



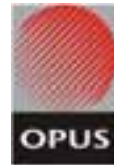
Dunedin 3 Waters Strategy

Orari Street Integrated Catchment Management Plan



Orari Street Integrated Catchment Management Plan 2010-2060

Contract No. 3206 Dunedin 3 Waters Strategy



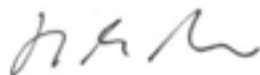
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Table of Contents

Executive Summary	1
Part 1: Introduction	12
1 Introduction	13
1.1 Background	13
1.2 Context	14
1.3 Overview	17
2 Planning and Statutory Background	20
2.1 Planning Framework	20
2.2 The Local Government Act (2002)	21
2.3 Resource Management Act (1991)	22
2.4 Building Act (2004)	27
2.5 Civil Defence Emergency Management Act (2002)	27
2.6 Non Statutory Documents	27
2.7 Resource Consents	28
2.8 Objectives of Stormwater Management	29
3 Consultation	32
3.1 3 Waters Strategy Consultation- Stakeholder Workshops and Community Survey	32
3.2 Resource Consent Submissions	33
3.3 Annual Plan Submissions	34
Part 2: Baseline	35
4 Catchment Description	36
4.1 Catchment Location	36
4.2 Topography and Geology	36
4.3 Surface Water	37
4.4 Groundwater	37
4.5 Land Use	41
4.6 Catchment Imperviousness	47
4.7 Stormwater Drainage Network	49
4.8 Customer Complaints	61
4.9 Water and Wastewater Systems	64
5 Receiving Environment	67
5.1 Marine Receiving Environment	69



5.2	Freshwater Receiving Environment	77
6	Stormwater Quality.....	88
6.1	Stormwater Quality Monitoring.....	88
6.2	Stormwater Quality Results	88
7	Stormwater Quantity	92
7.1	Introduction.....	92
7.2	Model Results.....	92
Part 3: Analysis		96
8	Assessment of Environmental Effects	97
8.1	Stormwater Quantity	97
8.2	Stormwater Quality	112
9	Catchment Problems and Issues Summary.....	120
9.1	Stormwater Quantity Issues.....	120
9.2	Stormwater Quality Issues.....	121
Part 4: Targets.....		124
10	Issues Prioritisation.....	125
11	Catchment Specific Targets and Approaches for Stormwater Management	129
11.1	Stormwater Quantity Targets and Approaches	130
11.2	Stormwater Quality Targets and Approaches	139
Part 5: Solutions		144
12	Stormwater Management Options.....	145
12.1	Introduction.....	145
12.2	Potential Options	145
13	Three Waters Integration.....	159
13.1	General	159
14	Options Evaluation.....	161
14.1	Options Evaluation Criteria and Methodology	161
14.2	Options Comparison.....	165
15	Option Selection	169
15.1	Approaches for Active Management.....	169
15.2	Approaches for Passive Management	170
Part 6: Way Forward		171
16	Recommendations.....	172



17	Implementation, Monitoring and Continuous Improvement of the ICMP	174
17.1	Implementation	174
17.2	Monitoring and Continuous improvement.....	174
18	References	175

List of Appendices

Appendix A: Existing Discharge Consent
Appendix B: Imperviousness Study
Appendix C: Ecological Monitoring Reports
Appendix D: Rainfall Analysis
Appendix E: Decision Making Frameworks



List of Figures

Figure 1-1: Scope of Work	18
Figure 1-2: ICMP Development Process.....	19
Figure 2-1: Legislative and Planning Document Hierarchies.....	20
Figure 4-1: Orari Street Catchment Location.....	38
Figure 4-2: Orari Street Catchment Contour Map	39
Figure 4-3: Orari Street Catchment Geology Map.....	40
Figure 4-4: Orari Street Catchment Land Use Zones	42
Figure 4-5: Archaeological and Heritage Sites	43
Figure 4-6: Recent Consents and Designations	45
Figure 4-7: Contaminated Land Sites	46
Figure 4-8: Current Imperviousness of the Orari Street Catchment.....	48
Figure 4-9: Glen Intake Structure, Including Weir and Screens	50
Figure 4-10: Pipe Diameter Frequency Distribution	50
Figure 4-11: Stormwater Drainage Network.....	51
Figure 4-12 : Pipe Network Ages.....	53
Figure 4-13: Stormwater Network Criticality.....	57
Figure 4-14: Flooding on South Road, near the Glen Road intake structure, February 2005.....	59
Figure 4-15: Stormwater Flooding Complaints.....	62
Figure 4-16: Wastewater Flooding Complaints	63
Figure 4-17: Three Waters Networks.....	66
Figure 5-1: Orari Street Stormwater Catchment Outfall	67
Figure 5-2: Marine Receiving Environment	68
Figure 5-3: Circulation of water in the Upper Otago Harbour (from Smith and Croot, 1993).....	70
Figure 5-4: Freshwater receiving environment.....	78
Figure 5-5: Orari Street 1 Stream Assessment Sites – (a) Upstream; (b) Downstream; and (c) Entrance to Stormwater Pipes near Downstream Site.....	80
Figure 5-6: Orari Street 2 Stream – (a) Assessment Site; and (b) Entrance to Stormwater Pipes.....	81
Figure 5-7: Orari Street 3 Stream Assessment Sites – (a) Upstream; (b) Downstream; and (c) Entrance to Stormwater Pipes near Downstream Site.....	83
Figure 5-8: Orