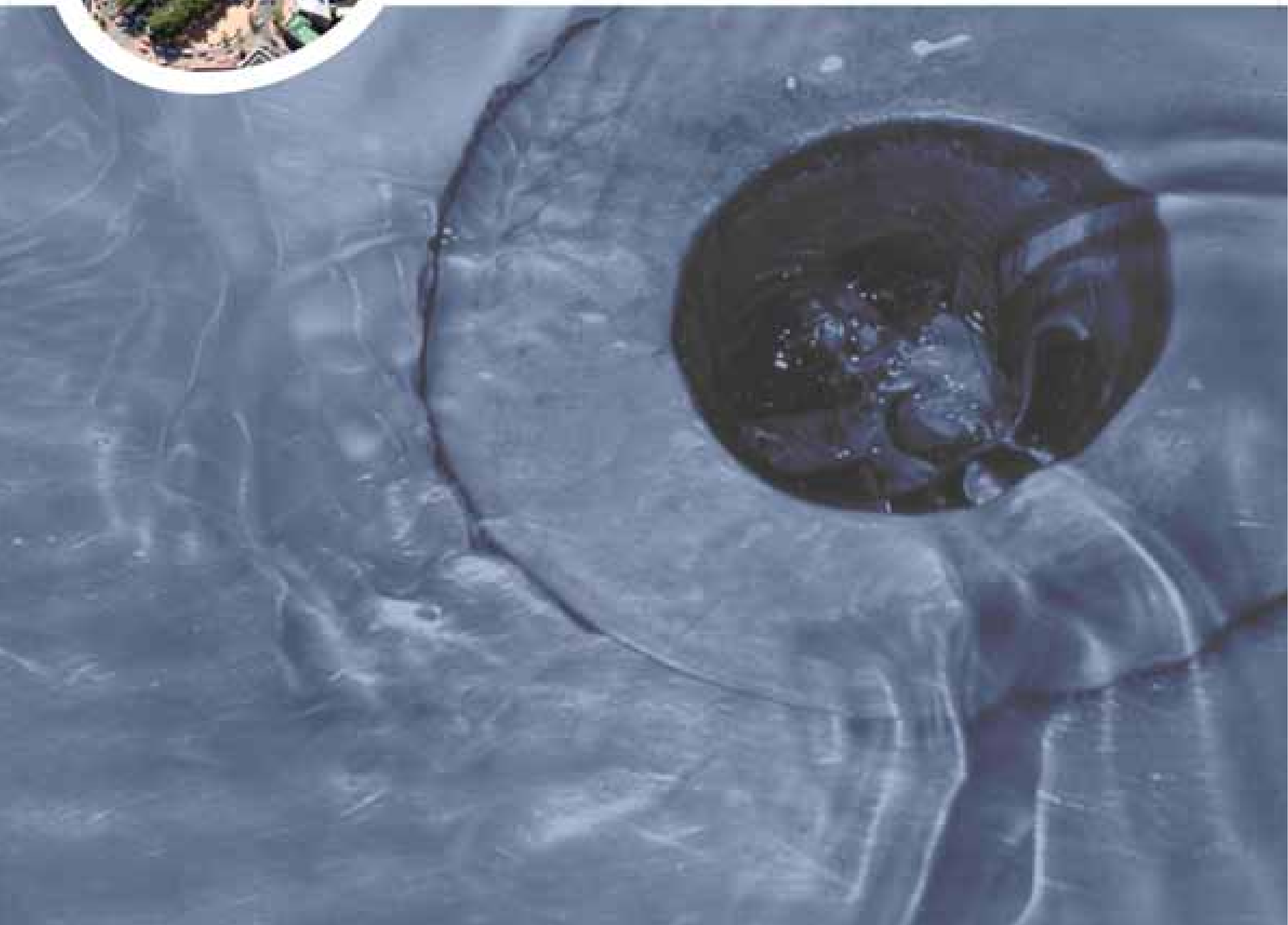
Table ES 4: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
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	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	tba	Ongoing
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months

Table ES 5: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Provide input into wastewater investigation and subsequent upgrade to reduce manhole overflows.	$ 20 k	6 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 St Clair 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 marine environment, as well as to provide future direction for DCC's stormwater management at a catchment specific scale.

In 2007, a short term (5 year) stormwater discharge consents were granted by the Otago Regional Council (ORC) permitting stormwater discharges into the Otago Harbour and the Pacific Ocean 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 marine 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 St Clair catchment (via the St Clair Bell Chamber outfall). The consent (Consent No. 2002.110), granted in November 2007, is for a period of five years. Condition 8 of the consent states:

> *"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 Second Beach that shall contribute to the effective and efficient management of stormwater in that catchment to minimise contamination of stormwater."*

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 St Clair catchment was ranked 9th out of 9 by this prioritisation, with a low score for sensitivity of the receiving environment (based on the fact that Second Beach is a 'high energy' environment compared with the Upper Otago Harbour). The absence of specific point source or diffuse pollution sources in the catchment (due to a lack of complaints of this nature and lack of pollution generating land uses) also contributed to the low score.

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.

TASK	STEP	DELIVERABLE
Stage 1 CITYWIDE PRIORITISATION AND REQUIREMENTS FOR CATCHMENT MANAGEMENT PLANNING	1.1 Defining Catchment Boundaries.	Catchment Boundary Map
	1.2 Development of prioritisation assessment framework	Agreed Assessment Criteria for Prioritisation
	1.3 Data Collation & Prioritisation of catchments	Draft Catchment Prioritisation Report
	1.4 Catchment Management Plan Framework	Draft CMP table of Contents
Stage 2 CATCHMENT CHARACTERISATION	2.1 Catchment Description	Catchment Description database
	2.2 Land Use Scenarios	Agreed land uses for current and future
	2.3 Discharge Monitoring	Monitoring report and data (subcontractor)
Stage 3 MODEL ANALYSIS	3.1 Definition of model extents	Agreed model extent
	3.2 Data Review and Collection	System Performance Report
	3.3 Model Development, calibration and validation	Model, metadata and model development report
	3.4 Assessment of Asset Capacity and Floodplain Development	Current level of service and flood hazard maps
	3.5 Stormwater Quality Model	Model, metadata and model development report
Stage 4 SCENARIO TESTING	4.1 Current and Future Landuse modelling	Issues report
Stage 5 OPTIONS ANALYSIS AND DEVELOPMENT OF CATCHMENT MANAGEMENT PLAN	5.1 Options Development	Agreed concept level options for comparison and assessment.
	5.2 Options assessment and Catchment Management Plan development	Draft and Final CMP reports
Stage 6 CATCHMENT REPRIORITISATION	6.1 Re-assessment of stormwater catchments	Final catchment prioritisation report

Figure 1-1: Scope of Work

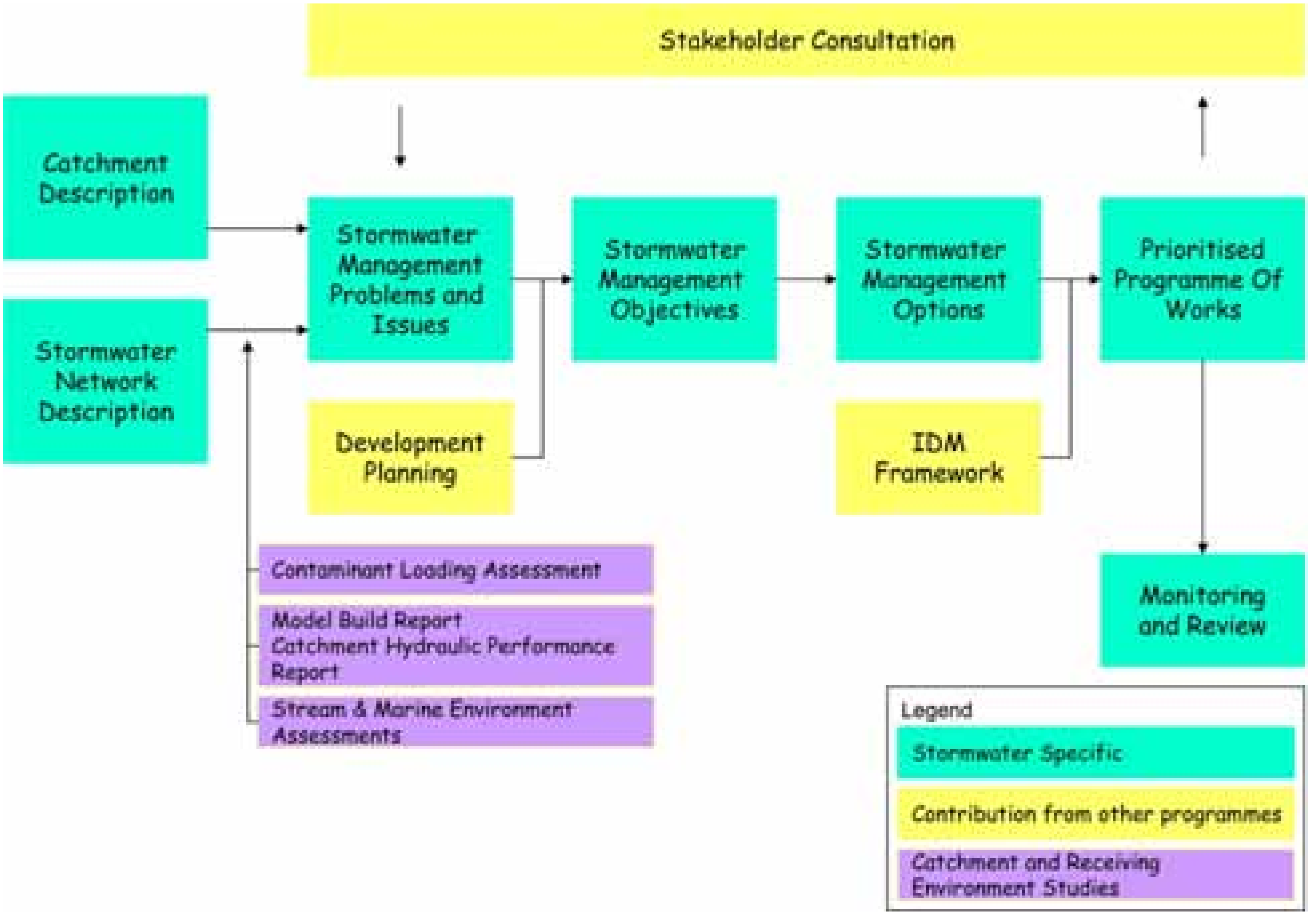


Figure 1-2: ICMP Development Process

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.

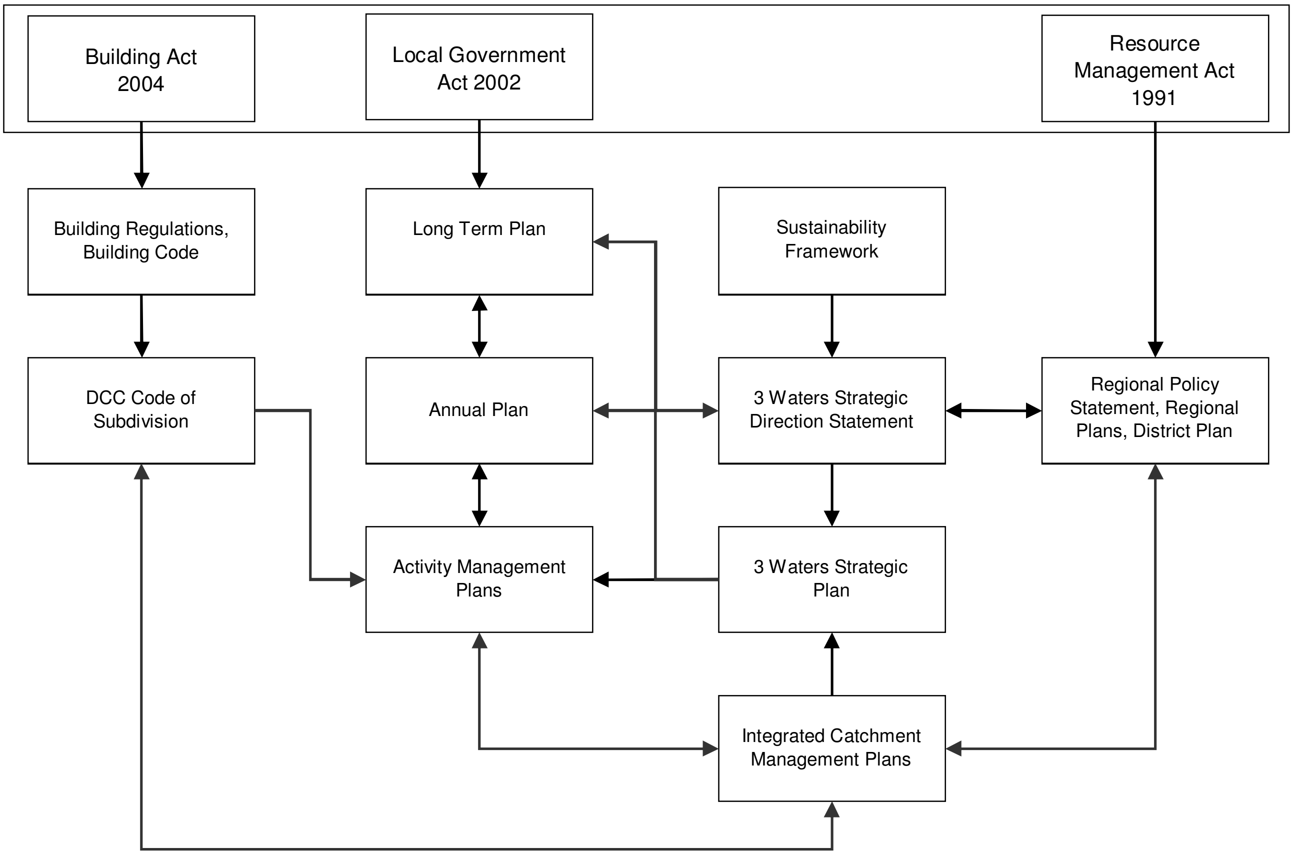


Figure 2-1: Legislative and Planning Document Hierarchies

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 St Clair stormwater catchment discharges directly into the Pacific Ocean, at both St Clair Beach, and Second Beach. The NZCPS must therefore 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 St Clair catchment on the receiving environments. 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 this ICMP. As local or regional councils must enforce standards imposed by a 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 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 this 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 St Clair 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. The land use in the St Clair catchment is almost entirely residential, with a small area zoned rural (the golf course).

Careful consideration will need to be given to this land use zone and any potential changes to this zone 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 St Clair 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 on all aspects of DCC's operations and decision making through the following sustainability principles:

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

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

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

2.6.4 3 Waters Strategic Direction Statement and 3 Waters Strategic Plan

The purpose of the 3 Waters Strategic Direction Statement is to align the management of Dunedin's three waters activities with the city's sustainability principles. This document provides direction for the detailed 3 Waters Strategic Plan which will be largely influenced by the content of all of the ICMPs. It is through the 3 Waters Strategic Plan that the ICMPs will provide input to long term community planning objectives and ultimately, Activity Management Plans (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 St Clair Catchment is unlikely to comply with the conditions of the rule due to the likelihood of contaminants having some effect on the receiving environment, along with the potential for flooding. 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 below and provide the overarching objectives that guide the development of this ICMP. These objectives are at the core of the relevant statutory and non-statutory documents addressing stormwater management, including the 3 Waters Strategic Direction Statement. These objectives have been developed with the aim of achieving benefits across the four wellbeings (environmental, social, economic and cultural), and have been set within the context of a 50 year timeframe.

Table 2-1: Strategic Stormwater Management Objectives

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

2.8.2 Activity Management Plan / LTP Objectives and Targets

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

DCC also 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 intended that the following areas will be able to be reported on following the ICMP completion if appropriate and necessary:

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

Table 2-2: Activity Management Plan Measures and Targets

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

tbc: to be confirmed.

3 Consultation

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

3.1 3 Waters Strategy Consultation – Stakeholder Workshops and Community Survey

For specific consultation relating to the 3 Waters Strategy, stakeholders were divided into three groups; environmental, economic / business and social / cultural. The outcomes of the specific consultation workshops were used to inform a community telephone survey to gauge the views of the wider community including catchment residents. Specific groups were also consulted directly, including: Käi Tahu ki Otago, 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 storm events, thus putting a greater episodic demand on the system; and thus likely to require increased capacity. This may be compounded by decreases in permeable land resulting from increased property development in certain areas.
- That managing volumes (which is partially related to quality) requires a more encompassing view of the system and its management.

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

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

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

3.2 Resource Consent Submissions

The resource consent process for the coastal discharge permits identified the residents within the affected catchments as interested parties. Matters raised by submitters in relation to coastal stormwater discharge permit applications are also a valuable source of stakeholder opinion. A majority of the submissions echo the views outlined above however the 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 the Department of Conservation (DOC) Otago Conservancy.

3.2.1 Käi Tahu Cultural Impact Assessment

In October 2005, DCC commissioned Käi Tahu ki Otago Limited (KTKO Ltd.) to undertake a CIA (KTKO Ltd., 2005) on the discharge of stormwater into Otago Harbour and at Second Beach (the assessment excludes St Clair beach, as no consent applications were applied for with respect to discharges to St Clair 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 to Second Beach, 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.

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:

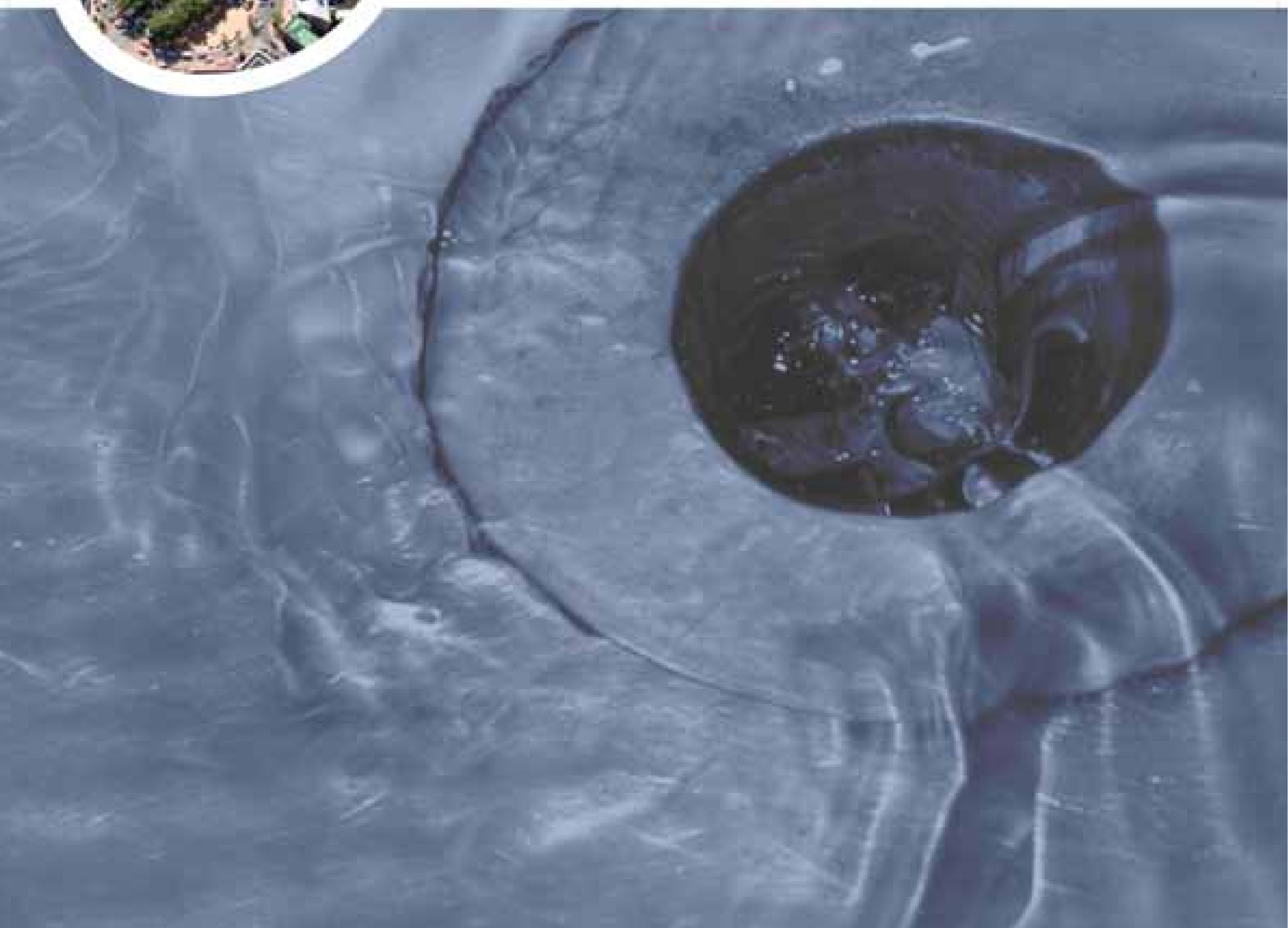
- Reducing the area of impervious land;
- Use of grass swales to filter stormwater;
- Covering car-parking areas and other areas where increased contaminants may be found;
- Sediment/grease traps to be installed at all industrial premises, petrol stations and car parks;
- Management plans for industrial 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

The St Clair catchment is a mostly hilly catchment, covering an area of approximately 164 ha (Figure 4-1). The catchment extends from the southern end of the suburb of Caversham, and is bounded in the north by South Road, and in the east by Forbury Road. Forbury Hill lies to the south-west, and the coastline between Cargill Castle and St Clair Beach forms the southern boundary of the catchment. The catchment includes the suburbs of St Clair, Kew and Forbury, and parts of the suburbs of Caversham, St Clair and Corstorphine East.

4.2 Topography and Geology

Figure 4-2 provides a contour map of the St Clair catchment using 2 m contours. Figure 4-3 shows the geology of the catchment (Bishop and Turnbull, 1996, revised 2004).

The catchment is characterised by steep gullies along the head of the catchment in the west. The topography becomes flatter with low lying areas towards the east. The head of the catchment has an elevation of approximately 154 m above mean sea level.

The topography of the catchment has been created by volcanic lava flows that occurred in the mid to late Tertiary period, with several volcanic episodes evident in the topographic and geologic maps (Md1e, Md2e and Md3e basalt). The volcanic deposits are very resilient to erosion and weathering, with the rock material typically providing variable infiltration capacity, depending on fractures in the rock. Small areas to the north and east of the catchment, along Forbury Road, have sand and gravel dominated underlying geology, which is likely to have greater infiltration capacity.

The steep terrain at the head of the catchment directs surface water into three main gullies and several smaller gullies in the north of the catchment. The main gullies surround Cliffs Road, Bedford Street and Motu Street. The gullies head towards the low lying areas of South Dunedin and St Kilda in the east.

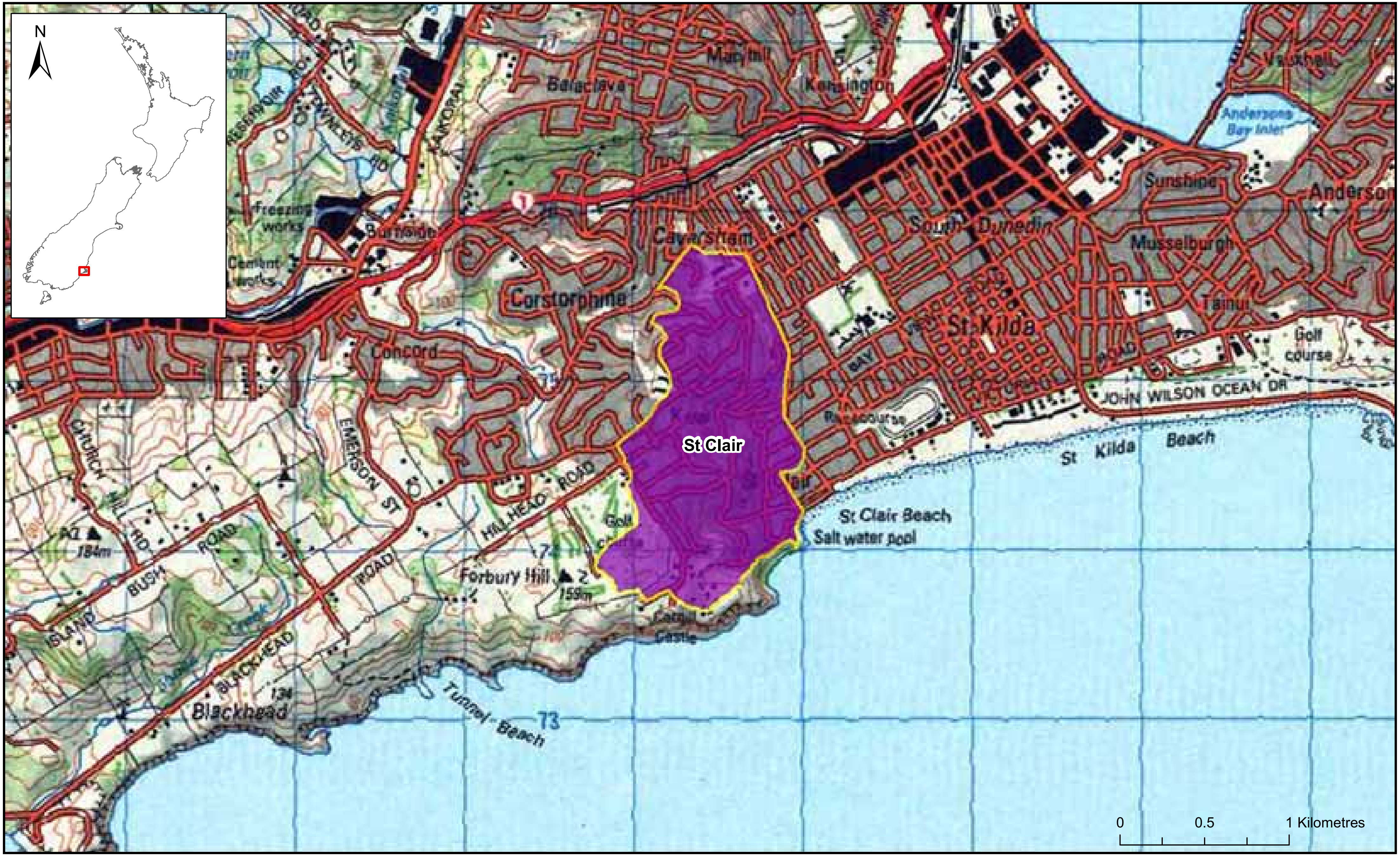
4.3 Surface Water

An assessment of a number of streams in the 3 Waters Strategy Project catchments was undertaken by Ryder Consulting Ltd in 2010. 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 4-10 later in this report).

As described above with respect to catchment topography and geology, and in the network description below (Section 4.7.1), a number of stream gullies direct stormwater from the west of the catchment towards the main stormwater collection pipe running along Forbury Road in the east. The stormwater network has been based on these natural watercourses, and many of them have significant piped sections. Three streams were identified in the St Clair catchment as still being notable watercourses, and selected for assessment. The corresponding Stream Assessments Report (Ryder, 2010c) contains information on characteristics of the streams based on assessments at four sites. These are discussed in detail in Section 5.2.

4.4 Groundwater

There is limited information relating to groundwater surface levels in the St Clair catchment, and over much of the Dunedin urban area. ORC do not currently require groundwater monitoring in the area for consent purposes, and anecdotally, the groundwater in the Dunedin area is believed to be shallow, and also believed to be influenced by tide levels, however this is unlikely to affect most of the St Clair catchment, which rises steeply above sea level. No information on groundwater quality is available, due to a lack of monitoring sites.



Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-1 St Clair Catchment Location	DISCIPLINE Stormwater	Drawn: KC	Status: Final		
			Checked: HES	Scale: 1:20,000	Plot Date: Sep 2011	
			Approved: SDH	Job. No: 42173227	Map No: Figure 4-1	Revision: -
			Date: Sep 2011			

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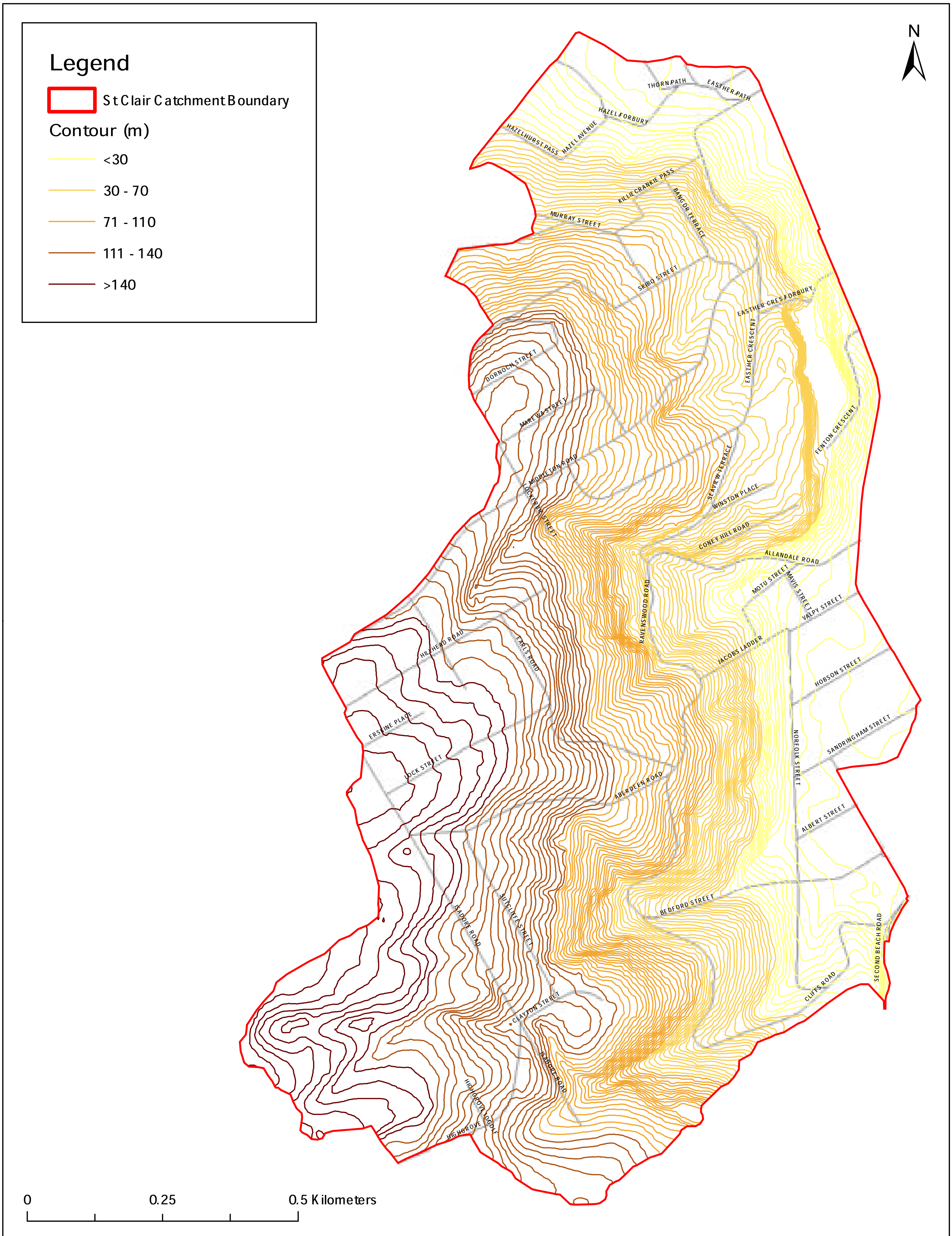

Dunedin City Council / URS / Opus	Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-2 St Clair Catchment Contour Map	DISCIPLINE Stormwater	Status: Final	
				Scale: 1:6,500	Plot Date: Sep 2011
				Drawn By: CO	Approved: HS
				Checked: JH	Date: Sep 2011
				Job No: 42173227	Map No: Figure 4-2 / Revision: -

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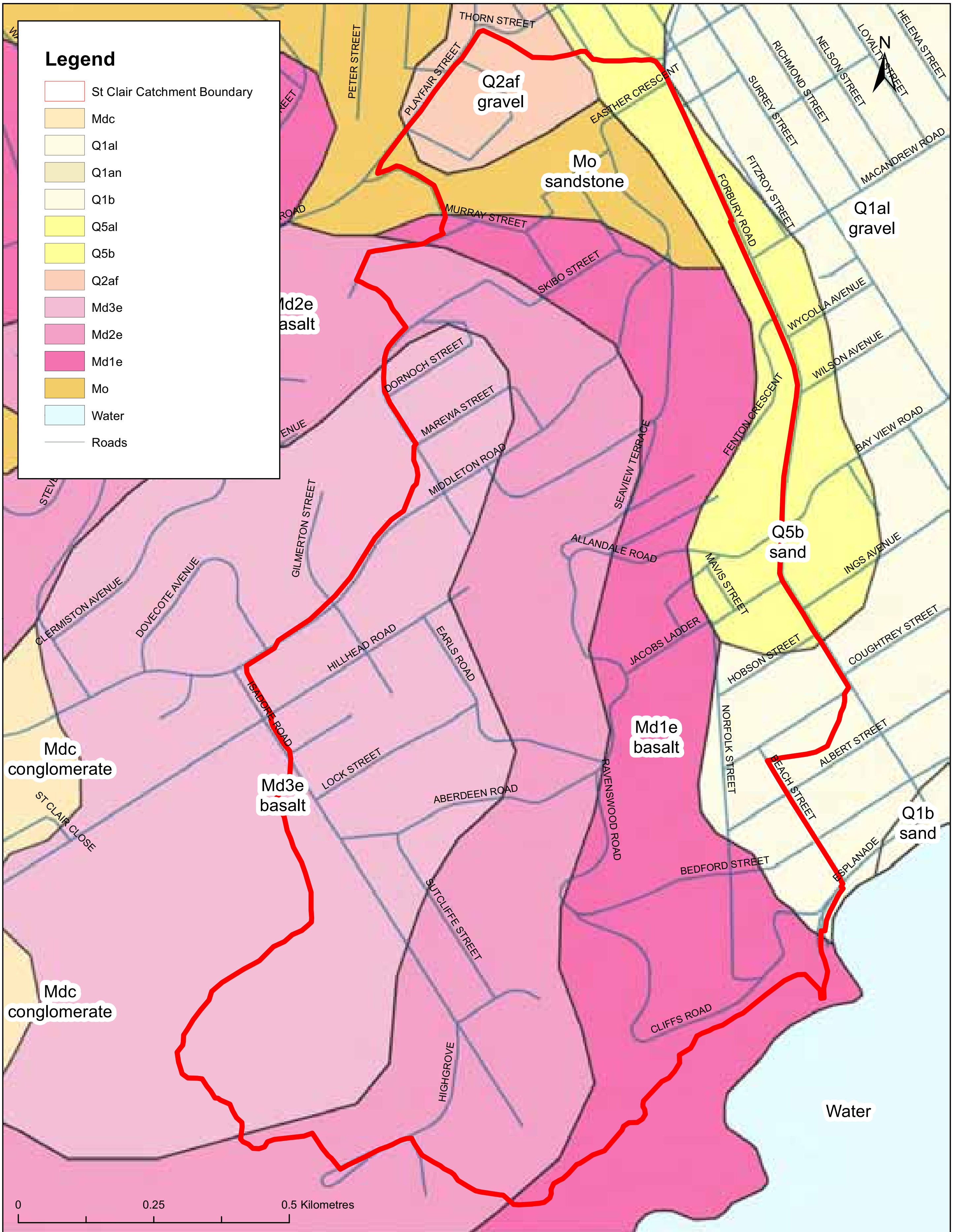

DUNEDIN CITY COUNCIL / OPUS	Dunedin 3 Waters Strategy	**ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN** **Figure 4-3** **St Clair Catchment Geology Map**	**DISCIPLINE** **Stormwater**	Status: **Final** Scale: 1:6,500 — Plot Date: Sep 2011 Drawn By: CO — Approved: HS Checked: JH — Date: Sep 2011 Job No: 42173227 — Map No: Figure 4-3 — Revision: -

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4.5 Land Use

4.5.1 Historical and Current Land Use

Early settlement in the St Clair suburb included farming and horticulture uses. A farm occupied the centre of the catchment, and market gardens were established by draining the flat swampy land nearer the coast (mainly within the South Dunedin stormwater catchment). There was also a quarry near Fenton Crescent supplying materials to the brickworks located in the South Dunedin catchment. From the early 1900s, however, the St Clair suburb became essentially residential, and home to many of the city's wealthy residents.

Currently, the St Clair catchment is almost entirely residential, with the exception of the St Clair Golf Course, located in the south west of the catchment. Refer Table 4-1 and Figure 4-4.

Table 4-1: Current Land Use in the St Clair catchment

DCC Zone	Proportion of Catchment
Residential 1	87.9 %
Residential 2	2.0 %
Rural	10.2 %

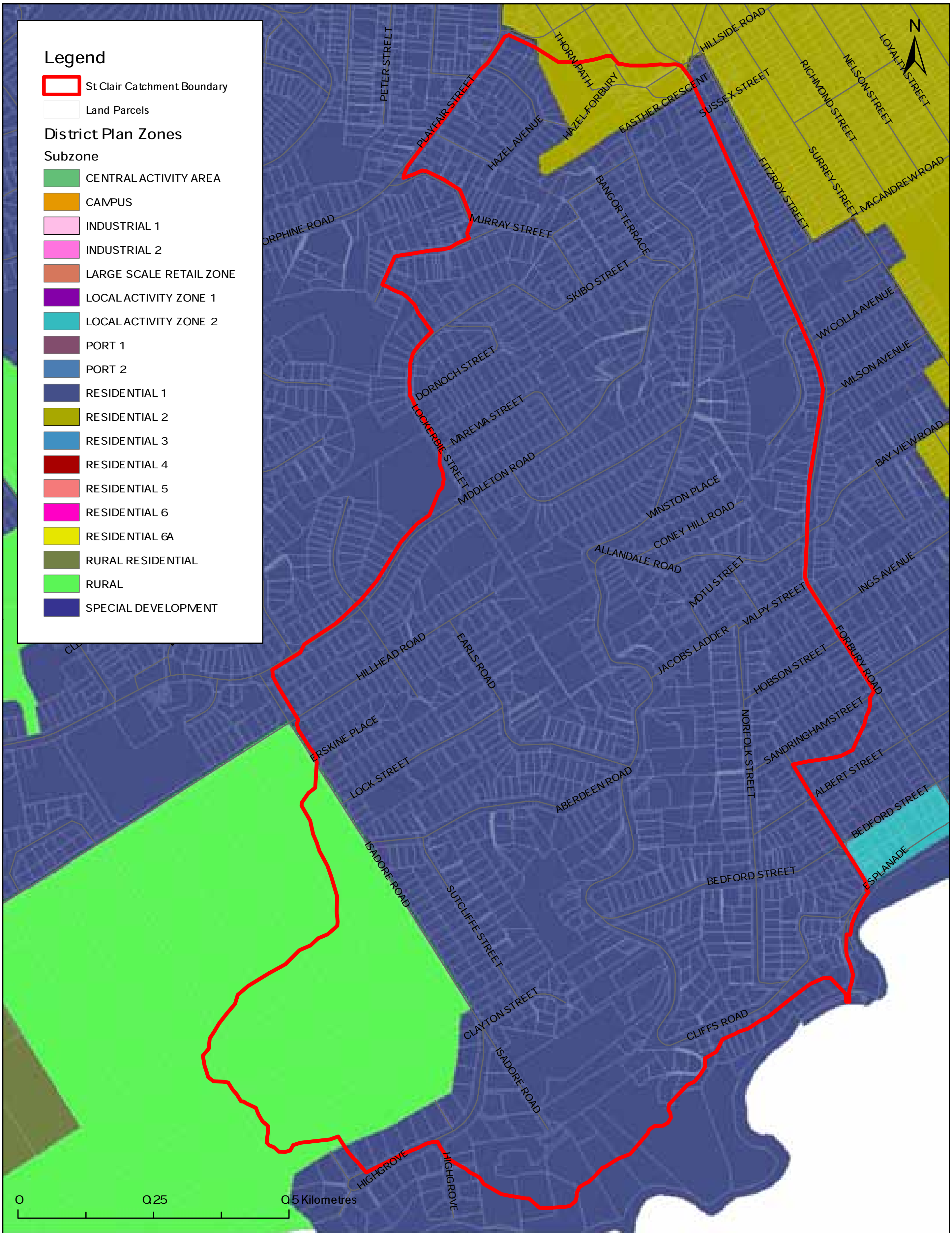
4.5.2 Cultural and Heritage Sites

According to DCC records of significant archaeological and heritage sites within Dunedin city, Heritage structures are scattered throughout the catchment, however, there are no archaeological sites or heritage precincts recorded in the District Plan for this catchment. Refer Figure 4-5.

The heritage structures in the catchment consist of historic houses (Lisburn House and Middleton Lodge), and Caversham Church.

There was a Māori settlement in the area close to the St Clair Esplanade in pre-European times, and artefacts have been discovered close to the western end of the Esplanade and occasionally uncovered in the dunes which lie to the east. It is believed that there was also a burial site close to Cargill's Castle, however, Cargill's Castle lies just outside the St Clair catchment boundary.

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 3.3.



Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-4 St Clair Catchment Land Use Zones	DISCIPLINE Stormwater	Status: Final	
			Scale: 1:6,500	Plot Date: Sep 2011
			Drawn By: CO	Approved: HS
			Checked: JH	Date: Sep 2011
			Job No: 42173227	Map No: Figure 4-4 / Revision: -

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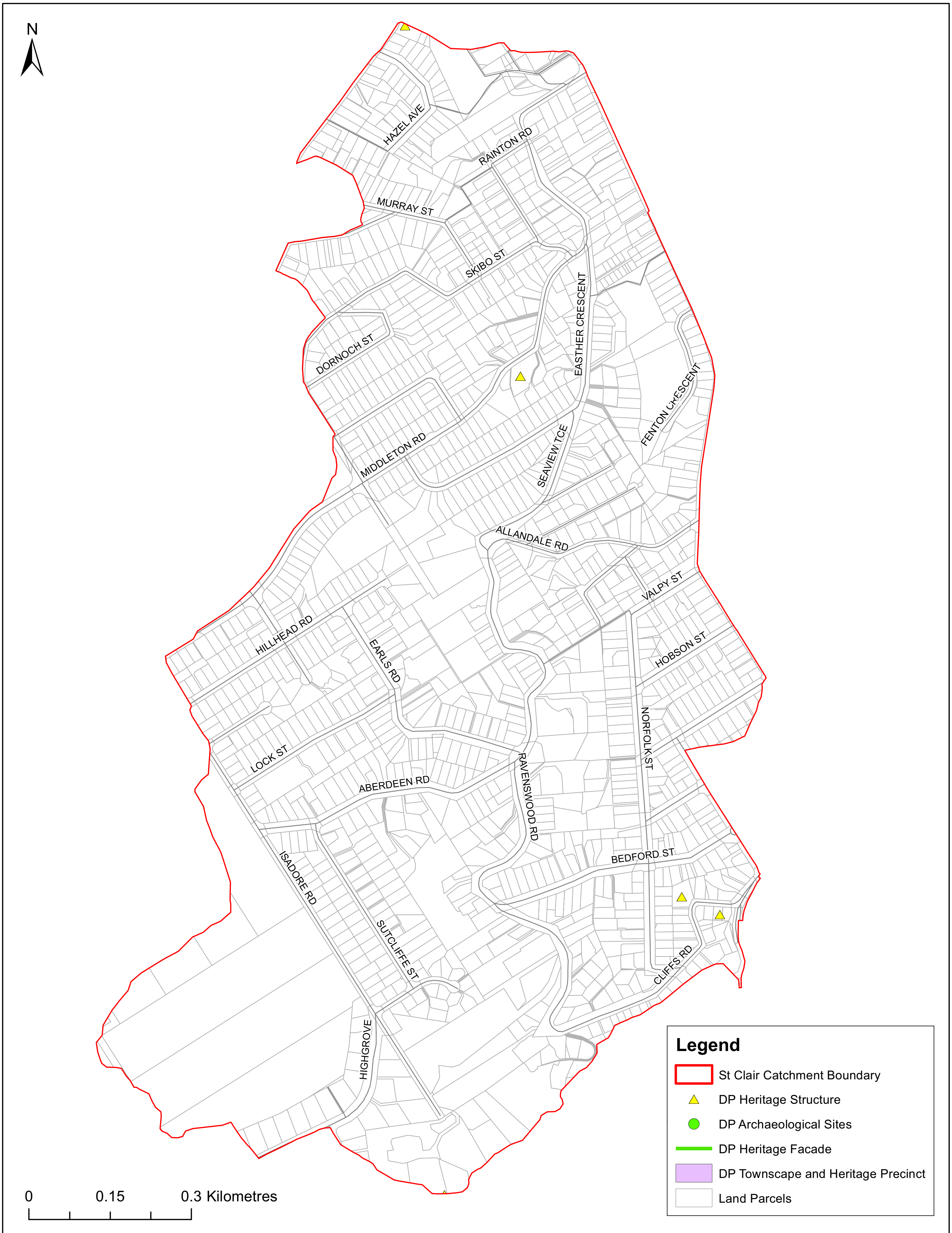

Dunedin 3 Waters Strategy	**ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN** **Figure 4-5** **St Clair Catchment Archaeological and Heritage Sites**	**DISCIPLINE** **Stormwater**	Status: **Final**

Scale: 1:6,500	Plot Date: Oct 2011		
Drawn By: CO	Approved: HS		
Checked: JH	Date: Oct 2011		
Job No: 42173227	Map No: Figure 4-5	Revision: -	

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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 St Clair 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).

There is one District Plan designation located at the north of the catchment; it is a school site.

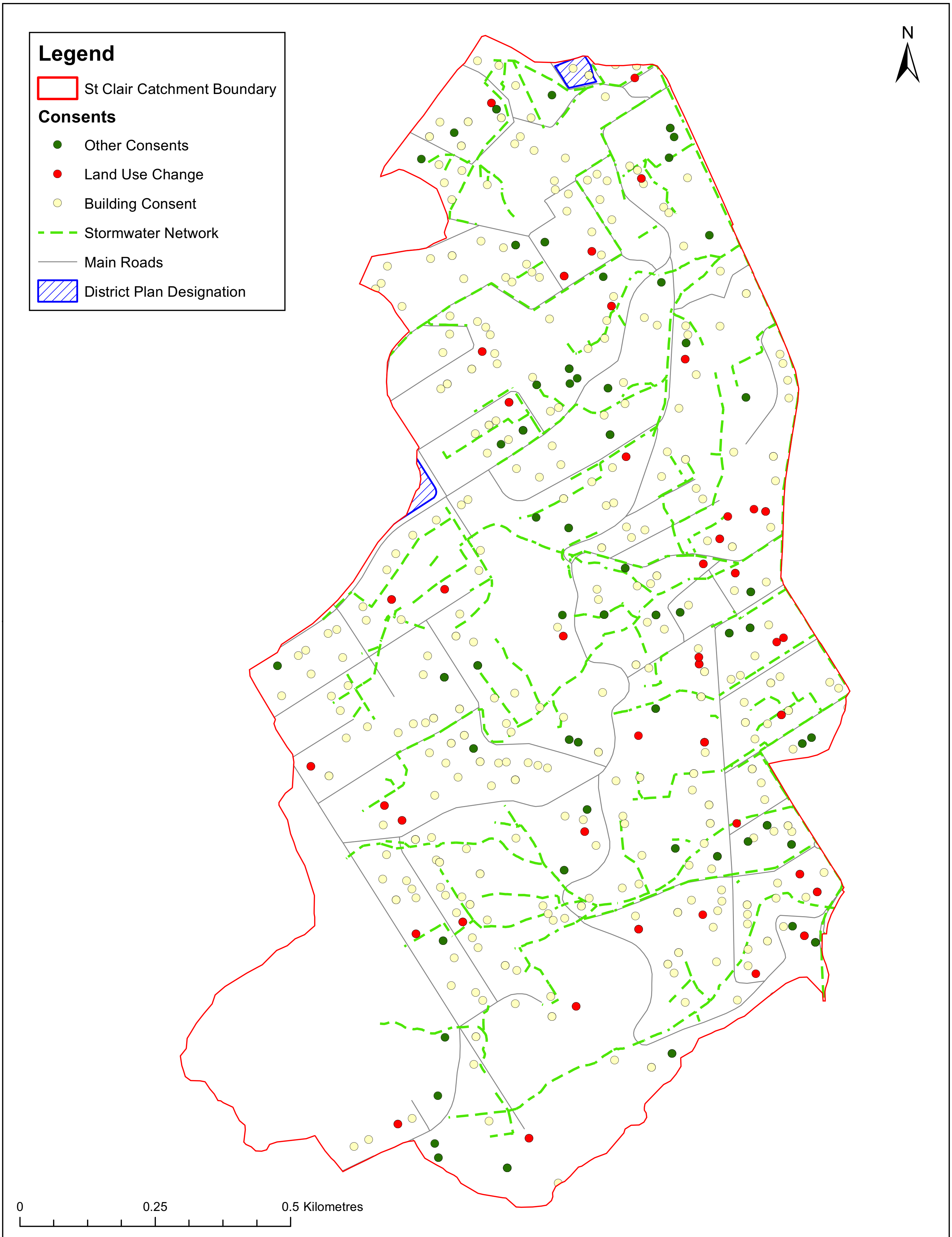
Figure 4-6 provides the location of the resource consents granted by DCC and the District Plan designations within the St Clair catchment.

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.

There are three identified areas of reclamation in the catchment, identified as brownfield / reclamation sites. These are located off Ravenswood Road, Bedford Street, and Middleton Road.

Figure 4-7 provides the location of the known contaminated land sites within the St Clair catchment.



Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-6 St Clair Catchment Recent Consents and Designations	DISCIPLINE Stormwater	Status: Final		
			Scale: 1:6,500	Plot Date: Sep 2011	
			Drawn By: CO	Approved: HS	
			Checked: JH	Date: Sep 2011	
			Job No: 42173227	Map No: Figure 4-6	Revision: -

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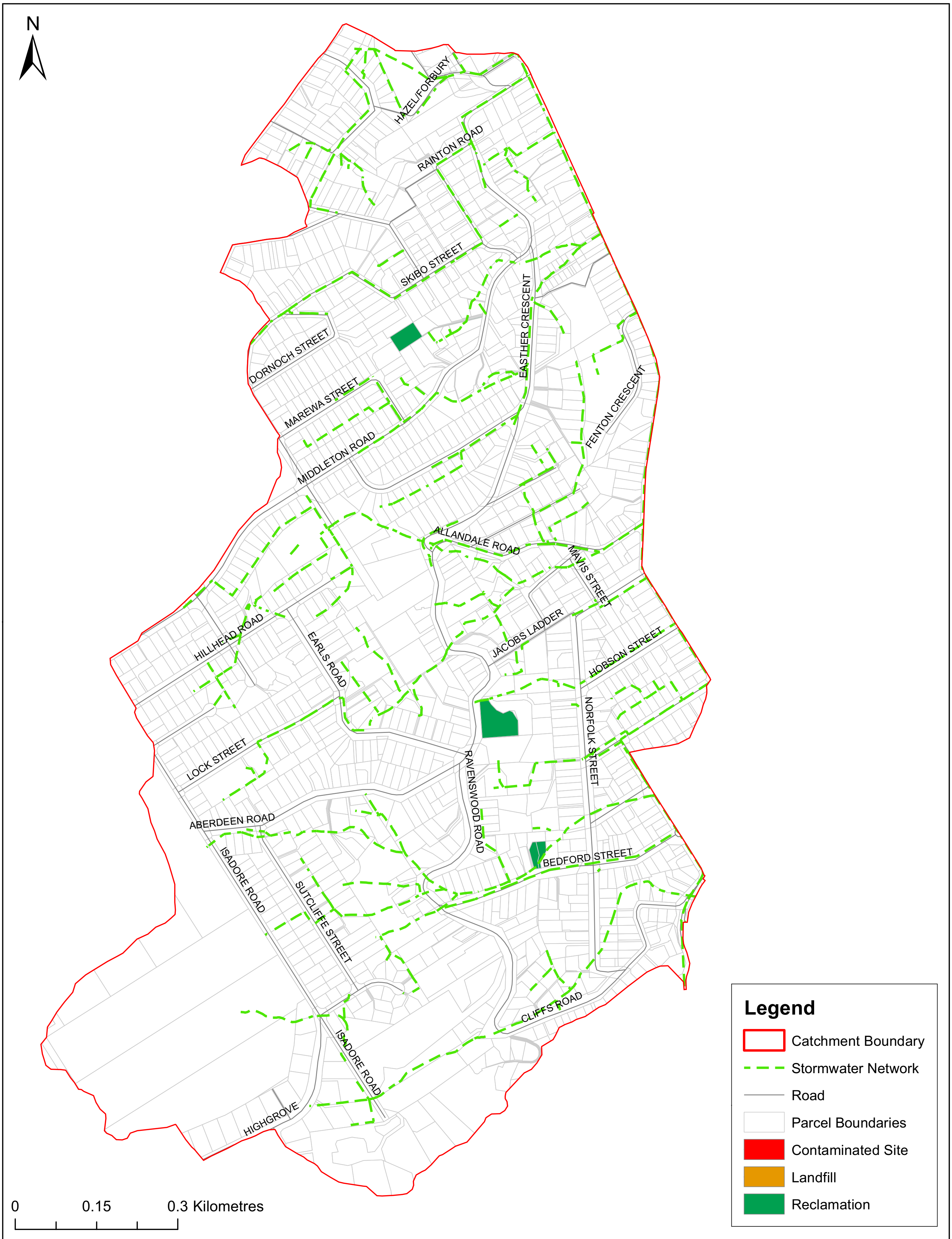

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Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-7 St Clair Catchment Contaminated Land Sites	DISCIPLINE Stormwater	Status: Final	
			Scale: 1:6,500	Plot Date: Oct 2011
			Drawn By: CO	Approved: HS
			Checked: JH	Date: Oct 2011
			Job No: 42173227	Map No: Figure 4-7 / Revision: -

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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 St Clair 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 Dunedin City District Plan provisions.

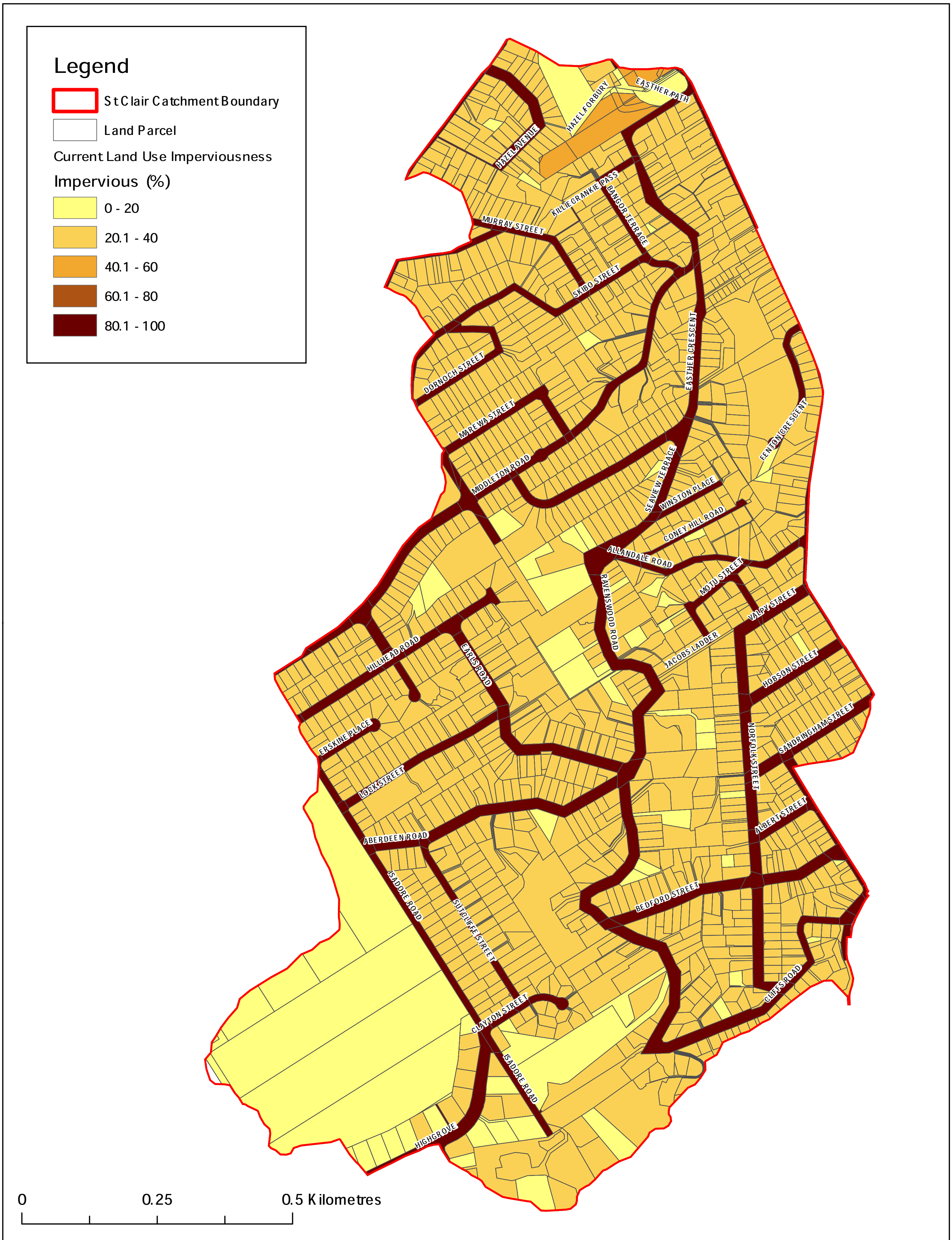
4.6 Catchment Imperviousness

Figure 4-8 provides a map of current imperviousness for the St Clair catchment (refer Appendix B for calculation methods). Overall, including roads and land parcels, the St Clair stormwater catchment is estimated to have a current imperviousness of approximately 43 %.

Approximately 90 % of the St Clair catchment is zoned residential (88 % Residential 1 and 2 % Residential 2). The remaining 10 % is zoned as rural, and contains the St Clair Golf Course. Housing in the Residential 1 zone typically has lower site coverage than other residential zones, with the Dunedin City 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 in the north of the catchment are estimated to have a higher imperviousness (approximately 56 %).

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 applied for the 2060 land use scenario. In 2060 the Residential 1 zone has a maximum allowable imperviousness of 49 %, while the Residential 2 zone could be up to 72 % impervious.



DUNEDIN CITY COUNCIL / OPUS	Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-8 St Clair Catchment Current Imperviousness	DISCIPLINE Stormwater	Status: Final		
				Scale: 1:6,500	Plot Date: Sep 2011	
				Drawn By: CO	Approved: HS	
				Checked: JH	Date: Sep 2011	
				Job No: 42173227	Map No: Figure 4-8	Revision: -

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4.7 Stormwater Drainage Network

4.7.1 Network Description

The stormwater network in the St Clair catchment is predominantly pipes, and has ten branches running west to east, a large 'interceptor' pipeline running north to south, and three outfalls. The stormwater network in the catchment, based on DCC GIS data, is illustrated in Figure 4-10.

In some of the steeper bush covered areas, mostly located in the upper reaches of the catchment, flows are collected via natural open drains, which in turn are intercepted by the stormwater pipe network. Stormwater from the flatter sections in the eastern part of the catchment is conveyed entirely via pipe.

Nine out of the ten branches discharge into a large pipe along Forbury Road; this main stormwater line ultimately discharges to Second Beach via the Bell Chamber Outfall and to St Clair Beach via a bifurcation located approximately 120 m upstream of the Bell Chamber Outfall.

The southernmost branch (a primarily open watercourse with several piped sections) collects stormwater from the south of the catchment and part of the golf course and discharges independently into St Clair Beach via a culvert beneath the junction of Second Beach Road and Cliffs Road.

As graphed in Figure 4-9, a significant proportion of the catchment is served by smaller diameter pipes, less than 250 mm in diameter. The length of larger 1050 mm diameter pipe is the main stormwater line, laid along Forbury Road, flowing towards the south.

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

- The Bell Chamber Outfall – this outfall consists of a large conical concrete structure containing six orifices of varying dimensions distributed around the chamber, two of which include debris screens. The outfall is located at Second Beach and is vulnerable to strong wave action; it has been designed accordingly to resist the wave action and minimise rock intrusion.

- The St Clair Beach South Outfall – located on the waterfront adjacent to Second Beach Road, this outfall discharges stormwater from the main pipeline that runs to the Bell Chamber Outfall.

- The St Clair Beach North Outfall – this outfall discharges stormwater from the southernmost branch of the network (predominantly open channel).

- Bypass manhole – in the north of the catchment, near the intersection of Forbury Road and Hillside Road, this structure allows overflows to and from the South Dunedin stormwater network.

- Seven watercourse intake screens located throughout the network.

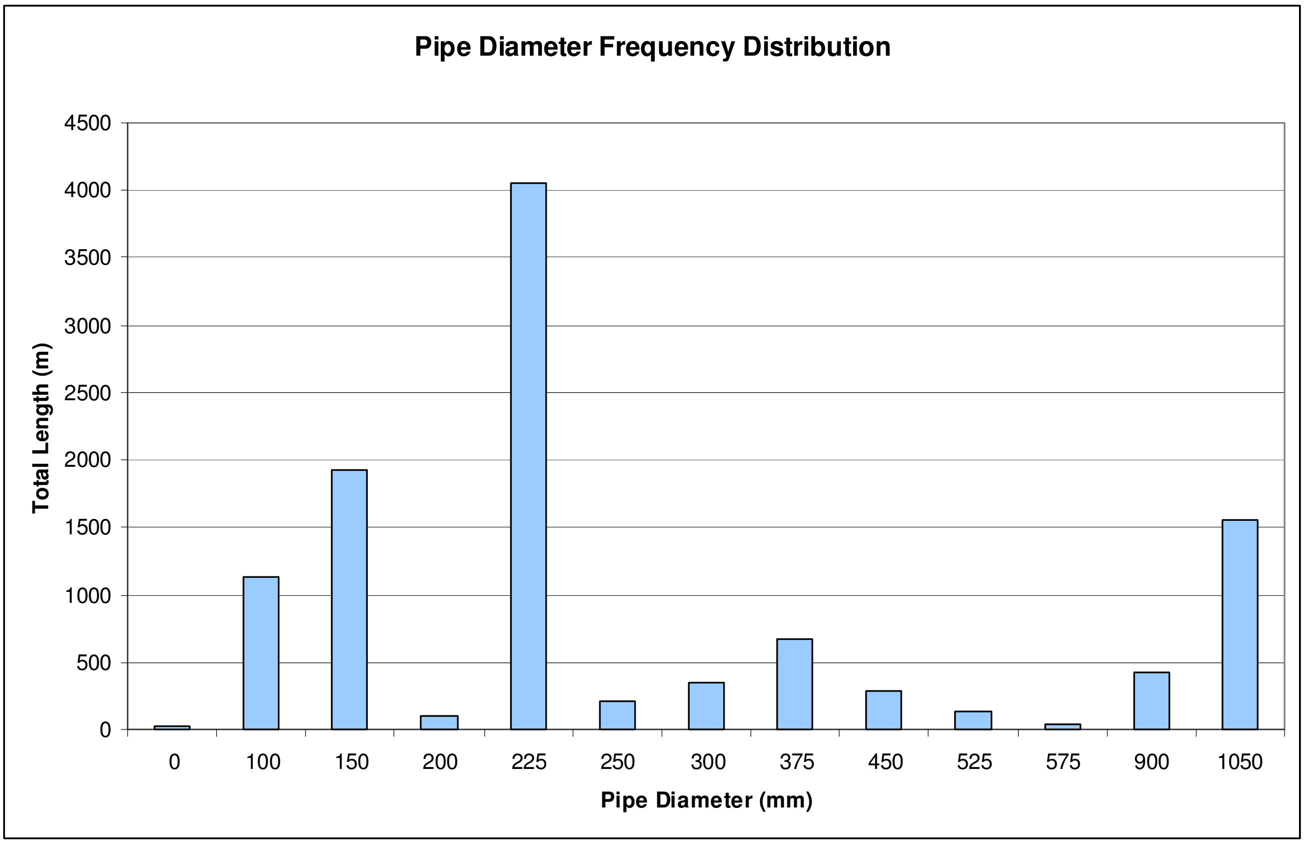
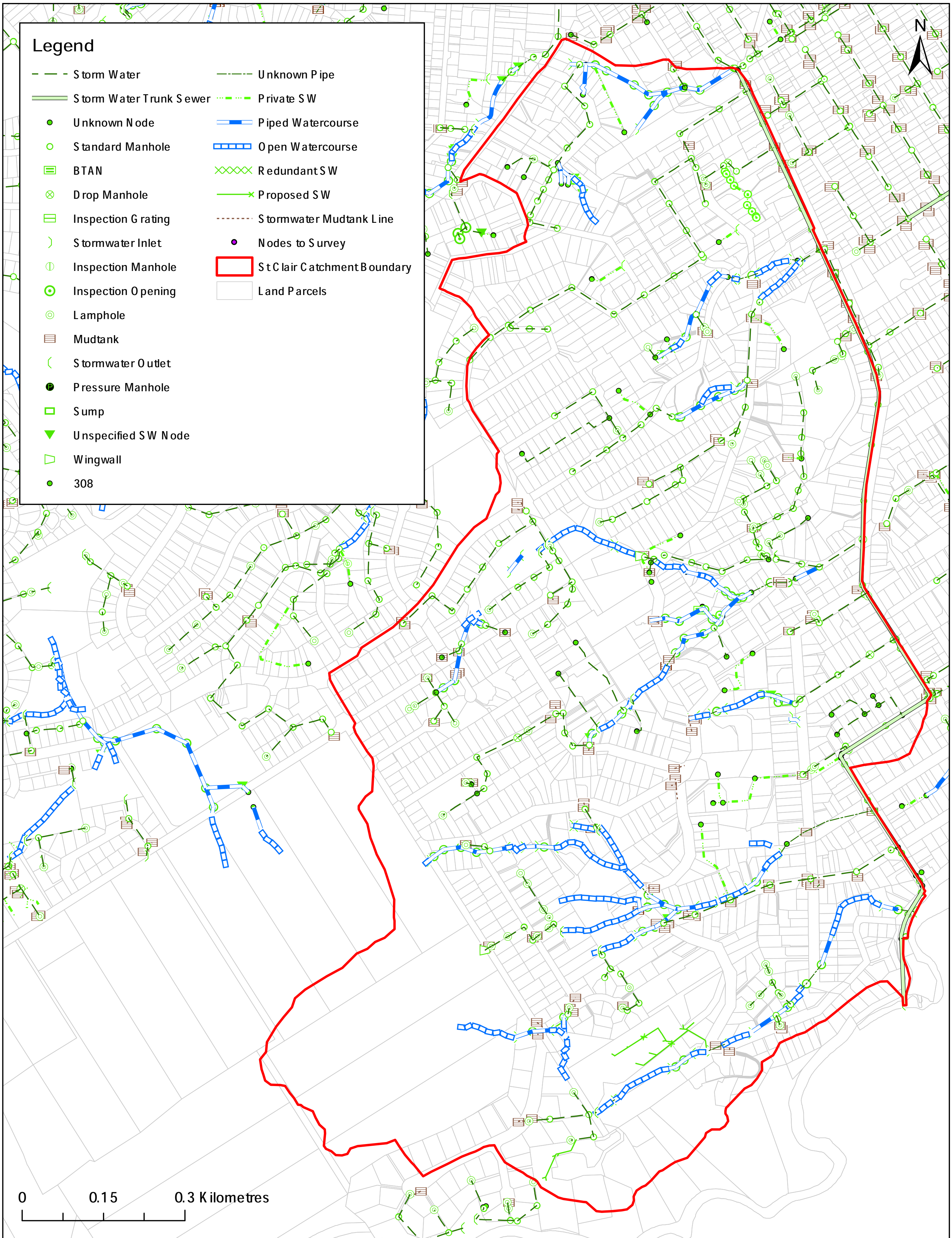


Figure 4-9: Pipe Diameter Frequency Distribution



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Dunedin 3 Waters Strategy

ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-10

St Clair Catchment Stormwater Drainage Network

DISCIPLINE

Stormwater

Status:	Final		
Scale:	1:6,500	Plot Date:	Sep 2011
Drawn By:	CO	Approved:	HS
Checked:	JH	Date:	Sep 2011
Job No: 42173227	Map No: Figure 4-10	Revision: -	

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4.7.2 Network Age

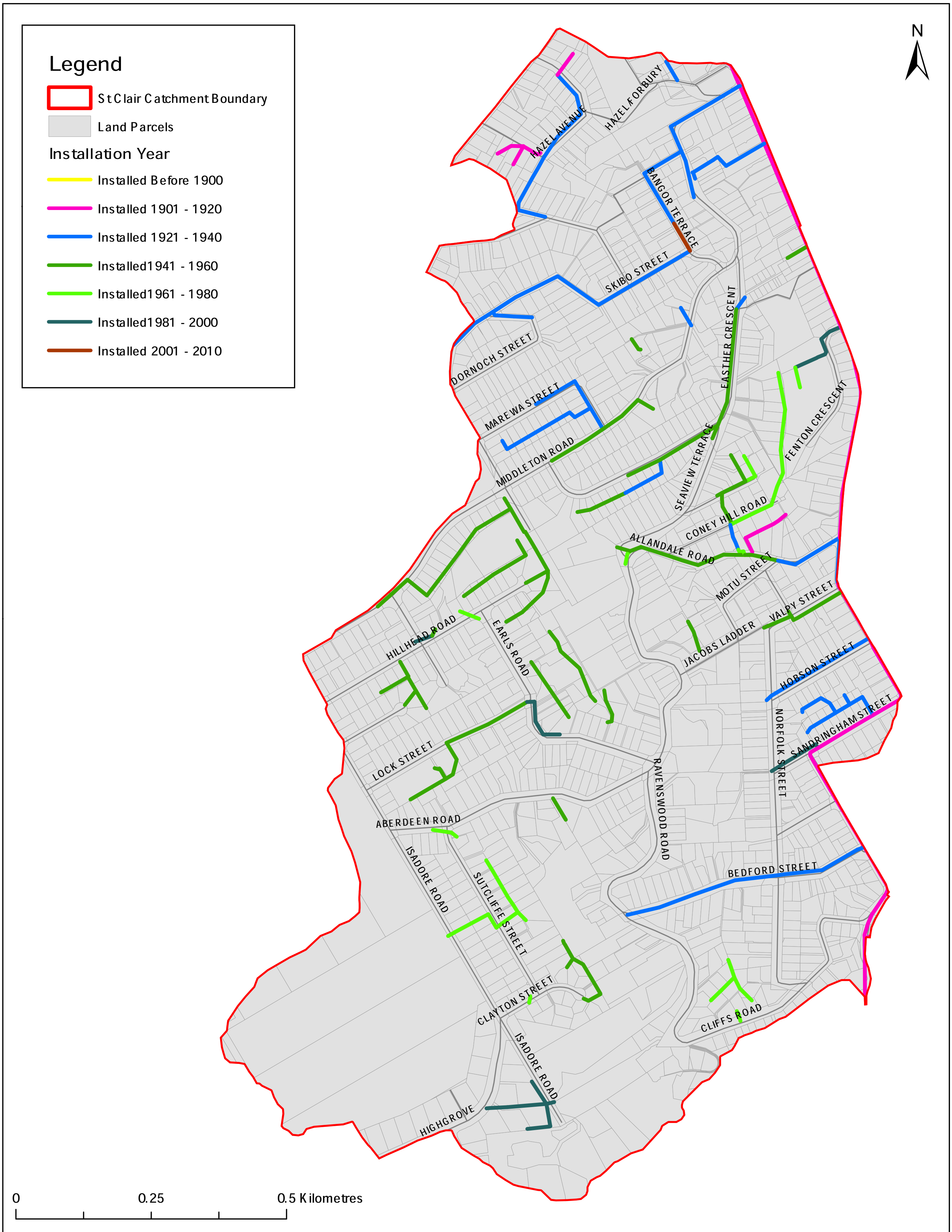
Table 4-2 below provides a breakdown of pipe age in the St Clair catchment. Figure 4-11 provides a map of pipe age based on location.

The data shows that the majority of the pipework in the St Clair 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, 84 % 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	49	2185	20
Installed 1921 to 1940	70-90 years	73	3434	32
Installed 1941 to 1960	50-70 years	94	3528	32
Installed 1961 to 1980	30-50 years	45	1042	10
Installed 1981 to 2000	10-30 years	22	640	6
Installed 2001 to 2009	< 10 years	2	59	1



DUNEDIN CITY COUNCIL / OPUS	Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-11 St Clair Catchment Pipe Network Ages	DISCIPLINE Stormwater	Status: Final Scale: 1:6,500 Drawn By: CO Checked: JH Job No: 42173227	Plot Date: Sep 2011 Approved: HS Date: Sep 2011 Map No: Figure 4-11 Revision: -

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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.

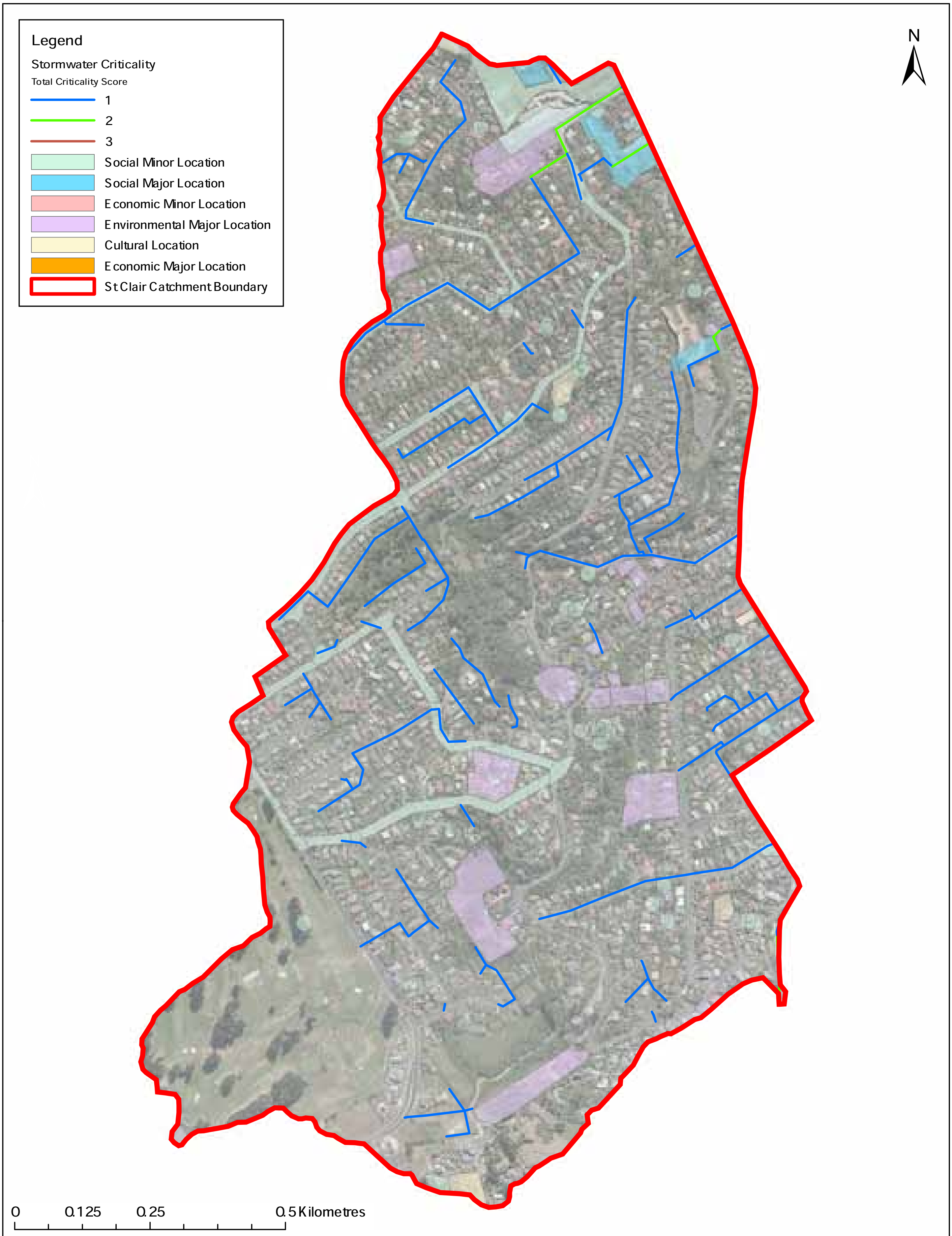
Figure 4-12 shows a map of the St Clair catchment, with criticality and the four wellbeing locations identified. This map shows pipe criticality only. Pipe condition assessment is currently being undertaken throughout the city on selected pipes, however to date no information is available on pipes in the St Clair catchment.

There are a number of ‘major environmental’ locations identified in the St Clair catchment; these are predominantly due to landslide risk, or sites of historic landslides. Other locations of note are schools or significant trees. The majority of the pipes in the catchment have a criticality score of 1, indicating that there are no major issues with respect to pipe location, with the possible exception of proximity of landslide risk to pipes on Easther Crescent.

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

ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-12

St Clair Catchment Stormwater Network Criticality

DISCIPLINE	Status: Final		
Stormwater	Scale: 1:6,500	Plot Date: Sep 2011	
	Drawn By: CO	Approved: HS	
	Checked: JH	Date: Sep 2011	
	Job No: 42173227	Map No: Figure 4-12	Revision: -

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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. This investigation did not, however, examine the stormwater system, or look at the wastewater system near St Clair beach, therefore the extent of saline groundwater intrusion into the stormwater network is unknown. The majority of the stormwater system in the St Clair catchment is laid well above sea level, however tidal influence on the system via the Bell Chamber outfall is discussed further in Section 8.

4.7.5 Operational Issues

Discussions were held with DCC operations personnel during the catchment walkover (27th September 2010) 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 March 2011. Discussions highlighted that there were very few major issues in the catchment, with the only issues mentioned being localised shallow flooding along Forbury Road, and general city-wide maintenance of intake structures (catchpits and watercourse intakes), discussed further in Section 4.7.6 below.

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. 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 closed circuit television (CCTV) programme.

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

Network Management

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 outlined overleaf:

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

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

Transportation Operations

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

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

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

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

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

The cleaning and maintenance of stormwater structures in the road is currently perceived by Water and Waste Business Unit 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.

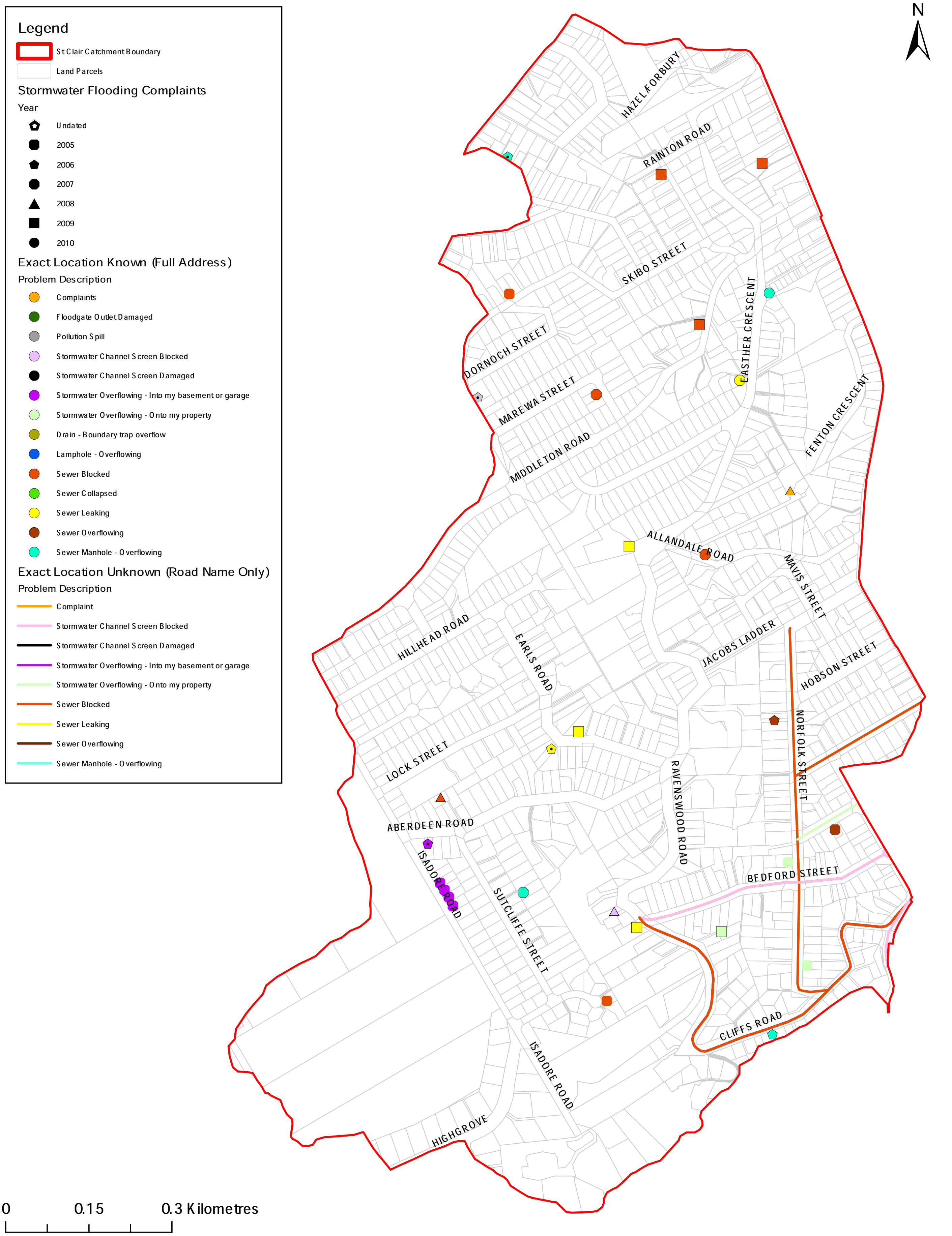
4.8 Catchment Flooding

Based on DCC customer complaints information collated between 2005 and 2010, there were 55 recorded stormwater flooding complaints in the St Clair catchment that relate to blockages, leakages or overflows, or that are unspecified. Twelve of these have imprecise locations and could only be identified by road name. A map of stormwater complaints is provided as Figure 4-13.

Stormwater flooding complaints are generally scattered around the catchment, however there is a cluster near the intersection of Ravenswood Road, Bedford Street and Cliffs Road, where four network branches (mainly open channel) converge. There is another cluster of complaints along Isadore Road, near the golf course – these were recorded over a number of years, however there appears to be no public drainage network serving these properties, and stormwater issues may therefore be due to problems with the private or roading drainage network, or overland flow from the golf course. Multiple complaints originate from several addresses within the catchment, with only 31 unique addresses and 7 roads making up the 55 complaints. A large number of the stormwater flooding complaints appear to be near open watercourse sections of the network, indicating that intake structures may be blocking and causing overflow.

Wastewater customer complaints information compiled between 2005 and 2010 (Figure 4-14) show a relatively large number of complaints in the St Clair catchment (52, from 42 addresses). These complaints appear to be fairly evenly distributed across the catchment, with small clusters in some locations. A number of locations have recorded both wastewater and stormwater complaints; this could indicate that there are issues with both networks, or that residents have been unsure whether flooding was from the stormwater or the wastewater system.

As discussed in Section 4.9.2, Phase 2 wastewater modelling has confirmed the likelihood of manhole overflows in the catchment, supported by the complaints data. Further investigation has been recommended to address these issues. There are no known direct cross connections between the stormwater and the wastewater system, however this investigation is likely to explore the capacity of both networks at critical locations.



DUNEDIN CITY COUNCIL / URS / OPUS	Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-13 St Clair Catchment Reported Stormwater Flooding	DISCIPLINE Stormwater	Status: Final Scale: 1:6,500 Drawn By: CO Checked: JH Job No: 42173227	Plot Date: Sep 2011 Approved: HS Date: Sep 2011 Map No: Figure 4-13 Revision: -

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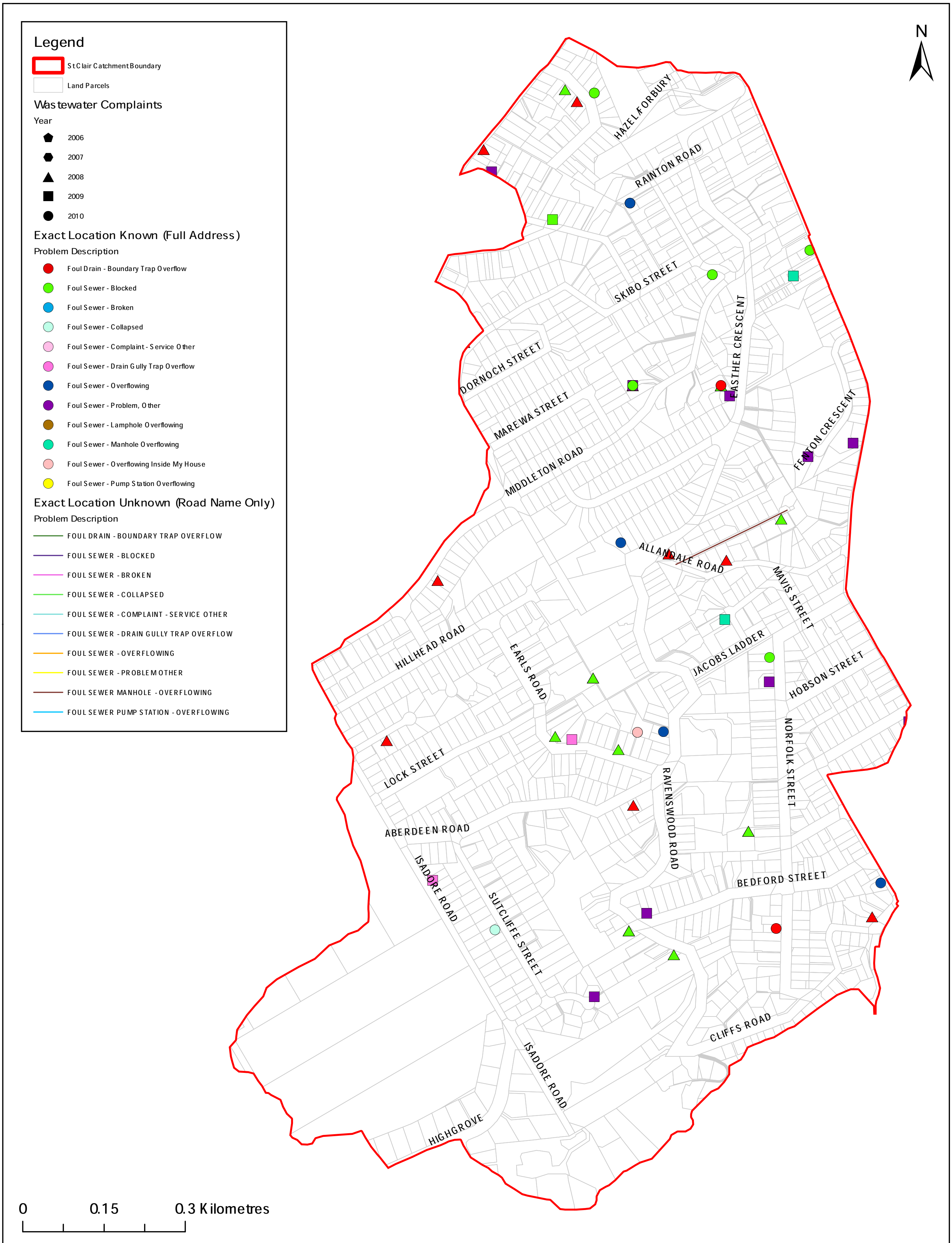

Dunedin 3 Waters Strategy

ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-14

St Clair Catchment Reported Wastewater Flooding

DISCIPLINE

Stormwater

Status: Final			
Scale: 1:6,500		Plot Date: Sep 2011	
Drawn By: CO		Approved: HS	
Checked: JH		Date: Sep 2011	
Job No: 42173227		Map No: Figure 4-14	Revision: -

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4.9 Water and Wastewater Systems

Figure 4-15 provides a layout of the three waters networks in the St Clair 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 St Clair 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 St Clair catchment is supplied from the Lookout Point Pressure Reducing Valve (PRV), and the Glenpark and Māori Hill reservoirs. The catchment includes part of the Corstorphine and Intermediate water supply zones. There are approximately 23 km of water supply pipes in the St Clair catchment, ranging from 20 mm to 250 mm, most of which are less than 200 mm in diameter. The majority of the supply pipes in this catchment are constructed from cast iron, asbestos cement and PVC.

Leakage within the zones is difficult to assess due to a suspected flow through the zone boundary into the Intermediate zone.

Fire flows in the south of the catchment are limited due to aged cast iron mains to the north of the water supply zones.

4.9.2 Wastewater System

The main areas of investigation into the Dunedin City wastewater system for Phase 1 were: system capacity, hydraulic performance, wastewater overflows and pumping stations. Current and future anticipated issues within the system at a macro level were identified. Flow survey and modelling from Phase 1 revealed a strong wet weather influence on the wastewater system city-wide, caused by both direct and indirect entry of stormwater via storm induced inflow and infiltration (I&I). 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.

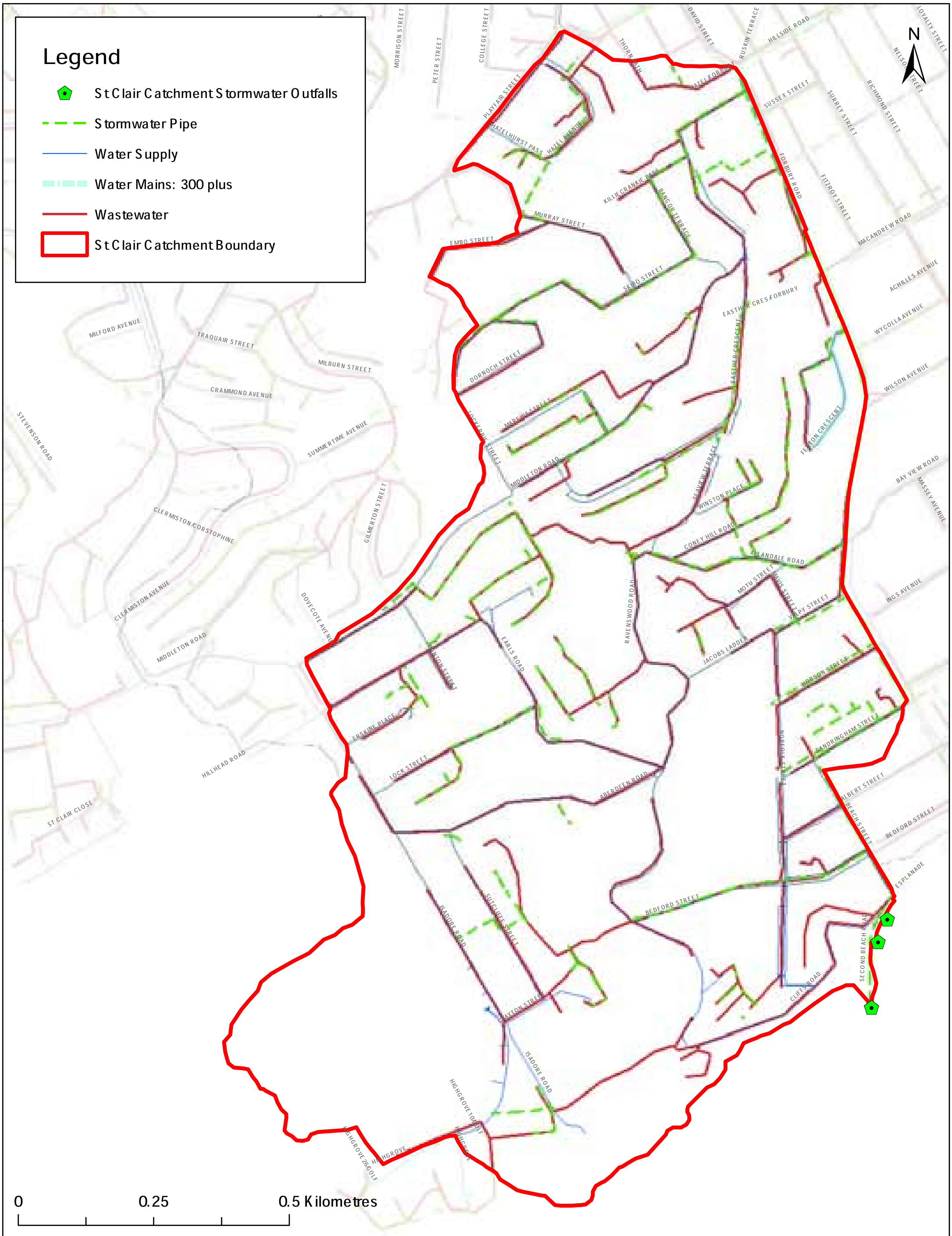
The Dunedin City wastewater system collects wastewater from commercial, industrial and residential customers in Dunedin City. It is split into three distinct schemes: the Dunedin Metropolitan Scheme, the Mosgiel Scheme and the Green Island Scheme.

The wastewater system within the St Clair 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 St Clair catchment comprises approximately 19 km of wastewater pipeline, approximately 89 % of which are between 150 mm and 300 mm in diameter.

Flows from this catchment are conveyed to the MIS through St Kilda via a trunk sewer.

Phase 2 wastewater investigations revealed that a number of wastewater manhole overflows occur during rainfall events within this catchment. This has been verified by customer complaints records. Recommendations from the Phase 2 wastewater investigations include further investigation of the manhole overflow problems. This will be incorporated into DCC's future activity planning.



Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-15 St Clair Catchment Three Waters Networks	DISCIPLINE Stormwater	Status: Final	
			Scale: 1:6,500	Plot Date: Sep 2011
			Drawn By: CO	Approved: HS
			Checked: JH	Date: Sep 2011
			Job No: 42173227	Map No: Figure 4-15 / Revision: -

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5 Receiving Environment

This section identifies and describes the stormwater receiving environment for the St Clair 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, have contributed to the state of this environment.

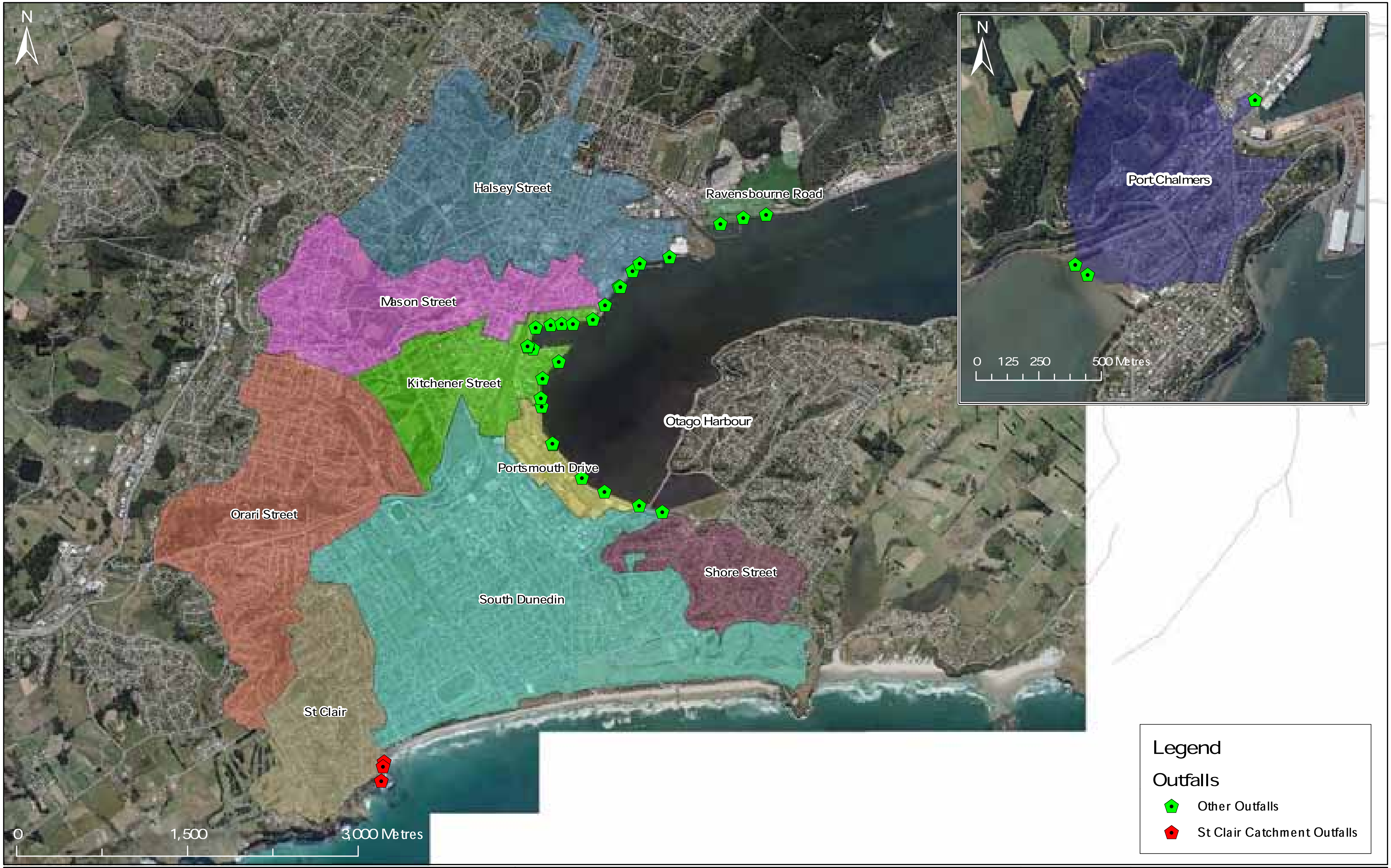
Part 3 of this report identifies and analyses the effects that specific stormwater management practices are considered to be having on the receiving environment of the catchment. Where the effects are considered to be unacceptable, options for avoiding, remedying or mitigating the effects are discussed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

The stormwater network in the St Clair catchment discharges directly to the marine environment of the Pacific Ocean via three outfalls located at Second Beach (Figure 5-1) and St Clair Beach (Figure 5-2). The location of all of the outfalls relative to the catchment and the Pacific Ocean receiving environment is illustrated in Figure 5-3.

There are several natural stream sections within the stormwater network, which originate from historic watercourses in St Clair catchment. Three of these streams were considered suitable for assessment of stream health, as part of the 3 Waters Strategy investigations (refer Section 5-2). Two of the streams contain a combination of piped and natural sections, and all receive discharges from the stormwater network as well as direct runoff from surrounding land.

Figure 5-1: St Clair Catchment Bell Chamber Outfall at Second Beach

Figure 5-2: St Clair Catchment Outfalls at St Clair Beach, Looking Southwest



Dunedin 3 Waters Strategy

ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 5-3

St Clair Catchment Marine Receiving Environment

DISCIPLINE	Drawn: MM	Status: Final	
Stormwater	Checked: TE	Scale: 1:30,000	Plot Date: Sep 2011
	Approved: HES	Job. No: 42173227	Map No: Figure 5-3 / Revision: -
	Date: Sep 2011		

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5.1 Marine Receiving Environment

Monitoring of the marine 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 in the Otago Harbour (2007, 2008, 2009, and 2010). While marine sediment monitoring was not a condition of consent for the St Clair catchment, monitoring was undertaken in 2010, as discussed below. The annual marine monitoring involves the following, and while intended to identify the effects of stormwater discharges, as noted above, may be measuring the effects of historical contamination (particularly in the case of sediment monitoring), as well as the effects of 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. Cockles / mussels were collected from within 20 m of the confluence of the stormwater outfall and waters edge at low tide. The flesh of the cockles is then analysed for heavy metals and polycyclic aromatic hydrocarbons (PAHs).

- Sediment monitoring: Replicate samples are collected from the top 200 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 outfall, 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.

The majority of studies carried out to establish the condition of the marine environment in Dunedin have focused on the Otago Harbour. However, stormwater from the St Clair catchment discharges to open coast (Pacific Ocean) at Second Beach and St Clair Beach. As such, little historic information is available regarding this location.

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 marine 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 major DCC outfalls and uses 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, where available, in order to determine the condition of the receiving environment.

The following reports are provided for reference in Appendix C, although it must be noted that the majority apply to the Otago Harbour receiving environment rather than the open coastline:

- Ryder (2010a). Ecological Assessment of Dunedin's Marine Stormwater Outfalls.

- Ryder (2010b). Compliance Monitoring 2010. Stormwater Discharges from Dunedin City.

- 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 St Clair Marine Environment

Stormwater is received from the St Clair catchment and discharged to the open coast (Pacific Ocean), which is a high energy environment, via three outfalls; the locations of which are shown in Figure 5-3.

The main stormwater line discharges via the Bell Chamber Outfall to Second Beach. The substrate at this location comprises large cobbles and small to large boulders. A branch off the main stormwater line, as well as stormwater from a predominantly open watercourse, discharges to St Clair Beach. The substrate at this location comprises clean, fine sand.

5.1.2 Recreational and Cultural Significance

The coastline around the St Clair catchment is an important area for tourism and recreation, and the area is listed in the Otago Regional Plan: Coast as a Coastal Recreation Area. The beaches are amongst the most popular in Dunedin and are renowned surf beaches. There are a number of hotels, restaurants and tourism operators in the area that benefit from the coastal location.

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 ki Otago have with the coastal environment. Further consultation with Käi Tahu is discussed in Section 3 of this report.

5.1.3 Marine Ecology

The resource consent associated with the stormwater discharge from the St Clair catchment has conditions requiring biological monitoring. This requires the annual sampling and analysis of mussel flesh adjacent to the Bell Chamber outfall. The 2010 study investigated macroalgae and epifauna in the vicinity of both Second Beach and St Clair Beach.

The biological investigations undertaken to date look at the effects of the presence / absence of particular stormwater associated contaminants on the ecological communities of the harbour. Table 5-1 below provides typical sources of urban stormwater contaminants.

Table 5-1: Sources of Stormwater Contaminants

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

The results of the biological monitoring at Second Beach for consent requirements (2007 to 2010) can be summarised as follows:

- Mussels: All contaminants analysed in the sampled mussel flesh were measured in low levels. The concentration of heavy metals measured in mussel flesh (2007-2010), have remained well below the New Zealand accepted food guidelines levels for shellfish flesh (ANZ Food Standards Code 2002; NZ Food Regulations 1984).

- The 2010 monitoring report concludes that there is little evidence of contamination of shellfish by stormwater at this site.

The results of the 2010 study can be summarised as follows:

- Macroalgae: Macroalgal cover was sparse with low diversity at both the St Clair Beach and Second Beach outfalls.

- Epifauna: Epifauna at both the St Clair Beach and Second Beach outfalls was restricted to hard substrate. It was found to be typical of intertidal animals in high energy environments, dominated by small barnacles, snails, limpets and chitons.

- Diversity and abundance was not found to change significantly with distance from the outfalls.

It is difficult to distinguish between the potential ecological effects of stormwater quality in any particular catchment. Marine ecology is likely to be affected by a number of other factors in this location including other discharges, exposure at low tide, freshwater input and the physical processes in this high energy environment.

However, the annual monitoring for resource consents to date indicates that the ecology near the Bell Chamber Outfall is not being adversely affected by stormwater quality in this catchment.

5.1.4 Marine Sediments

The resource consent associated with the outfalls from the St Clair catchment does not have any sediment monitoring requirements. However, samples were taken from within 20 m and greater than 20 m from the outfall at St Clair Beach as part of the 2010 study. The substrate at Second Beach was unsuitable for sampling due to its coarse nature.

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

As the marine environment at St Clair Beach is a high energy environment, the substrate in this location will be frequently re-worked by the tides. The opportunity for the deposition of sediments and build up of contaminants is therefore limited at this location.

The study results for sediment analysis are presented in Table 5-2. Contaminant levels in the sediments at St Clair Beach were found to be low with all contaminant levels measured well below ANZECC (2000) low trigger values.

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

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

Contaminant	ANZECC Trigger Value[1]		St Clair Beach Outfall		Comment
			<20 m	>20 m	
	Low	High	2010	2010	
Arsenic (As)	20	70	3.5	2.8	All samples below ANZECC low trigger value
Cadmium (Cd)	1.5	10	BDL	BDL	All samples below ANZECC low trigger value
Chromium (Cr)	80	370	3.2	1.9	All samples below ANZECC low trigger value
Copper (Cu)	65	270	1.7	1.0	All samples below ANZECC low trigger value
Nickel (Ni)	21	52	4.9	2.4	All samples below ANZECC low trigger value
Lead (Pb)	50	220	0.84	0.92	All samples below ANZECC low trigger value
Zinc (Zn)	200	410	5.4	5	All samples below ANZECC low trigger value
PAHs	4	45	BDL	BDL	All samples below ANZECC low trigger value
Enterococci*	-	-	<2	<2	Very low concentrations
Faecal coliforms*	-	-	<2	<2	Very low concentrations

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:

(yellow)	Exceeds Low ANZECC Trigger Value
(orange)	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 determining the current state of the streams within each catchment and identifying the potential effects of stormwater discharge 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 any changes in the condition of the freshwater receiving environment over time.

The assessment of stream health indicates, in part, the effect of ongoing stormwater discharges into the watercourses. Streams in the St Clair catchment have been receiving stormwater from urban development (both diffuse and concentrated) since the mid 1900s, and prior to that, from farming and horticultural land uses. 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 and development also results in changes to the flow dynamics and in-stream environment, and incorporation of fish barriers, in some instances.

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

> *"In Dunedin, a watercourse is defined as any natural, modified or artificial channel through which water flows or collects, either continually or intermittently, or has the potential to do so, and includes rivers, streams, gullies, natural depressions, ditches and drainage channels. This also includes any culvert or stormwater pipe that replaces a natural channel. A watercourse is owned by the property owner through which the watercourse passes through from the point of entry to the exit point of the property boundary."*
>
> *"Property owners are responsible for the following:*
>
> - *Ensuring that there are no obstructions or impediments in the watercourse which may inhibit the flow of water; and*
> - *Ensuring that any grates or outlets within your property are kept clear of debris at all times."*

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

Three streams with natural channels were identified as suitable for assessment in the St Clair catchment. A total of four sites were assessed in June 2010. The locations of the streams and assessment sites are shown in Figure 5-4.

Sampling sites were selected at the upstream and downstream ends of the largest stream (St Clair 1). The other two had lower flows and only short sections accessible for sampling, only one site was therefore selected on these streams (St Clair 2 and 3).

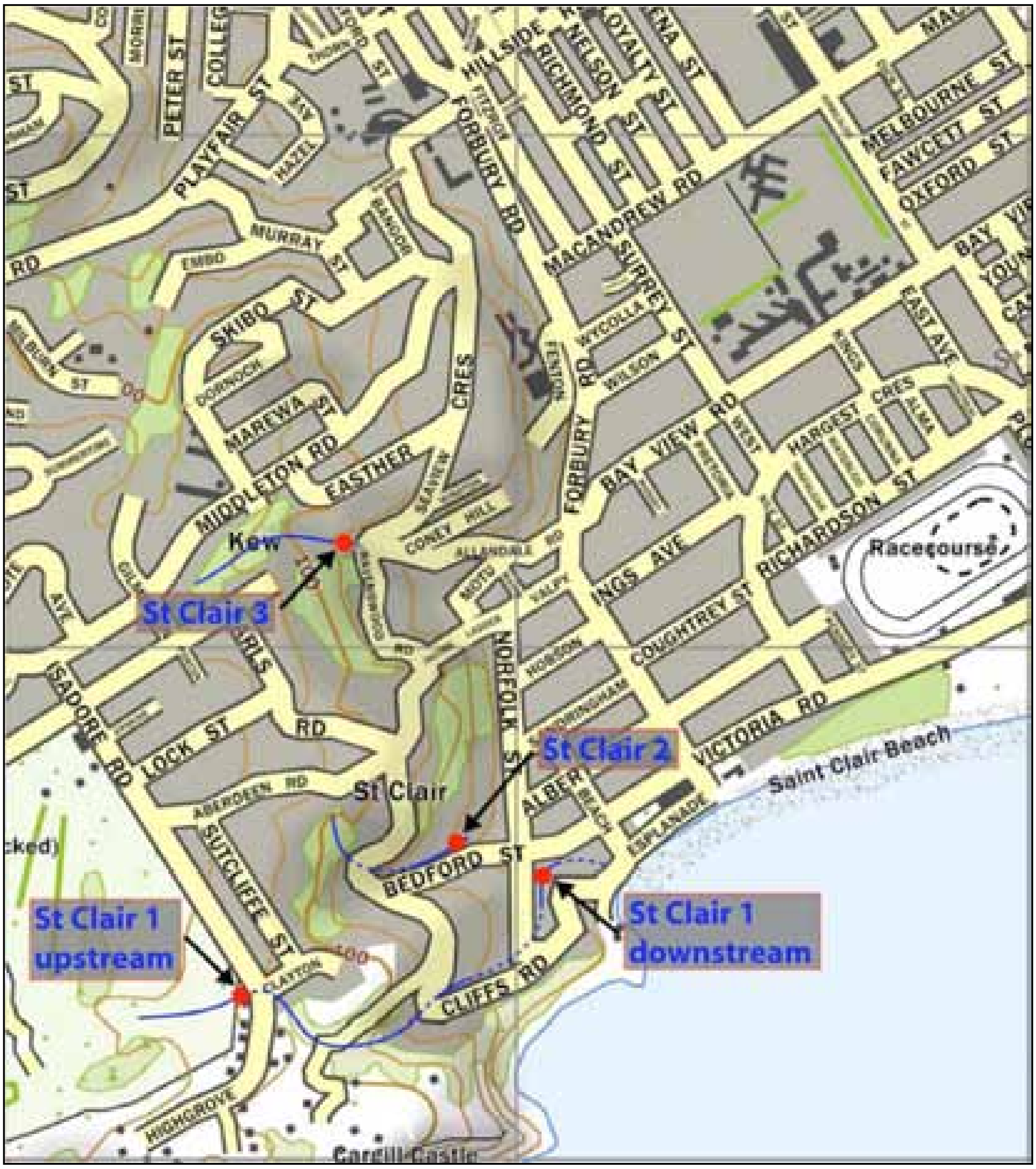

Figure 5-4: Freshwater Receiving Environment

5.2.1 Habitat Characteristics

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

Table 5-3: Assessment Site Characteristics

Characteristic	St Clair 1 - Upstream	St Clair 1 - Downstream	St Clair 2	St Clair 3
Length	20 m	40 m	20 m	50 m
Channel width	1 m	1.0 - 2.0 m	1.0 - 1.5 m	1.0 - 3.0 m
Channel depth	1 - 20 cm	3 - 40 cm	2 - 20 cm	2 - 40 cm
Bank height	0.3 m	0.3 - 1.0 m	0.5 m	0.5 - 1.0 m
Bank stability	High.	Moderately high with some undercutting.	Moderately high.	Very high.
Wetted width	0.5 m	0.5 - 1.0 m	0.5 -1.0 m	0.5 - 1 m
Dominant riparian vegetation	Short and long grasses.	Residential gardens with a canopy of trees and a sub canopy.	Canopy of trees, ground cover of ivy.	Canopy of trees, ground cover of ivy.
In-stream features	Shallow riffles with some runs.	Runs, short sections of shallow riffles and deeper pools.	Shallow riffles and some small pools.	Shallow riffles with runs and pools.
Bed substrate	Cobbles with some sections of clay-like substrate and gravels.	Gravels, cobbles and boulders with large areas of clay-like substrate.	Cobbles and boulders.	Cobbles, boulders and extensive areas of bedrock.
Other	Woody debris and leaves absent – stream flows through golf course.	Woody debris and leaves common. Some moss.	Leaves common and woody debris and moss uncommon.	Moss, woody debris and leaves common.

St Clair 1 Upstream

The upper reaches of this stream flow through the St Clair Golf Course before being piped beneath the road. The stream then exits to a natural channel that has been modified in recent years with channel straightening and the removal of riparian vegetation.

The stream is highly visible as it is contained within a golf course. Several footbridges cross the channel. As the golf course is private and therefore public access restricted, the amenity values are limited to viewing of the stream as opposed to access to it. See Figure 5-5.

St Clair 1 Downstream

The lower reaches of this stream flow through sections of stormwater pipe and natural channel before entering the sea at St Clair Beach (north outfall). The assessment site was located in a section of natural channel behind residential properties, which form the dominant land use in the lower catchment. See Figure 5-5.

Amenity values are limited as the stream channel is contained on private properties.

Figure 5-5: St Clair 1 – Left: Upstream Assessment Site; Right: Downstream Assessment Site

St Clair 2

This stream flows in a natural channel through forested and urban upper reaches before being piped under a road and flowing into sections of piped and natural channel.

The channel at the assessment site (Figure 5-6) is contained between residential properties and Bedford Street, with several driveway/bridge crossings of the channel. The site was located at the downstream end of the natural channel, immediately upstream of the entrance to the stormwater pipes. A debris gate was present in the middle of the assessment site.

Land use in the stream catchment comprises urban residential properties and large areas of bush cover.

Amenity values of the stream are limited to views through dense tress from Bedford Street and from the private driveways/bridges along the road.

Figure 5-6: St Clair 2 – Left: Assessment Site; Right: Entrance to Stormwater Pipes at Downstream End of Site

St Clair 3

This stream flows in a natural channel through forested and urban upper reaches before entering stormwater pipes at the intersection of Ravenswood Road and Seaview Terrace. The stream is piped under a private driveway in its middle reaches and contains several debris grates in the final open section prior to entering the stormwater pipes downstream.

Land use in the stream catchment is mainly urban residential with large areas of bush cover.

The stream is contained almost entirely on private residential land where thick forest and steep gradients prevent access for much of its length. Amenity values are therefore restricted. Refer Figure 5-7.

Figure 5-7: St Clair 3 – Left: Assessment Site; Right: Entrance to Stormwater Pipes at Downstream End of Site

5.2.2 Water Quality

The pH level in the streams at all four assessment sites were 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 at all sites. A higher conductivity indicates higher levels of nutrient enrichment.

The Third Schedule of the RMA (1991) states that a dissolved oxygen (DO) level of 80 % is an acceptable minimum standard for lowland river environments in New Zealand. DO levels were above minimum standards at all sites assessed.

5.2.3 Stream Ecology

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

A survey of the benthic algal cover and aquatic plants was undertaken 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 describe the fish community within the stream, electric fishing was carried out, at locations representative of the different habitats within the stream. Where electric fishing was not able to be carried out efficiently, spotlighting was carried out to visually identify the fish.

The results of the stream ecological assessment are 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: Grasses were present along the stream edges at the upstream site of St Clair 1. Small patches of filamentous green algae and a thin film of diatoms on the cobbles was also observed. At the downstream site of St Clair 1, diatoms were also observed. Benthic algae was not visible at St Clair 2 and 3 sites.

- Macroinvertebrates: A total of 18 different taxa were observed within the St Clair streams. The average number of taxa per sample was consistently below the national average of 14 (as determined in a nation-wide survey by Quinn and Hickey 1990).

- Macroinvertebrate communities throughout the sites were dominated by Potamopyrgus antipodarum snails and oligochaete worms. High quality scirtid beetles were also present in abundance at the upstream site of St Clair 1.

- Macroinvertebrate community health index scores were very low throughout the catchment. They were indicative of a 'poor' or 'fair' quality habitat (using narrative terminology of Stark and Maxted 2004). The poorest quality invertebrate communities were observed at the St Clair 2 site.

- St Clair 2 and 3 sites had the threatened isopod Austridotea benhami. This is likely to be the most vulnerable of the three isopod species found in New Zealand due to its limited geographical range and agricultural and urban development present in the catchments in which it is found (Chadderton et al, 2003). Using the 'threat of extinction' classification, DOC has listed this species as 'range restricted' (Hitchmough et al, 2007).

- Fish: No fish were caught or observed in the three streams of this catchment at the time of survey. However, galaxiids have been observed in the lower reaches of the St Clair 1 stream by landowners in the past. It is therefore likely that they are present in the stream on occasion.

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, and summarised below.

Habitat and ecosystem quality was generally moderate throughout the catchment with water quality generally 'poor' due to high conductivity levels, suggesting nutrient enrichment.

St Clair 1 upstream was generally 'poor' habitat quality with 'poor' abundance of invertebrates and fish. At the downstream site however, habitat quality was generally 'good' and ecology was varied. Whilst isopod species was observed, invertebrate communities were found to be 'poor'.

Whilst the habitat quality of the St Clair 2 site was found to be 'good' to 'excellent', the ecology was found to be 'poor'.

The habitat and ecosystem of the St Clair 3 site was of particularly good quality, with most stream features of 'good' or 'excellent' quality, a 'good' abundance of invertebrates, but a 'poor' abundance of fish.

There are currently no relevant National Policy Statements or National Environment Standards (NES) relating to freshwater systems. There is a Proposed NES 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 streams in the St Clair catchment varies, but is in general as might be expected for modified urban streams. The presence of features of interest (isopods) in the St Clair 2 and 3 streams indicates a good quality for a modified urban stream.

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

Feature	St Clair 1		St Claire 2	St Clair 3
	Upstream	Downstream		
Riparian vegetation	Poor	Good	Good	Good
Bank stability	Good	Good	Excellent	Excellent
Flow variability	Poor	Good	Good	Good
Bed substrate	Good	Good	Excellent	Excellent
In-stream cover	Poor	Good	Poor	Good
Water quality	Poor	Poor	Poor	Good
Invertebrates	Poor	Poor	Poor	Good
Fish	Poor	Good	Poor	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 St Clair 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 consent. The Bell Chamber outfall from the St Clair catchment has been included in this sampling regime. It should be noted, however, that since the second main outfall (St Clair Beach south outfall) also discharges stormwater from the same stormwater line, stormwater quality will be identical at the two outfalls.

Limited monitoring has also been undertaken at the St Clair Beach north outfall, measuring FWAs and faecal coliforms.

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

Monitoring of the stormwater quality at the Bell Chamber 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 St Clair catchment Bell Chamber outfall at Second Beach, which is undertaken via a grab-sampling technique, providing a 'snapshot' of stormwater quality during a storm event. Data is also presented indicating FWAs and faecal coliform levels in the stormwater from the St Clair Beach outfall 2009-2010.

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.

Considerable variability can be expected in stormwater sampling due to antecedent conditions (the number of dry days prior to rainfall) and event characteristics (intensity and duration of rainfall) affecting the amount of sediment (and hence contaminants) present in the stormwater. Additionally, the grab-sampling technique employed may have taken a sample at any point during the event.

The annual monitoring results indicate that the level of contaminants in the stormwater is variable between the years monitored, but is generally low. Many contaminants have been below detectable levels across the monitoring years and all contaminants were measured below the range typically observed from this type of catchment when compared with stormwater data from the variety of sources listed in Tables 6-2 and 6-3.

The exception to this is the levels of E.coli and faecal coliforms. Whilst levels have fluctuated over the monitoring years, the stormwater results for 2010 from the Bell Chamber outfall indicate elevated E.coli and / or faecal coliform levels with faecal coliforms being higher than the typical range for urban stormwater for faecal coliforms (1,000 – 21,000 MPN/100 ml) (Metcalf and Eddy, 1991). Generally, measurements have been well above that sampled in the Port Chalmers catchment discharge (an entirely residential catchment).

The presence of FWAs within the stormwater can be an indication of human waste contamination. FWAs may also be present in low concentrations from other activities such as vehicle washing.

FWA concentrations measured in the stormwater from this catchment are not particularly high and the peaks in FWA concentrations do not correspond with the peaks in E.coli / faecal coliform levels. In some cases, FWA levels are at the lowest measured when faecal coliform levels in the stormwater are at their highest.

This may indicate that the fluctuations in E.coli / faecal coliforms are not related to wastewater inputs. High microbial counts are not unexpected in first flush stormwater samples with animal faeces and decaying vegetable matter being washed into the stormwater system (Ryder 2010b).

The Phase 2 wastewater investigations for the 3 Waters Project have, however, highlighted that there have been wastewater manhole overflows in the catchment, verified by complaints records (as discussed in Section 4.8 and 4.9.2). The recommendations the Phase 2 of the wastewater study include the further investigation of these overflows. There may therefore be a relationship between the reported overflows and the microbial levels in the stormwater from this catchment, as wastewater manhole overflows are likely to enter the stormwater system via catchpits.

Table 6-1: Stormwater Quality Consent Monitoring Results – St Clair Catchment Outfalls

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
Second Beach													
2007	7.7	BDL	BDL	0.0007	0.0027	0.0009	0.001	0.038	BDL	5	0.147	560	560
2008	7.3	0.0013	0.00006	0.0028	0.012	0.0021	0.011	0.16	37	BDL	0.19	6800	8300
2009	7.4	0.0015	0.00006	0.0035	0.019	0.0022	0.013	0.15	41	BDL	0.098	14000	14000
2010	7.3	BDL	0.00007	0.00086	0.0054	0.00133	0.00021	0.092	BDL	BDL	0.04	4800	92000
St Clair Beach													
2009	-	-	-	-	-	-	-	-	-	-	0.261	-	3900
2010	-	-	-	-	-	-	-	-	-	-	0.222	-	12000

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 St Clair Catchment Stormwater Quality with Other Stormwater Quality Data

Contaminant (g/m^3)	Time Proportional Dunedin	Christchurch Recommended Provisional Mean Values[1]	Pacific Steel, Auckland[2]	Brookhaven Subdivision[3]	Australian Stormwater Mean [4]	Urban Highway, USA[5]	New Zealand Data Range[2]	St Clair 2010
	Residential / Industrial	Christchurch	Industrial	Residential	Australian sites	Highway	Urban	Residential
TSS	8 - 330	33 - 200	124	5 - 49	164	142	-	BDL
Zinc	0.05 - 2.50	0.40	2.80	0.003 - 0.260	0.910	0.329	0.09 - 0.80	0.092
Copper	BDL - 0.23	0.05	0.08	0.002 - 0.031	0.08	0.054	0.015 - 0.110	0.0054
Lead	BDL - 0.087	0.075	0.23	0.003 - 0.007	0.25	0.4	0.06 - 0.19	0.00021

BDL = below detection limit

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 St Clair 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 'St Clair Model Build Report' (URS, 2011a), and the 'St Clair Catchment Hydraulic Performance Report' (URS, 2011b); 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 for 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 moderately low because of a lack of validation with reported flooding; however the model has been calibrated, and was built using accepted sound methodology by experienced modellers and engineers. 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: St Clair Model Results – Current Land Use

Hydraulic Performance Measure	ARI	Current Land Use
Percentage of manholes predicted to overflow	1 in 2[1] yr	2.1
	1 in 5 yr	4.1
	1 in 10 yr	11.4
Number of land parcels with flood depth potentially >= 300 mm[2]	1 in 2 yr	0
	1 in 5 yr	1
	1 in 10 yr	2
	1 in 50 yr	5
	1 in 100 yr	5
Estimated flood extent (% of catchment area with flood depth >= 50 mm)[3]	1 in 2 yr	0.0
	1 in 5 yr	0.0
	1 in 10 yr	0.1
	1 in 50 yr	0.2
	1 in 100 yr	0.3
Modelled percentage (by number) of pipes surcharging	1 in 2 yr	11.0
	1 in 5 yr	37.9
	1 in 10 yr	53.0
Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover)	1 in 2 yr	0.5
	1 in 5 yr	4.7
	1 in 10 yr	6.7

[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] Excludes flooding outside of the St Clair catchment boundary (0.5 ha during current 1 in 10 yr ARI event, up to 1.4 ha during the 2060 1 in 100 yr ARI extreme event).

Table 7-2: St Clair 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	12.4	15.5	17.6	17.6	18.1
Number of land parcels with flood depth potentially >= 300 mm[1]	1 in 10 yr	2	2	2	2	5
	1 in 50 yr		7		7	
	1 in 100 yr					14
Estimated flood extent (% of catchment area with flood depth >= 50 mm)[2]	1 in 10 yr	0.1	0.1	0.1	0.1	0.2
	1 in 50 yr		0.3		0.3	
	1 in 100 yr					0.6
Modelled percentage (by number) of pipes surcharging	1 in 10 yr	57.1	58.4	60.3	60.7	64.4
Percentage of manholes with free water level within 300 mm of cover	1 in 10 yr	8.3	6.2	5.2	5.2	7.8

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

[2] Excludes flooding outside of the St Clair catchment boundary (0.5 ha during current 1 in 10 yr ARI event, up to 2.2 ha during the 2060 1 in 100 yr ARI extreme event).

DUNEDIN CITY COUNCIL / OPUS	Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 7-1 St Clair Catchment Model Extent	DISCIPLINE Stormwater	Status: Final		
				Scale: 1:6,500	Plot Date: Sep 2011	
				Drawn By: CO	Approved: HS	
				Checked: JH	Date: Sep 2011	
				Job No: 42173227	Map No: Figure 7-1	Revision: -

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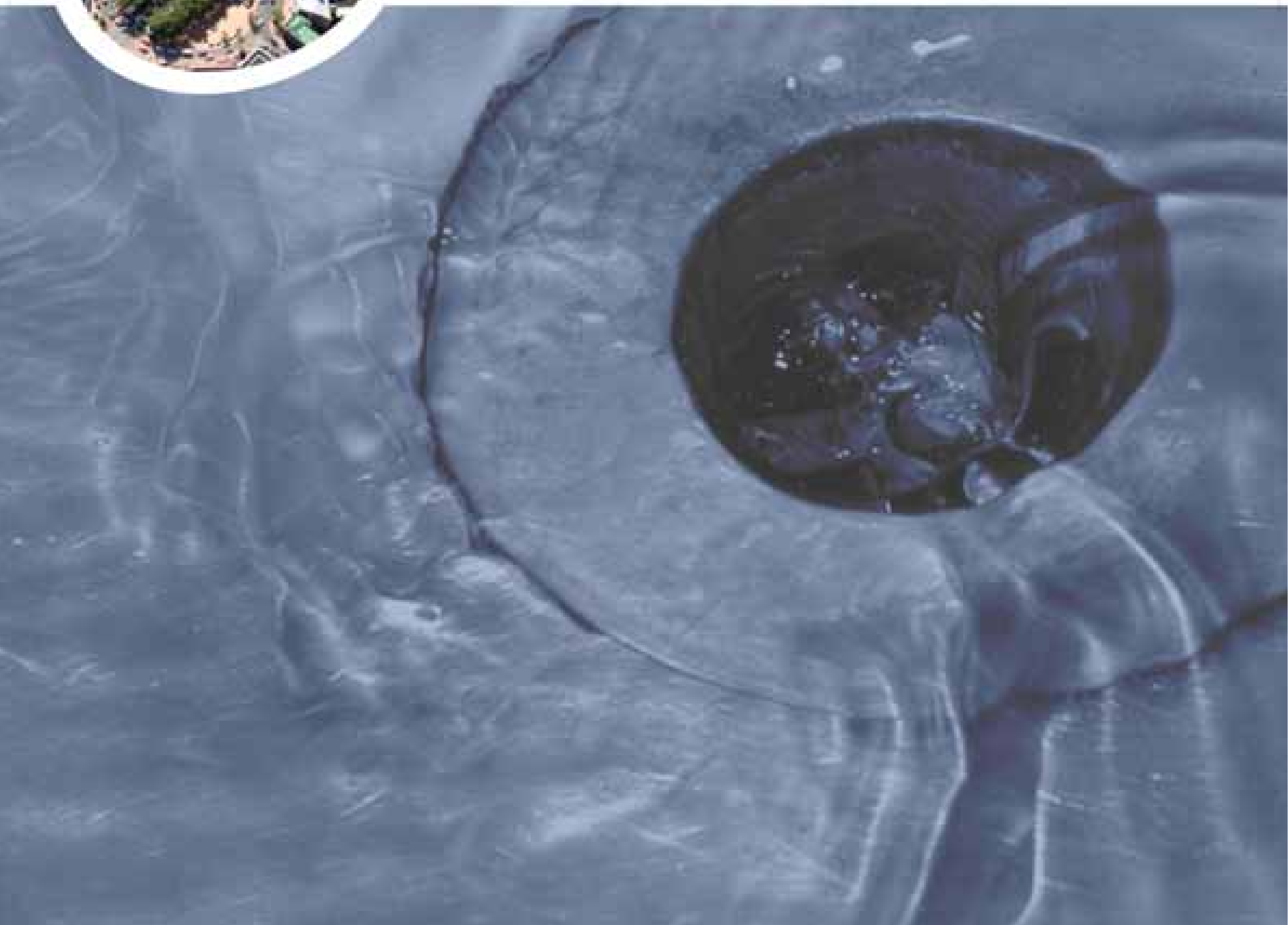
Part 3

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 carparks, and they can also include, but to a lesser extent, grassed and garden areas. In Dunedin, the stormwater network controls the urban runoff, collecting the flows within the system and directing it to the receiving environment. The stormwater network therefore provides a number of benefits to the community.

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

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

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

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

8.1.2 Stormwater Quantity Effects

The hydraulic model results, summarised in Table 7-1 and 7-2 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. A moderate level of calibration was achieved with observed data from two out of three selected calibration events. The model replicates known flooding in some areas of the catchment and provides a moderately low level of confidence in its ability to broadly estimate the St Clair catchment response to extreme rainfall events. The level of confidence is based in part on the limited asset data available in the catchment.

The effects of stormwater quantity on the network within the St Clair 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.

Because of the moderately low confidence in the model results, this Assessment of Environmental Effects (AEE) relies strongly on anecdotal evidence, originating from reported events by the general public and consultation meetings / workshops with the Network Management and Maintenance staff of DCC. Unconfirmed model outputs of significance can be used to focus future modelling and investigation work in the catchment.

The sections below on infrastructure capacity, nuisance flooding, habitable floor flooding and flood hazard are predicted model outcome scenarios, and could only be partly validated through actual reported historical higher level events, i.e. 1 in 10 yr ARI upwards. Actual flooding level data for those events was, however, not obtainable.

In reality, rainfall events of a smaller return period and short duration, which might cause temporary surface water flooding, are very unlikely to be reported by the general public. The results of the hydraulic flood modelled scenarios are therefore to be used as one of the tools for emergency planning and asset management.

8.1.3 Infrastructure Capacity

The model indicate that approximately 90 % of the modelled network can accommodate flows of at least a 1 in 10 yr ARI rainfall event; although these pipes may be surcharged only some manholes experience some levels of overflow. Figure 8-1 illustrates the model results for this event.

The main interceptor pipe along Forbury Road, which dictates the capacity of the overall system, appears to provide a lower level of service. Manhole overflows from just upstream of Macandrew Road down to Wilson Avenue accumulate in the north-bound lanes of the street and stormwater is predicted to cross over the road into the South Dunedin catchment for rainfall events in excess of a 1 in 5 yr ARI.

During the 1 in 10 yr ARI rainfall event most of the predicted flooding that remains in the St Clair catchment appears to be confined to roads. Shallow to moderate flows are predicted within existing open channel margins, with the deepest flooding being at the intake screen of 30 Middleton Road. Other intakes experience moderate to deep ponding during more extreme events.

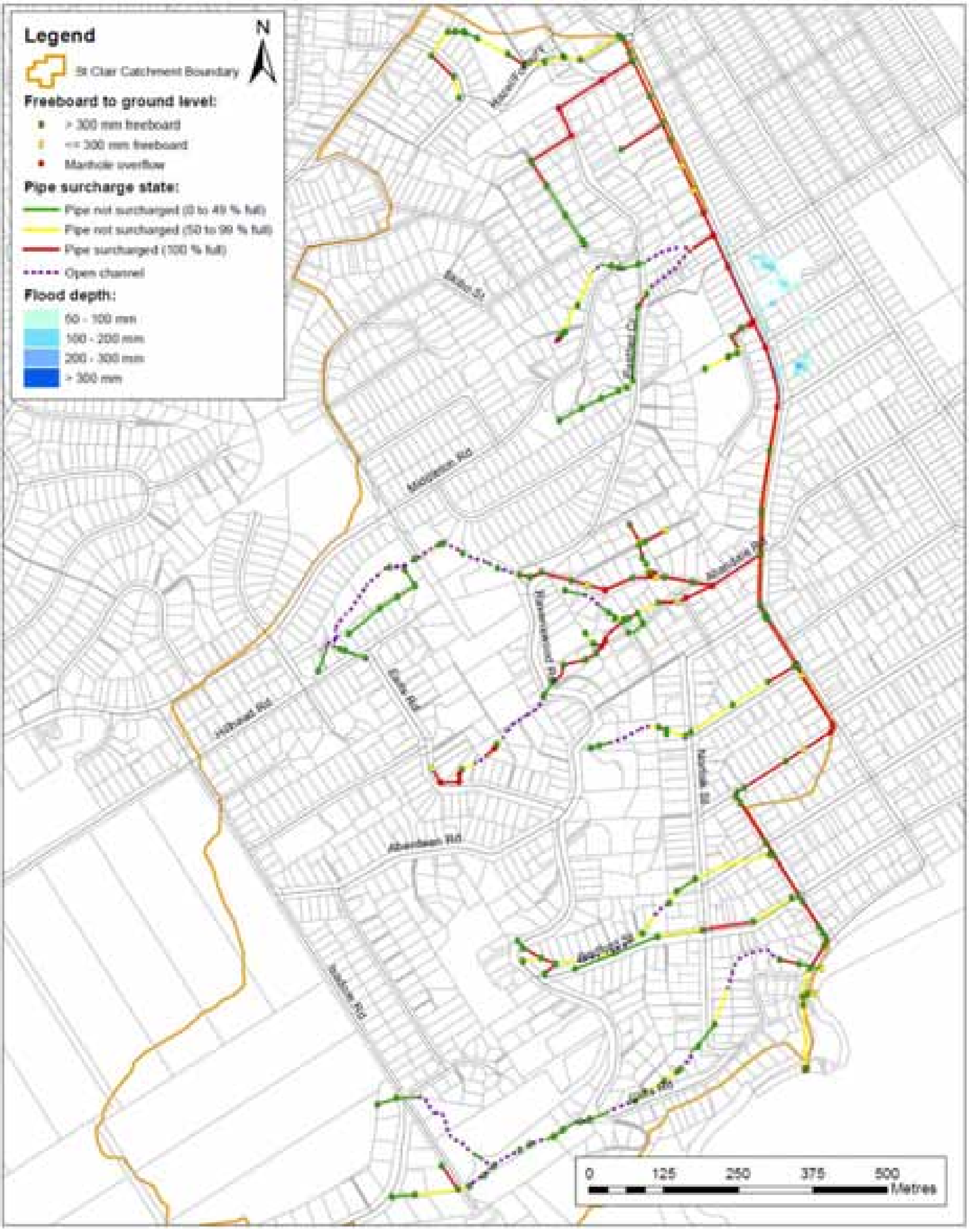


Figure 8-1: 2010 Predicted Level of Service – 1 in 10 yr ARI Rainfall

Depths exceeding 300 mm are predicted on only two land parcels (excluding roads and railways) during the 2010, 1 in 10 yr ARI rainfall event, and on one land parcel during the 1 in 5 yr ARI rainfall event.

In terms of predicted surface flooding during the 1 in 100 yr ARI rainfall event, less than 1 % of the catchment area is estimated to experience flooding to a depth greater than 50 mm. However, a significant proportion of the flooding volumes from this catchment cross over into the South Dunedin catchment (approximately 66 % of overflows from the St Clair network during the 1 in 100 yr ARI – Current planning scenario).

The modelled St Clair stormwater network is not tidally influenced for tide levels up to the 2010 MHWS (101.03 mRL), as all three of the outfalls have inverts assumed to be above this level.

8.1.3.1 Key Structures

Due to the low confidence in the hydraulic model, key structures under DCC's management are discussed in this section with respect to their simulated and reported performance during rainfall events.

St Clair Beach North Outfall

The St Clair Beach North Outfall collects surface water from the southernmost branch in the catchment, which is predominantly open channel. The outfall is fitted with an inclined screen for health and safety purposes, and to prevent debris form entering the network without restricting the discharge (Figure 8-2). The majority of the network upstream of this outfall is not predicted to surcharge during a 1 in 10 yr ARI rainfall event.

Figure 8-2: St Clair Beach North Outfall

Bell Chamber Outfall

The Bell Chamber Outfall (refer to Figure 5-1) houses six outlets of various dimensions and invert elevations, two of which have debris screens fitted. These outlets are predicted to become fully inundated during the 2060, 1 in 100 yr ARI event, with maximum modelled depths in the order of 600 mm to 740 mm at the various outlets. These depths are largely a result of the 1 in 20 yr ARI storm surge tide level, with the next closest peak depths at the six outlets ranging from 180 mm to 300 mm during the 2060, 1 in 50 yr ARI event. The chamber is regularly cleared of rocks that are deposited in the chamber by wave action during high tides.

St Clair Beach South Outfall

The St Clair Beach South Outfall branches off the main pipeline approximately 120 m upstream of the Bell Chamber Outfall (Figure 8-3), and the model predicts that this outfall discharges similar volumes to the Bell Chamber Outfall. Stormwater discharge has been observed from this outfall by DCC Network Management and Maintenance staff.

Despite containing a rise in the pipe (i.e. negative gradient) in a pipe section before the outfall, flows are predicted at this outfall during all events, with only the 1 in 2 yr ARI and 1 in 5 yr ARI events producing peak flows of less than 0.5 m^3/s.

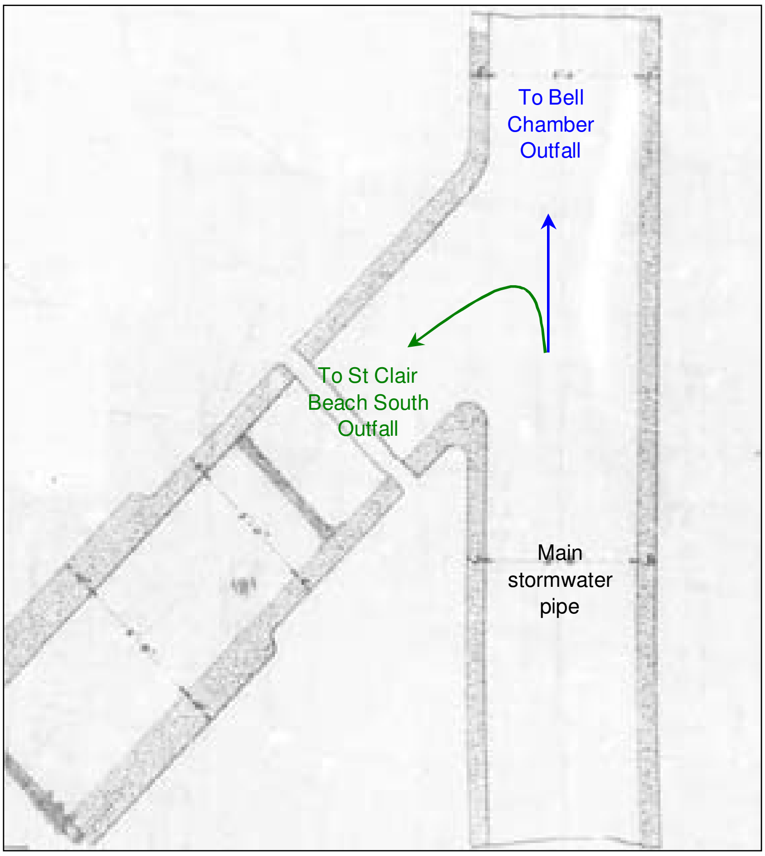


Figure 8-3: Diagram of Flow direction from the Main St Clair Stormwater Line to two Outfalls

Forbury Corner Bypass

At the bottom end of David Street, near the Forbury Road roundabout in the north of the St Clair catchment, there exists a high level overflow directly connecting this network to the South Dunedin stormwater network. A manhole investigation provided the dimensions and relative invert levels of the manhole and overflow, thus confidence in the modelled parameters of this element of the network is high.

Flows into the South Dunedin network via this bypass are predicted for all events equal to or greater in magnitude than a 1 in 10 yr ARI rainfall event.

Model results from the South Dunedin catchment model indicate that the connecting pipe is surcharged for all modelled events (using a 2 hour critical duration), thus although the overflow was not included in the network of the South Dunedin catchment model, it can be assumed that there will be exchanges of flow in both directions for most extreme rainfall events, depending on the relative flow depths in the overflow-connected pipes.

Consideration should be given to combining the South Dunedin and St Clair catchment models to achieve a more accurate analysis of the flows in these two networks.

Inlet Screens

Seven intake screens were identified during the model build as being locations of potential flooding issues, and were subsequently modelled using a combination of in-built and user-defined head – discharge relationships. The intakes operated as expected, some causing moderate flooding due either to the constriction of flow into the downstream pipes or the modelled level of blockage of the screen, or both. Of the seven intake structures modelled, only one (30 Middleton Road) appears to be at risk of overflowing during events up to a 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 storm 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 St Clair catchment appears to be located primarily along Forbury Road, or associated with watercourse intakes further up in the catchment; overflows in the east 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.

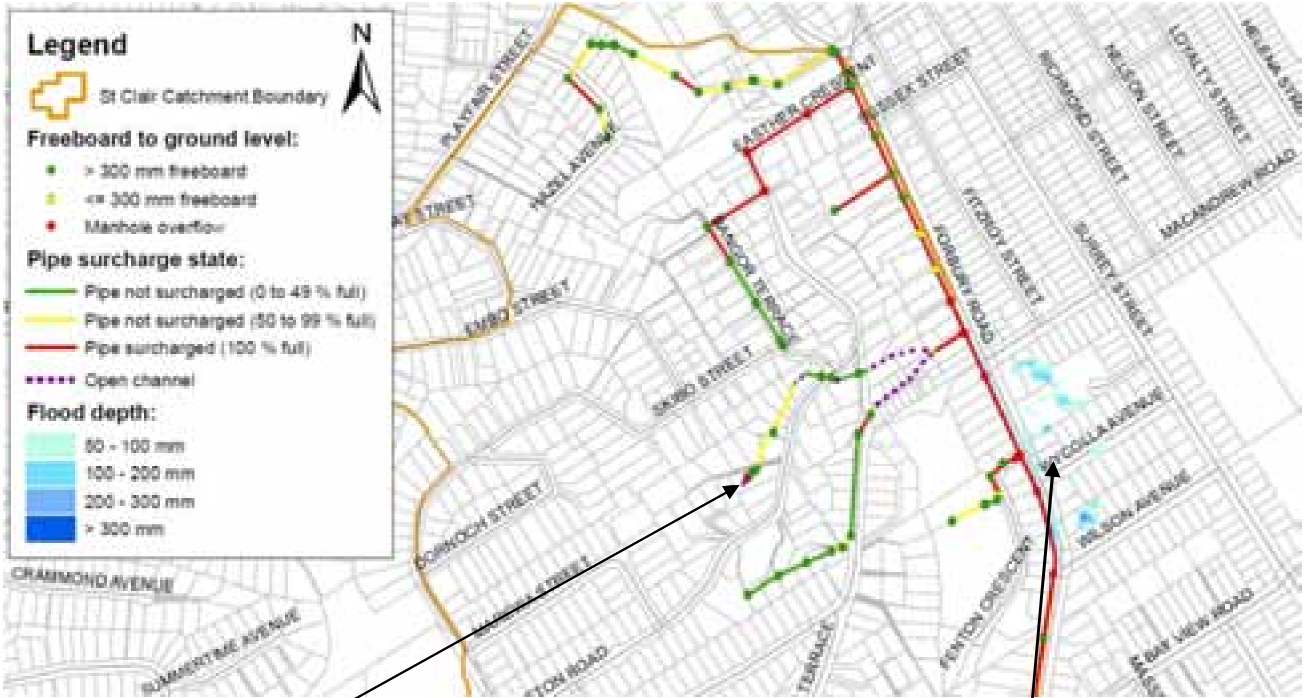
Nuisance flooding in the St Clair catchment during the 1 in 10 yr ARI event is minimal and is restricted to two main locations; Forbury Road area and 30 Middleton Road, as described in Table 8-1, and illustrated in Figure 8-4 and Figure 8-5.

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

Location	Description	Predicted Cause	Minimum Rainfall Event (ARI yr)
Forbury Road (from Approximately 80 m north of Macandrew Road to Wilson Avenue)	Overflows from multiple manholes on Forbury Road and intersecting roads flow east across the street and into the South Dunedin catchment, causing predominantly moderate ponding (50 – 300 mm deep) on several properties in the block between Forbury Road and Surrey Street, additional to flooding caused by the South Dunedin network performance. Flows also accumulate in the western kerb and lane(s) of Forbury Road.	A surcharging main pipeline along Forbury Road leads to overflow from manholes in topographically low points. Additionally, overflows from manholes on lateral pipes occurs.	1 in 10
30 Middleton Road	Deep ponding at the intake screen at the back of the property.	Located in a bush area, the intake screen regularly becomes blocked by leaves and mud (as modelled).	1 in 2

The intake at 30 Middleton Road consists of a wooden grate that was observed to be almost completely blocked by leaves and mud during a site visit in September, 2010. Furthermore, at the time of the visit, the homeowner reported that he has noticed flooding, but only over his lawn, and that the screen was partially blocked by mud and leaves. There were two complaints from this residence in 2009.

DCC Network Management and Maintenance staff have confirmed that overflows and localised nuisance flooding occurs along Forbury Road.



Predicted flooding at the inlet screen at 30 Middleton Road in the 2010, 1 in 10 yr ARI event

Predicted flooding along Forbury Road in the 2010, 1 in 10 yr ARI event, overflowing into the South Dunedin catchment

Figure 8-4: Predicted flooding at 30 Middleton Road and along Forbury Road from a current 1 in 10 yr ARI Event

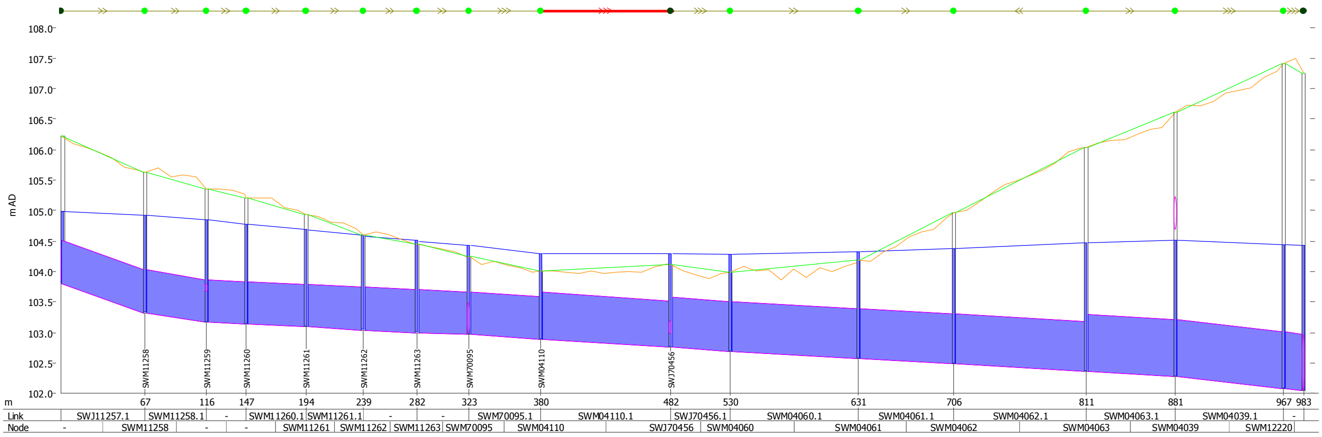


Figure 8-5: Long Section along Forbury Road Pipeline (between Easther Crescent and Valpy Street), current 1 in 10 yr ARI rainfall event

8.1.4.2 Habitable Floor Flooding

Predicted 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.

During the modelled 1 in 50 yr ARI events, five properties within the St Clair and South Dunedin catchments are predicted to experience flooding on part of their parcel to depths greater than 300 mm for the current land use. This number increases to seven for the 2060 land use and mean climate change scenario. 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 the parcels are only predicted to experience flooding on a very small part of the parcel. Furthermore, the modelled flood depths often appear to be confined to gullies at the rear of properties. It is considered to be extremely unlikely that floodwaters will enter habitable floors.

There are only two properties that are predicted to be at risk of habitable floor flooding (> 300 mm) during the 2010, 1 in 10 yr ARI event; one is located on Wilson Avenue in the South Dunedin catchment and is caused by overflows from Forbury Road, while the second is the Middleton Road residence discussed in Section 8.1.4.1. This intake is predicted to experience flooding from as little as the 2010, 1 in 2 yr ARI event, however the flooding appears to be located away from the buildings on the property and is unlikely to affect anything other than a garage, even during the extreme 2060, 1 in 100 yr ARI scenario.

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.

As with the majority of flooding scenarios, the emergency planning modelling identifies the intake at 30 Middleton Road as well as small parts of Forbury Road and the residences to the east of it as being the most at risk of deep and / or fast surface flooding in extreme events. These areas warrant pockets of 'moderate' to 'significant' hazard ratings during the current 1 in 100 yr ARI rainfall event, due to both depth and velocity. The 2060 1 in 100 yr ARI rainfall event (with a 1 in 20 yr ARI storm surge) introduces several small additional regions of 'moderate' to 'significant' hazard areas, which includes some of the catchment's intake screens and associated open channels. Refer Figure 8-6.

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.

Figure 8-6: Flood Hazard along Forbury Road, 2060 1 in 100 yr ARI rainfall event

8.1.5 Network Age, Operation and Maintenance

The model predictions indicate that the main interceptor pipe along Forbury Road struggles to contain flows up to a 1 in 10 yr ARI event. This length of pipe was laid before 1920, and is currently being inspected via CCTV as part of the condition assessment programme; the DCC pipe renewals programme provides an opportunity to potentially renew these pipes in the near future; new pipes would be designed to convey the future 1 in 10 yr ARI rainfall event.

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 / standards. The different asset management authorities / bodies appear not to have a coordinated approach on regular asset maintenance, e.g. trash screen clearance until an extreme rainfall event and surface water flooding is occurring and in most cases reported by the general public.

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 intake structure at 30 Middleton Road appears to be particularly sensitive to blockage. A number of other intake structures may also be at risk, based on the location of resident complaints about stormwater flooding. Regular sustainable asset maintenance would optimise performance for the current design, however re-design and upgrade in these locations could also be required.

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.

8.1.7 Summary of Effects of Stormwater Quantity

- Based on the modelling results, the current level of service of the piped stormwater network in the St Clair catchment is at least 1 in 10 years for the majority of the network, however the main interceptor pipe along Forbury Road (which dictates the capacity of the overall system) has a lower level of service, with a small number of overflows predicted during a 1 in 5 yr ARI rainfall event.

- Nuisance flooding is predicted and confirmed along the north-bound lane of Forbury Road, between Wilson Avenue and approximately 80 m north of Macandrew Road. Flooding in this vicinity becomes progressively worse during larger rain events, with overland flow predicted to cross the road and enter the South Dunedin catchment during events greater than or equal to a 1 in 10 yr ARI rainfall.

- Regular blockage of an intake structure at 30 Middleton Road is responsible for nuisance and deep flooding on this property. Blockage of other intake structures in the catchment may be prompting community complaints regarding flooding.

- Potential blockage of catchpits within the catchment is likely to contribute to flood duration and extent.

- Based on the assumed outfall levels modelled, the main stormwater system is not tidally influenced in a 1 in 10 yr ARI rainfall event with the current MHWS tide level.

- Flood depths exceeding 300 mm are predicted on one property during a 1 in 5 yr ARI rainfall event and two properties in a 1 in 10 yr ARI rainfall event, including one that is located in the South Dunedin catchment.

- During the 1 in 50 yr ARI rainfall events modelled, up to five properties are predicted to experience flooding on a small 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 seven properties experiencing small pockets of deep flooding. This is unlikely to enter habitable floors, however no floor survey has been undertaken.

- During a current (2010) 1 in 100 yr ARI rainfall event, predicted maximum flood hazard rating for the catchment is ‘moderate / significant’, however the flood hazard is generally confined to within open channels, or in small areas of land depression.

- A cross-connection with the South Dunedin stormwater network provides the opportunity for flow interactions between the two catchments during storm events; the extent of which are not yet fully understood. Further investigation and / or modelling surrounding this structure will provide a better understanding of its effects on the two networks.

8.2 Stormwater Quality

Stormwater quality is discussed in detail in Section 6. Annual monitoring of the quality of the stormwater discharged from the St Clair catchment, conducted using a grab-sample technique, has been undertaken (2007 to 2010).

The following is a summary of the annual stormwater monitoring results. The observations must be viewed in the context of a very small dataset and the limitations of the grab-sampling method (discussed below).

- The levels of contaminants in the stormwater from the outfall sampled in this catchment are low and within or below the range typical of stormwater quality from similar catchments, with the exception of faecal coliforms and E.coli.
- Microbial contamination (E.coli and faecal coliforms) has fluctuated over the monitoring years but generally remained within the typical range for stormwater, except in 2010 when the monitoring results showed a significant increase in levels of microbial contamination.
- FWA fluctuations do not correspond with fluctuations in the levels of microbial contamination.
- The results show some variability between years, particularly with respect to microbial contamination.

The potential source of microbial contamination in the stormwater from this catchment is difficult to distinguish and with one year's data indicating high levels within the stormwater it may be a recent issue or isolated incidents.

Measured peaks in levels of FWAs, an indicator of human wastewater contamination, do not correspond with peaks in the microbial contamination of the stormwater. Therefore contamination by human wastewater cannot be concluded with any certainty.

However, the outcomes of the 3 Waters Phase 2 wastewater study highlight known wastewater manhole overflows in the catchment, verified by customer complaints. This may have affected the stormwater quality results (refer Section 4.9). Further investigations may be required to confirm the potential sources of the microbial contamination within this catchment.

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

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

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

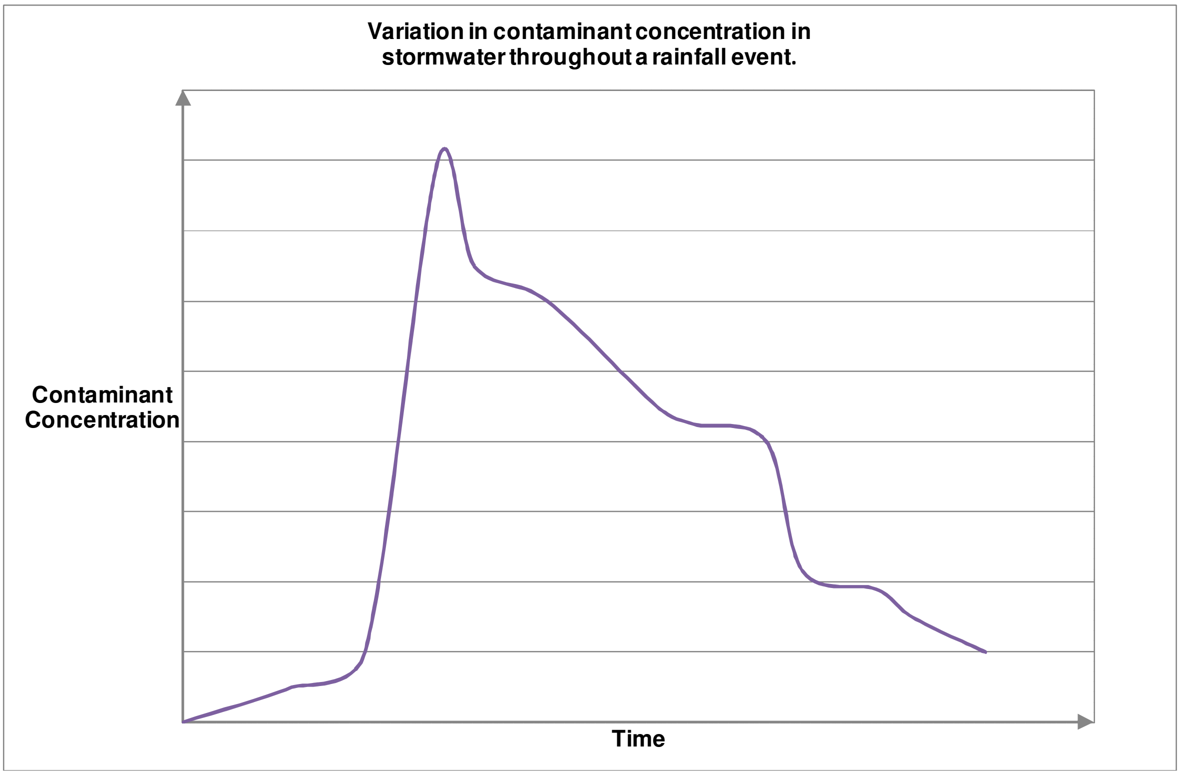


Figure 8-7: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event

(Based on time-proportional sampling carried out in Dunedin)

8.2.1 Marine Water Quality

The quality of the marine water will be affected by numerous contaminant sources including, but not limited to: beach users and the WWTP discharge approximately 4 km along the coast. Currently, marine water quality is not monitored by DCC and as such there is no clear link between the quality of stormwater leaving the outfall and the quality of the water in the Pacific Ocean.

While no national or international guidelines are available for stormwater discharge quality, ANZECC (2000) guidelines are available for marine water quality (as well as marine 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 quality monitoring would need to be undertaken alongside stormwater quality monitoring, and links established between stormwater discharge points and marine water quality in the immediate vicinity. Further clarity with respect to longer term environmental effects could then be established using sediment quality information.

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

Both St Clair beach and Second beach are high-energy environments; stormwater contaminants discharged at these locations will be quickly diluted and dispersed. While there was some evidence of increased microbial levels at Second Beach in the past, the commissioning of the new extended outfall from the Tahuna WWTP has led to a decrease in bacterial levels to below maximum acceptable levels for recreational contact at both St Clair and Second Beach.

8.2.2 Marine Sediment Quality

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

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

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

8.2.2.1 St Clair Beach Sediment Quality

The St Clair catchment outfalls discharge into a high energy environment and as such the opportunity for sediments to be deposited and contaminants to accumulate is limited due to the constant re-working of the substrate by the tides in this location.

The contaminant levels within the sediments at St Clair Beach are discussed in detail in Section 5. To summarise, the levels of contaminants in the marine sediments sampled in 2010 were found to be low, with all contaminants measured well below ANZECC low trigger values. Sediments at Second Beach were unable to be sampled due to the rocky substrate.

The results of the annual stormwater monitoring correspond with the levels of contaminants in the marine sediments, with no significantly elevated levels of contaminants in the stormwater, with the exception of microbial contaminants on a single occasion.

Whilst it is possible that the low contaminant levels in the sediments reflect the high energy environment and lack of sediment deposition and contaminant accumulation, it is also likely, based on the stormwater quality results, that the stormwater discharges are not significantly contributing to the contaminant levels in the sediments.

8.2.3 Marine Ecology

The resource consents for the stormwater discharges from the St Clair catchment require that the sampling and analysis of mussel flesh is undertaken from Second Beach. In addition, macroalgae and epifauna were investigated as part of the 2010 study.

The biological monitoring results to date do not provide any evidence that there is contamination of shellfish by stormwater from this catchment. Furthermore, faecal coliform counts within the mussel flesh were found to be low across all years monitored. This does not correspond with the high microbial counts measured in the stormwater in 2010. It does, however, indicate that it is unlikely that the stormwater is adversely impacting on the ecology in this location.

The 2010 study concludes that the ecological communities at St Clair Beach and Second Beach were typical of intertidal communities in high energy environments.

It should be noted that determining the ecological effects of contamination in the marine environment is difficult. Unless contamination levels are very high within the sediments it is difficult to distinguish between the potential adverse effects of contamination from stormwater, contamination from other sources, and the effects of other environmental variables.

8.2.4 Freshwater Habitat Quality

An assessment of stream health of three streams within the St Clair catchment was conducted by Ryder Consulting Ltd in 2010; refer to Section 5.2 for a description and results of this analysis.

Habitat and water quality varied throughout the catchment, and was generally found to be good, however, the St Clair 1 (upstream) site was found to have a greater number of habitat features of 'poor' quality. Despite reasonable habitat quality, ecological quality was generally 'poor'. This is discussed further in Section 8.2.5.

The streams are located within an urban residential area. They run through a mixture of private land and road reserve, and alternate between natural channel and stormwater pipes. Most of the catchment is developed, with the exception of small pockets of bush / reserve, hence water entering the stream will consist of runoff from hardstand areas (such as roads and driveways where contaminants such as heavy metals accumulate), roofs, lawns and gardens. Changes in riparian cover are reflected, to some extent, in the stream health. Based on the analysis, stream reaches in the St Clair catchment with more riparian cover appear to have better stream health.

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 St Clair catchment are urban residential and have an imperviousness of approximately 40 %. This suggests that the quality of the streams assessed in the St Clair catchment is as expected.

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

8.2.5 Freshwater Ecology

The aquatic ecology within the streams in this catchment was found to be generally poor at all sampling sites with below national average levels of benthic invertebrates, with the exception of St Clair 3, and no fish were caught or observed. The presence of freshwater crayfish observed at the St Clair 2 and 3 sites does, however, indicate that conditions are suitable for such species.

As the habitat quality of the streams was generally found to be good with some 'excellent' habitat features in certain locations, it is unlikely that the poor ecology is a result of habitat quality; however, fish passage is likely to be obstructed by the piped stormwater network. An abundance of litter and debris was observed throughout the channels sampled with a high abundance of leaves; this may further impede fish passage. Regular clearance of litter and debris would be required to allow uninterrupted flow and prevent blockage of screens.

Whilst the causes of poor ecological values remain inconclusive, it may be due to contamination of the freshwater from sources such as diffuse runoff from properties (gardens, roofs hardstand etc) or stormwater from the upstream piped network. It could also be a result of modifications to the stream systems (concrete channels, pipe network) up and downstream of the open channel sections reducing the extent of available habitat and preventing the migration of species up and downstream or due to debris / litter accumulation within the channels. Wastewater overflows in the catchment may also be finding their way to the streams, therefore affecting stream health. High conductivity at all sites could indicate nutrient enrichment (potentially due to wastewater).

8.2.6 Culture and Amenity

The coastline of this catchment is an important area for tourism and recreation. A decline in the quality of the marine environment and amenity values of the coast could adversely impact on recreational activities.

Limited amenity values have been identified for catchment streams, however at many locations they are within private land so the potential for visual amenity is limited.

Käi Tahu have a strong relationship with the marine environment and the discharge of stormwater and associated contaminants has the potential to significantly impact Käi Tahu values and beliefs. Any adverse impacts are associated with effects on the spiritual value of water, mahika kai, aquatic biota and water quality. However, stormwater quality in the St Clair catchment does not appear to be poor.

Poor quality of the stream environments could degrade the spiritual value of the watercourses. The amenity values of the streams in this catchment do not appear to be particularly high but some opportunities may exist to enhance amenity value.

To date there is no evidence to suggest that the quality of the marine environment in the St Clair catchment is deteriorating or that the quality of stormwater discharged is contributing to any deterioration in the marine environment. However, the high levels of faecal coliforms observed in the stormwater from the catchment in 2010 could indicate some contribution to contamination and should be explored further.

8.2.7 Summary of Effects of Stormwater Quality

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

- The stormwater quality from the St Clair catchment outfalls was found to be variable but the majority of contaminant levels measured were low and within or below the ranges considered to be typical for a catchment of this type. The exception was the 2010 sample, which indicated elevated levels of faecal coliforms and E.coli.

- The elevated microbial levels in the stormwater and high conductivity in catchment streams may be related to wastewater flooding incidents, as reported in wastewater network studies in the area.

- The levels of contaminants in the marine sediments sampled have been variable across the monitoring years but have remained low. All contaminants were measured at levels well below the ANZECC low trigger values.

- The biological sampling results suggest that the stormwater discharge from this catchment, in general, is not having an adverse effect on ecological health.

- There is no clear evidence to suggest that the stormwater discharge is contributing to contaminant levels in the sediments.

- The coastal environment has important cultural values and is an important area for tourism and recreation. The results of investigations do not indicate that marine quality is deteriorating as a result of the quality of stormwater from this catchment.

- The freshwater ecology was found to be generally poor at sites on all three streams within the catchment. These results may be attributable to the piping of sections of the streams, runoff from surrounding properties, potential wastewater contamination, and / or build up of litter and debris affecting habitat quality and impeding the migration of species up and downstream.

- Stream health may be compromising the cultural and amenity value of the watercourses in the 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 St Clair 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 St Clair catchment.

9.1 Stormwater Quantity Issues

9.1.1 Low Level of Service in Lower Catchment

The main interceptor pipe along Forbury Road, which dictates the capacity of the overall system, can only convey small rain events, e.g. a 1 in 5 yr ARI rainfall, without causing manhole surcharging and nuisance flooding. This is primarily due to network grade and size.

9.1.2 Nuisance Flooding

Nuisance flooding (between 50 mm and 300 mm deep) is predicted and confirmed in two main areas: along Forbury Road, from Wilson Avenue to approximately 80 m north of Macandrew Road; and surrounding an intake screen at 30 Middleton Road. In all instances, this nuisance flooding becomes progressively worse during larger rain events.

9.1.3 Deep Flooding (Current and Future Scenarios)

Deep Flooding (>300 mm deep) is predicted on one property during a 1 in 2 yr ARI rainfall event and two properties in a 1 in 10 yr ARI rainfall event.

During the current 1 in 50 yr ARI rainfall event modelled, up to five land parcels are predicted to experience flooding on part of their parcel to depths greater than 300 mm. Mean climate change and the 2060 land use during a 1 in 50 yr ARI event could result in seven parcels experiencing deep flooding, however, this flooding is not expected to threaten building interiors on many of the land parcels affected, as flood depths are often confined to gullies at the rear of properties. Hence, the number of properties at risk of habitable floor flooding is believed to be significantly less in both instances.

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

‘Moderate / significant’ flood hazard during large (1 in 100 yr ARI) rainfall events is predicted in small pockets in a number of areas throughout the catchment, but particularly at many of the catchment’s intake structures and in the associated open channels. Other pockets of flood hazard, as well as small strips along some roadsides, are scattered throughout the catchment, driven by topography.

9.1.5 Network Maintenance

Many intake structures in the catchment are on private land. Maintenance of these structures is critical to the optimal operation of the hydraulic network. In particular, intake structures at 30 Middleton Road and 14 Cliffs Road are subject to regular blockage from debris and mud.

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

9.1.6 Cross Connection with South Dunedin Stormwater Network

An identified high level bypass / overflow between the South Dunedin and the St Clair stormwater networks has the potential to transfer peak stormwater flows between the two networks.

9.1.7 Overland Flow into the South Dunedin Catchment

During large rainfall events, overland flow is predicted to enter the western edge of the South Dunedin catchment.

9.2 Stormwater Quality Issues

Sediment data collected from near the St Clair Beach outfalls during 2010 indicated low levels of contaminants (when compared with ANZECC sediment quality guidelines) for all contaminants.

Elevated levels of faecal coliforms and E.coli have been measured in the stormwater near the catchment outfalls, however similar levels were not detected in the marine fauna or substrates, indicating that the high measurements were potentially isolated events and / or that it is unlikely that the stormwater is adversely impacting on the marine ecology. The peaks in E.coli / faecal coliform levels do not correspond with peaks in FWA concentrations, suggesting that the source(s) of the contaminants is something other than wastewater overflows to the stormwater network, however wastewater studies undertaken in the catchment have confirmed that wastewater overflows do occur from network manholes.

Stormwater quality could be contributing to poor stream health in the St Clair streams surveyed, along with potential wastewater discharges. The management and maintenance of the stream physical environment could also be contributing to poor stream health at the assessed sites.

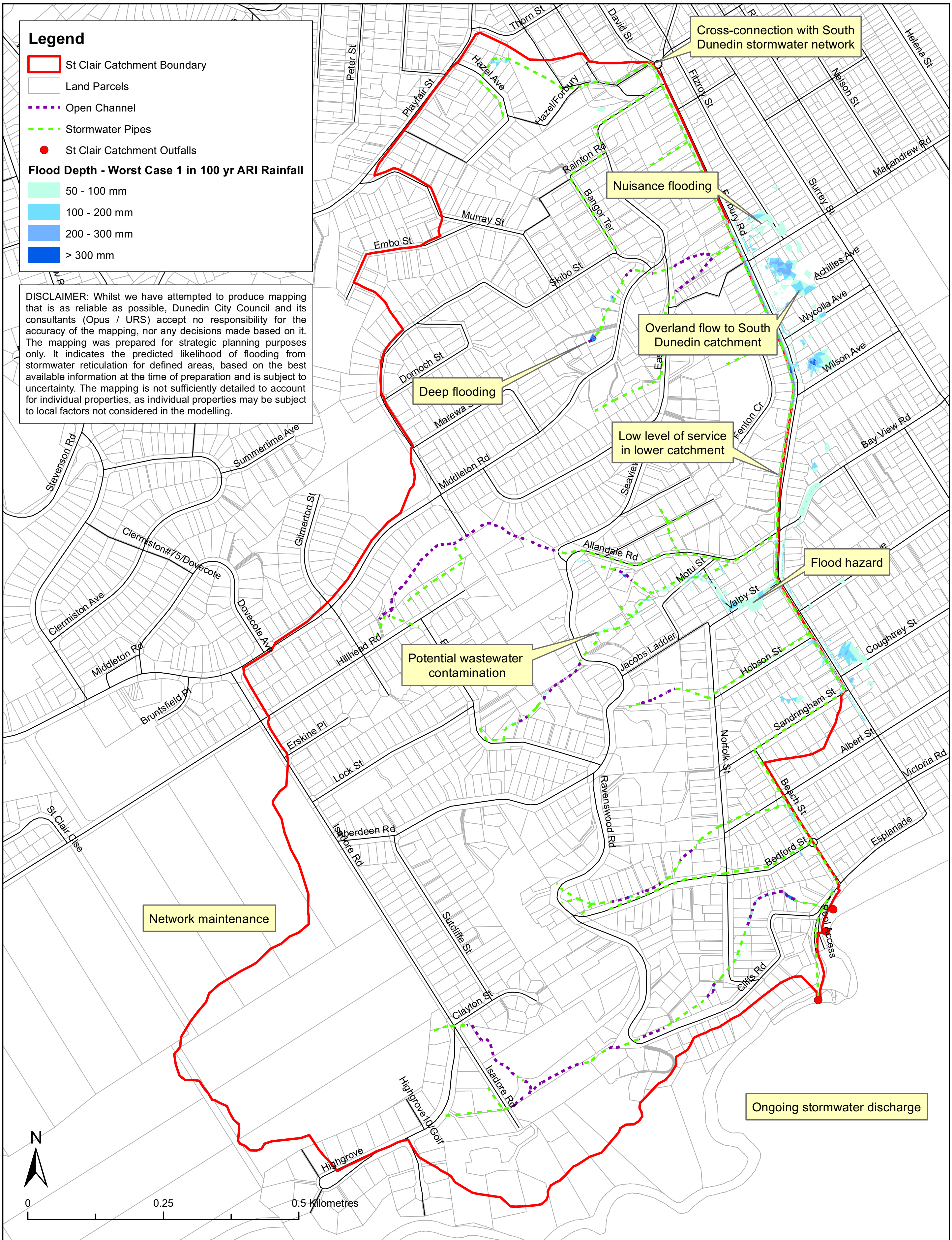
9.2.1 Ongoing Stormwater Discharge

Stormwater quality monitoring indicates that the stormwater quality discharged from the St Clair catchment appears to be typical of an urban residential catchment, and contaminant sources are likely to be this land use. Indications from recent monitoring do not show that current stormwater discharges are having an adverse effect on the receiving environment.

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

9.2.2 Potential Wastewater Discharges

The Wastewater investigations undertaken as part of the 3 Waters Strategy Project concluded that wastewater overflows (from manholes) did occur in the St Clair catchment. While only one stormwater sample indicated microbial contamination of the stormwater, stream water quality in the catchment is also poor, with high conductivity possibly indicating nutrient enrichment.



DUNEDIN CITY COUNCIL / URS / OPUS	Dunedin 3 Waters Strategy	ST CLAIR INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 9-1 St Clair Catchment Issues	DISCIPLINE Stormwater	Status: Final Scale: 1:6,500 — Plot Date: Sep 2011 Drawn By: CO — Approved: HS Checked: JH — Date: Sep 2011 Job No: 42173227 — Map No: Figure 9-1 — Revision: -

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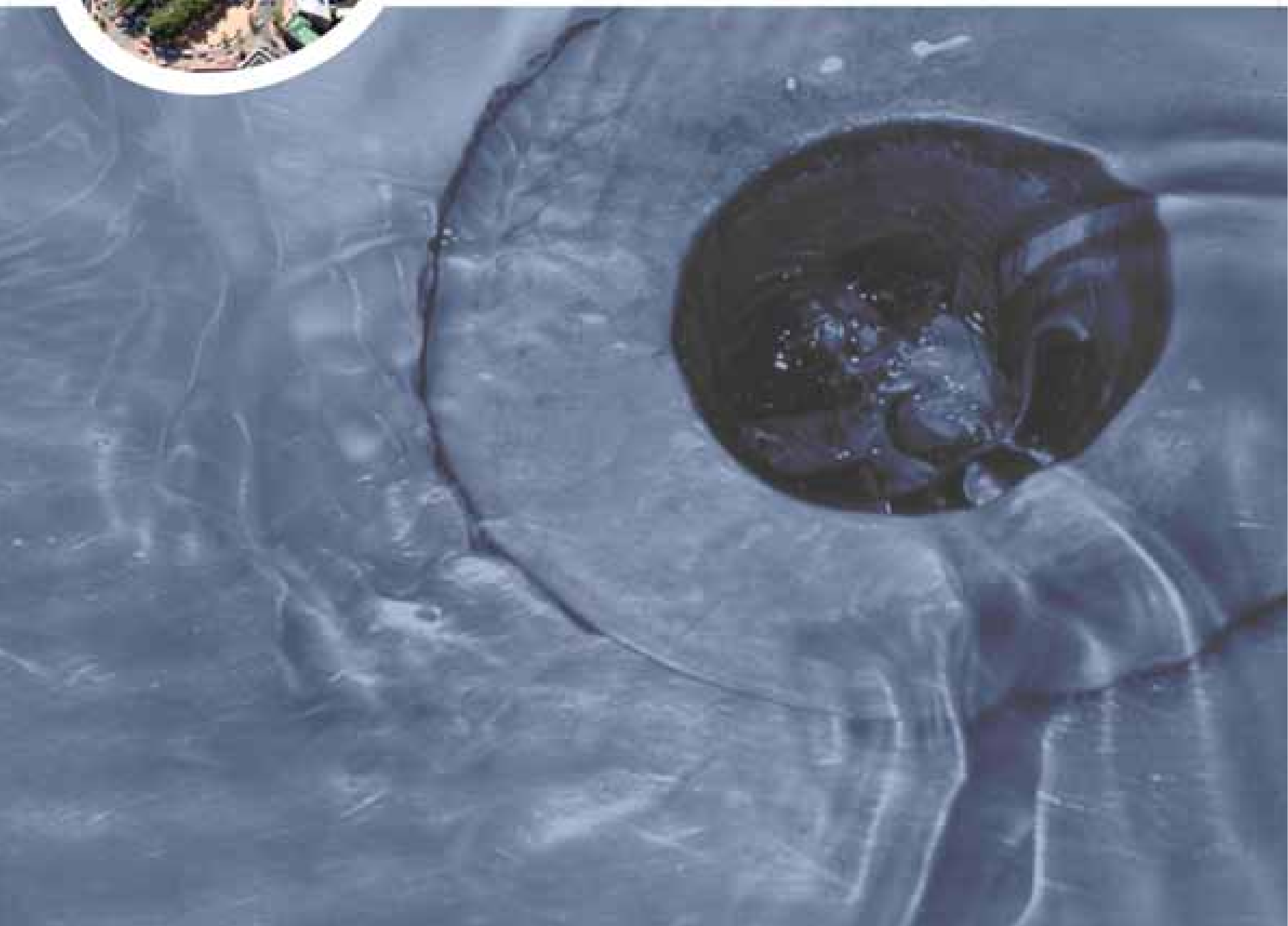
Part 4
Targets



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 St Clair 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
Potential Wastewater Contamination	40	3	Wastewater overflows from manholes are known to occur in the catchment. This knowledge, combined with evidence of wastewater effects on both freshwater and marine receiving environments, indicates that a moderate threat is present.	120	Manage Actively
Cross Connection with South Dunedin Stormwater Network	40	3	Possible discharges between networks during extreme events. Poor state of knowledge regarding the discharge. Additional stormwater into South Dunedin would exacerbate existing issues, and vice versa, although the extent to which this would occur is unknown.	120	Manage Actively
Low Level of Service in Lower Catchment	10	5	The current level of service of the network in the main interceptor pipe, which runs along the eastern edge of the catchment, is below DCC's target for new infrastructure, primarily as a result of inadequate pipe capacity. The remainder of the network has a level of service exceeding a 1 in 10 yr ARI rainfall event. Effects will be exacerbated by climate change, therefore adaptation is required in order to meet future long term objectives of no increase in properties at risk of flooding due to climate change. However, flooding due to low level of service occurs in limited areas.	50	Manage Passively
Network Maintenance	10	5	Inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures. Potential to exacerbate or transfer flooding effects. Blocking and poor maintenance of structures in parts of the catchment are contributing to nuisance and / or deep flooding in the upper catchment, however few properties appear to be at risk of habitable floor flooding, although no floor survey has been undertaken.	50	Manage Passively
Nuisance Flooding	10	4	Nuisance flooding occurring on western side of Forbury Road and surrounding the intake at 30 Middleton Road. Occurs during high frequency events. Flooding at intake is predicted to be mostly confined to channel margin in yard, however Forbury Road flooding is predicted to affect several properties to the east (in South Dunedin catchment) in a 1 in 10 yr ARI rainfall event.	40	Manage Passively

Issue	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Management Approach
Flood Hazard – Current and Future 1 in 100 yr ARI	40	1	Flood hazard in a small number of locations, mostly in areas already subject to deep flooding, in addition to other catchment intakes and associated watercourses. Not predicted in vulnerable locations. Issue will be addressed as part of Deep Flooding issue.	40	Manage Passively
Ongoing Stormwater Discharge	10	4	Ongoing discharge of stormwater (and associated contaminants) to the ocean. The extent of contamination is unconfirmed, but available data indicates that contaminants discharged are typical of land use.	40	Manage Passively
Overland Flow into the South Dunedin Catchment	10	3	Overland flow into the South Dunedin catchment is predicted to occur during events greater than a 1 in 10 yr ARI. The confidence in the model is moderately low, however, and further investigation may be required. Additional stormwater into South Dunedin would exacerbate existing issues with the stormwater and wastewater systems.	30	Manage Passively
Deep Flooding	10	2	Occurs in only 2 parcels in the 1 in 10 yr ARI rainfall event, and 5 in the current 1 in 50 yr ARI event. Suspected to be mostly exterior to buildings.	20	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 AEE section of this report (Section 8) has been used to identify the key stormwater management issues for the St Clair 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.

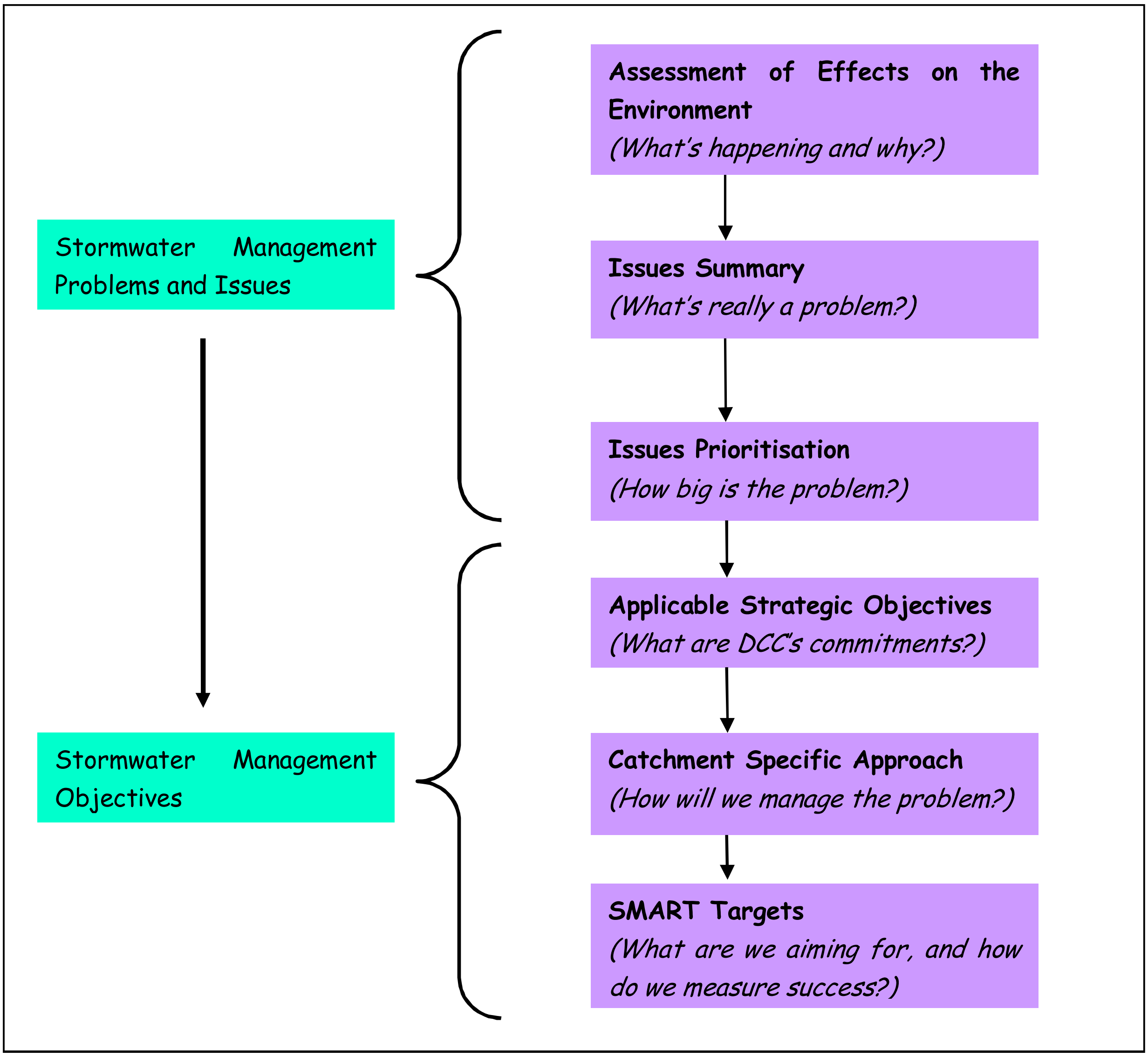


Figure 11-1: Target Development Process

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 outfalls discharging to the Otago 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 outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the St Clair 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 St Clair catchment. Approaches and targets developed for 'active' and 'passive' management of stormwater quantity issues in the St Clair catchment are discussed in more detail below.

11.1.1 Cross Connection with the South Dunedin Catchment Stormwater Network

While open cross connections between networks can provide relief during peak flows, they can potentially be transferring the issue by placing additional strain on the receiving network, particularly during extreme events. A good understanding of the flow regimes under which the bypass structure operates is required in order to accurately evaluate the effects of the flow transfers at this location.

Currently, knowledge of the interaction between the South Dunedin and St Clair stormwater networks via this cross connection is limited, however modelling has indicated that both networks are surcharged during high frequency rainfall events, indicating that any transfer of flows would exacerbate flooding in the receiving network. Therefore, the first target set for this issue is to develop a better understanding of the existing and predicted future overflows through the structure via further modelling. Following this, changes to the configuration of the bypass may be recommended in order to minimise overall surcharging of the two networks.

11.1.2 Low Level of Service in Lower Catchment

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

A 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 St Clair catchment lies within the South Dunedin group of this survey.

Compared with other catchments, the St Clair catchment has had a reasonably high number of stormwater complaints over the past five years, however 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.

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

11.1.3 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 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.

Despite being in private ownership, the efficient operation of watercourse intakes is key to ensuring that the stormwater system as a whole is performing optimally. This is particularly important in the St Clair catchment, which has a number of open watercourses. 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.

11.1.4 Nuisance Flooding

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

Options pursued to address 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.

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 the small number of areas already predicted to have deep flooding during a number of events. As such, the approach to this issue is one of passive management; ensuring that there is no increase in flood hazard due to development or climate change.

There is a relatively small difference between predicted hazard in the current and future scenarios, with small areas of additional flooding associated with natural channel intakes predicted in 2060. Based on the modelling undertaken (which was not a detailed model of climate change effects on sea levels), this is primarily due to climate change effects on rainstorm depths, rather than sea level rise, or land use development. The potential effects of climate change on this catchment will be considered by DCC's Climate Change Adaptation Plan (currently being developed).

11.1.6 Overland Flow into the South Dunedin Catchment

Overland flow is predicted to move into the South Dunedin catchment from the St Clair catchment during large storm 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 exceeding the capacity of the network.

An assessment of the South Dunedin catchment hydraulic model results, alongside the St Clair 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).

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 five land parcels may experience flood depths greater than 300 mm during a 1 in 50 yr ARI event, however it is believed that many of these properties are not at risk of habitable floor flooding, since the deep flooding areas are often very small and / or largely contained within watercourse margins.

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

Because the modelled flood extents indicate that flooding may not actually enter a number of buildings, parcels identified as potentially being subject to deep flooding during storm events with 1 in 50 yr ARI rainfall and smaller should be surveyed or a damage assessment undertaken to gauge the effects of deep flooding in the catchment.

Planned pipe renewals are expected to reduce the deep flooding predictions due to increased capacity in the pipe network.

Table 11-1: St Clair Catchment Management Targets: Stormwater Quantity

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Cross Connection with the South Dunedin Stormwater Network	Limited knowledge of the effects of the cross connection due to independent modelling of catchments. Stormwater exchange between the South Dunedin and St Clair networks may be reducing the available capacity of the receiving network during extreme events.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	***Manage Actively*** Quantify and investigate effects of overflows through the bypass structure between the two networks.	Quantify and assess the effects of overflows from St Clair on South Dunedin, and / or vice versa by 2013. > 66 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.
Low Level of Service in Lower Catchment	While network capacity in the upper catchment is in excess of the 1 in 10 yr ARI rainfall event, the capacity of the Forbury Road interceptor stormwater line (leading to the outfalls) is insufficient to convey the flows from the catchment.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. 95 % of customer emergency response times met. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Use customer complaints and ROS to gauge satisfaction with the stormwater system performance.	> 84 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in St Clair are potentially exacerbated by variations in the frequency and standards of catchpit and watercourse inlet screen cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Work with property owners to ensure screens and intakes are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Develop list of key stormwater assets in St Clair catchment requiring additional cleaning and maintenance checks by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Nuisance Flooding	Nuisance flooding is predicted and confirmed during small events in two main areas: along Forbury Road, from Wilson Avenue to approximately 80 m north of Macandrew Road; and surrounding an intake screen at 30 Middleton Road Not expected to inundate roads or be experienced for long periods of time.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. > 60 % residents' satisfaction with the stormwater collection service.	***Manage Passively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Undertake an inspection of all open channel sections, to record status of intake structures. Monitor customer complaints and / or undertake site visits to confirm locations of flooding.	> 84 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. 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
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 identified in areas predicted to have deep flooding during a number of events. Transport routes are not predicted to be severely affected – inundation across roads is predicted to be shallow or confined to the sides of the road.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Design new pipes with capacity to convey a 1 in 10 yr ARI 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.
Overland Flow into the South Dunedin Catchment	Overland flow is predicted to move into the South Dunedin catchment from the St Clair catchment, along Forbury Road during small events, as well as Beach Street during large storm events.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	***Manage Passively*** Maintain or improve existing level of service in network. Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised). Investigate effects on South Dunedin catchment, and re-prioritise issue if significant.	Assess the effects of overland flooding from St Clair catchment on South Dunedin catchment. > 84 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060.

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 2 parcels affected by deep flooding during a current 1 in 10 yr ARI rainfall event; rises to 5 during a current 1 in 50 yr ARI rainfall event in current, and 7 land parcels in the mean climate change future planning scenarios.	Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	***Manage Passively*** 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. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 16 properties at risk of deep flooding (> 300 mm) during a 1 in 50 yr ARI rainfall event. Undertake habitable floor survey and / or damage assessment of potentially flooded properties. > 84 % 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 St Clair catchment are presented in Table 11-2 below.

It should be noted that the Coastal Plan 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.

The marine receiving environment of the St Clair catchment (the Pacific Ocean, at St Clair Beach and Second Beach) differs significantly from the remainder of the catchments' receiving environment (the Otago Harbour), in both its recreational uses and the physical processes in action. Consequently, most of the monitoring information to date from the Otago Harbour is not comparable to the stormwater quality data for the St Clair catchment. Therefore, the targets and approaches set out below describe a catchment specific approach to stormwater quality.

11.2.1 Potential Wastewater Contamination

A single stormwater sample with elevated wastewater contaminants was taken in 2010. This may indicate a wastewater discharge within the catchment. Wastewater studies undertaken in the area have reported predicted and reported manhole overflows from the wastewater system. Additionally, catchment stream assessments have measured high conductivity levels in streams, an indicator of nutrient enrichment.

Recommendations made as part of the 3 Waters Strategy Wastewater study have been made to resolve wastewater overflows in the catchment.

11.2.2 Ongoing Stormwater Discharge

Despite variability in sampling results, the monitoring data at present indicates that the levels of contaminants in stormwater from the St Clair catchment stormwater are low; furthermore there is no evidence of adverse effects on the marine receiving environment. Therefore based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach.

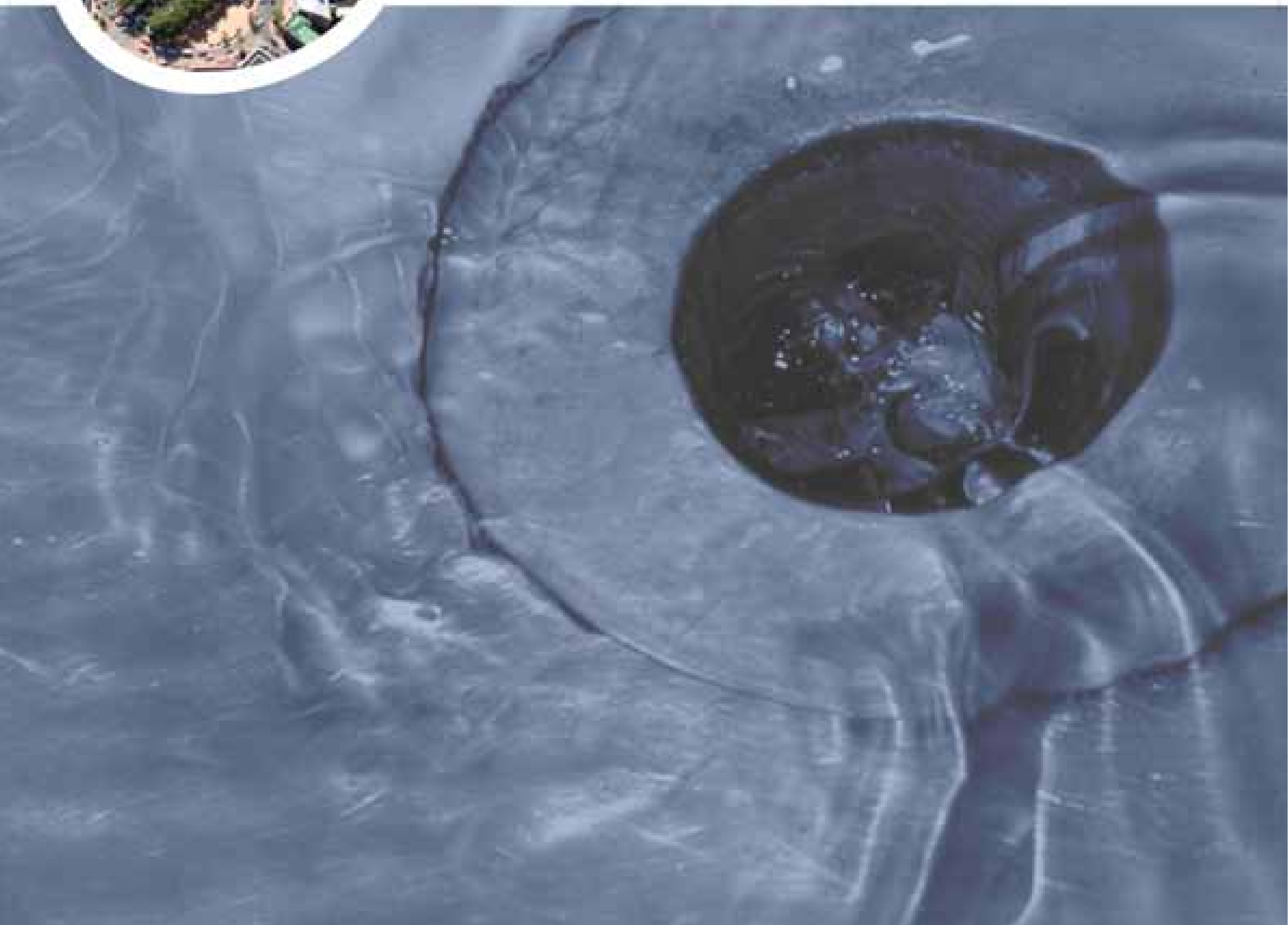
DCC are committed to looking for quick-win opportunities where point source contamination has been identified, and at a minimum, to ensuring that stormwater quality does not deteriorate as a result of new development or changes in land use in the catchment. Examples of this include:

- 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.

Table 11-2: St Clair Catchment Management Targets: Stormwater Quality

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Potential Wastewater Contamination	Single stormwater measurement in 2010 indicating potential wastewater contamination. Possibility of manhole overflows from the wastewater system supported by 3 Waters Wastewater Study and stream assessments.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Actively*** Support further investigation into overflows in catchment. Use improved monitoring programme to enable better understanding of potential catchment contamination.	Improve data relating to levels microbial contamination and potential sources of contamination within the catchment by 2012. Implement management options to remediate problem where necessary.
Ongoing Stormwater Discharge	Stormwater discharged contains relatively low levels of stormwater contaminants; no measurable adverse effects on the receiving environment. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	***Manage Passively*** Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.

Part 5
Solutions



12 Stormwater Management Options

12.1 Introduction

Options are presented below to manage the stormwater issues identified in the St Clair 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 9 of this document;
- Option must not have greater negative environmental, social or cultural consequences than the 'do nothing' option;
- Option should not contravene any explicitly stated political objective;
- Option should not result in an increase in the risk category; and
- Option should not increase health and safety risks compared with the 'do nothing' option.

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

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

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

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

12.2 Potential Options

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

12.2.1 Cross Connection with the South Dunedin Catchment – Manage Actively

Due to uncertainties regarding the amount of water transferred between the St Clair and South Dunedin networks at the north end of Forbury Road, the recommended approach for this issue is to quantify and investigate effects of overflows through the bypass structure between the two networks.

Because both the St Clair and South Dunedin networks are surcharged during reasonably small rainfall events, it is likely that the cross connection is exacerbating flooding in one or other of the catchments, however the timing of network flows, as well as the location of predicted manhole overflows needs to be explored further.

As the South Dunedin and St Clair hydraulic models have been built using an identical methodology, the merging of the two models would enable this issue to be better understood. Potential for network upgrades that would benefit both catchments could also be examined; the South Dunedin network is very hydraulically constrained, and upgrades in the St Clair network may assist in alleviating flood issues on The Flat.

12.2.2 Low Level of Service in Lower Catchment– Manage Passively

Hydraulic modelling results indicate that the network in the upper catchment has a good level of service (in excess of the 1 in 10 yr ARI rainfall event), while the main stormwater interceptor line along Forbury Road has a low level of service, reducing the effectiveness of the overall network.

The Forbury Road stormwater line is currently being assessed as part of the network condition assessment programme. 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 '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.

The ROS can also be used to gauge satisfaction with the stormwater system performance. The St Clair catchment is 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

12.2.3 Network Maintenance – Manage Passively

Flooding extents and durations in the St Clair catchment could potentially be exacerbated if critical catchpits and watercourse inlets are not adequately maintained.

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.

Observations during catchment walkovers, community complaints, DCC Network Management and Maintenance comments, and model results all indicate that flooding in the Middleton Street area is either caused or exacerbated by blocked structures in the watercourse.

The following approach has been recommended for this issue:

- Ensure consistency city-wide of stormwater structure cleaning and maintenance.
- Ensure cleaning and maintenance schedules and contracts are sufficiently robust.
- Identify areas in catchment where more regular cleaning and maintenance could reduce flooding risk.
- Undertake an inspection of all open channel sections, to record status of intake structures.
- Ensure damaged screens are replaced / fixed.
- Work with property owners to ensure screens and intakes are properly maintained.

The options to be considered at each site in order to reduce the risk of flooding due to watercourse inlet blockage will be site dependent, and could include localised detention, watercourse piping, or a more rigorous maintenance regime. 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. Watercourse intakes in this catchment are a possible safety hazard due to the deeply incised nature of the streams at the location of the intakes. Inspections will identify whether hazards exist at each location.

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 St Clair catchment, the following structures would be included:

- Intake Structures on Middleton Road and Cliffs Road; and
- Catchpits along Forbury Road.

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.

12.2.4 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 and options to improve network maintenance and the level of service in the lower part of the St Clair catchment, will relieve the nuisance flooding in the catchment over time.

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 nuisance and / or 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 storm event (including climate change allowances).

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 St Clair catchment can be considered as part of the city-wide climate change adaptation plan. Recent flooding on Forbury Road (May 2011) occurred during king tide events, and could be an indicator of the likely effects of increased sea level on stormwater infrastructure performance.

12.2.6 Overland Flow into the South Dunedin Network – Manage Passively

Modelling, supported by DCC Network Management and Maintenance staff comments, indicates that flooding from the Forbury Road area flows overland into the South Dunedin catchment.

Upgrades in the St Clair 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 is still likely to occur during large events, when the system capacity is reached, or catchpits are unable to accept high intensity flows.

It is critical to establish an understanding of the effects of this overland flow on South Dunedin. Network analysis undertaken in the South Dunedin ICMP (URS, 2011b) indicated surcharging manholes in the area between Forbury Road and Tonga Park, where flood flows are predicted to travel from Forbury Road. Major surface flooding is not, however predicted during events up to or including the 1 in 100 yr ARI event, from the South Dunedin network alone. Surcharging manholes indicates, however, that nuisance flooding may occur, and that there would be no capacity to receive additional surface flows from outside the catchment.

It is recommended that following outcomes of this ICMP, the flood hazard in South Dunedin is reviewed with respect to this information; additional modelling, in the form of combination of part of the St Clair model with the South Dunedin model, may be necessary to quantify the risk. This is also recommended to resolve the uncertainty regarding the cross-connection near the Forbury Road / Hillside Road intersection, and may provide opportunities to improve the performance of both the St Clair and the South Dunedin stormwater networks.

12.2.7 Deep Flooding – Manage Passively

For future developments, there is a strategic objective to prevent this potential floor flooding during a 1 in 50 year event. 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 would be useful in the St Clair catchment, as a number of areas of deep flooding predicted by the model appear to be in watercourse gullies or in small pockets on land parcels, indicating that habitable floors may not actually be under threat. Approximately 24 land parcels are predicted to be at risk during a future 1 in 50 yr ARI rainfall event.

12.2.8 Potential Wastewater Contamination – Manage Actively

The suspected presence of a wastewater discharge has only been identified based on a single stormwater quality sample, and may have been a one-off event. However, wastewater overflows in the catchment have been confirmed via the wastewater studies undertaken as part of the 3 Waters Strategy Project, and stream water quality appears to be compromised. This issue has been prioritised as manage actively due to the known presence of overflows in the catchment, along with the fact that wastewater discharge to the environment is a key stakeholder issue, and DCC are committed to avoiding such discharges. St Clair is also a bathing beach, at which wastewater discharges are a potential threat to human health.

It is proposed that this issue be managed through investigations recommended by the wastewater studies. Monitoring of stormwater discharge for wastewater indicators could also provide some indication of the presence of wastewater in the stormwater discharge.

12.2.9 Ongoing Stormwater Discharge – Manage Passively

The monitoring data at present indicates that the levels of contaminants in stormwater from the St Clair 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.

The management of stormwater discharges as new or re-development occurs could be undertaken using several mechanisms applicable to a purely residential catchment:

- 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 under-capacity.

13.1.2 Wastewater

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

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

- I&I has been identified as a problem in number of wastewater catchments city-wide. I&I may be occurring from any location in the network, for example, from mains right up to private laterals. Stormwater can enter through manhole joints and covers, broken pipes or dislodged joints. A portion of the I&I may be due to cross connections between the stormwater and wastewater, a result of illegal connections, or old combined connections which are a legacy of the once combined system.

- There are known constructed wastewater overflows which discharge wastewater to the stormwater system during wet weather. DCC state in the 3 Waters Strategic Direction Statement that they want to limit the use of these overflows in the short term with the long term target being total removal. As the overflows only occur in wet weather, if I&I can be limited in the first instance, the use of these overflows would reduce.

The 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.

A significant number of system performance issues were identified by the Phase 1 works, and were subsequently investigated during Phase 2. Manhole overflows from the wastewater system were identified, and recommendations made to undertake works to resolve this issue. Recent works in the catchment will in part address these issues, but ongoing investigation and works may yet be required.

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 St Clair catchment, the predominant 'passive management' of issues, and identification of single options for higher priority issues dictates that 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	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 year event.	Replicates or reduces current flow patterns up to 1 in 10 year event.	Replicates or reduces current flow patterns up to a 1 in 100 yr ARI event.
	Option flexibility	Constrained.	Flexible for short term scenarios but cannot be staged.	Will accommodate all scenarios but minimal staging.	Flexible for all but extreme scenarios and can be staged.	Flexible for all scenarios and can be staged.

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

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

15 Option Selection

As comparison of alternative options was not undertaken for the St Clair catchment, all options presented in this ICMP have been recommended.

15.1 Approaches for Active Management

The issues that have been prioritised as requiring 'active management' are: Cross connection with the South Dunedin Network, and Potential Wastewater Discharge. The following options are recommended in order to manage those issues:

- Combine the St Clair and South Dunedin stormwater models (1-D and 2-D);
- Support investigations into the operation of the wastewater system to avoid manhole overflows; and
- Undertake monitoring of stormwater to identify presence (or otherwise) of wastewater contamination.

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.
- 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.
- Develop list of key stormwater structures for more regular cleaning as part of existing and/or future maintenance contracts, incorporating catchpits on Forbury Road, and watercourse intakes on Middleton Road and Cliffs Road.
- Utilise ROS information to continuously gauge customer satisfaction with the stormwater service.
- Identify and undertake floor level survey and damage assessment of 24 land parcels potentially affected by deep flooding (up to a 1 in 50 yr ARI).
- 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 St Clair catchment.

Part 6
Way Forward

16 Recommendations

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

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

Table 16-1: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Combine the South Dunedin and St Clair 1-D and 2-D stormwater models.	$ 20 k	3 months
120	Undertake further stormwater monitoring to investigate the extent of potential wastewater contamination and likely sources within the catchment.	$ 10 k	Ongoing
50	Undertake comprehensive watercourse inspections.	$ 50 k	3 - 6 months
50	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	$ 0	Ongoing
20	Identify and undertake floor level survey and damage assessment of properties potentially internally affected by deep flooding (up to a 1 in 50 yr ARI).	$ 20 k	3 - 6 months

Table 16-2: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
50	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	$ 0	2 months
50	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
30	Review flood hazard in South Dunedin catchment, incorporating effects from the St Clair catchment.	$ 10 - $ 20 k	2 months

Table 16-3: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
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	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	tba	Ongoing
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	$ 20 k	2 months

Table 16-4: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
120	Provide input into wastewater investigation and subsequent upgrade to reduce manhole overflows.	$ 20 k	6 months

17 Implementation, Monitoring and Continuous Improvement of the ICMP

17.1 Implementation

As detailed in Section 1 of this report, a number of DCC documents are 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 (eg as targets are met), and may either be minor updates or major changes.

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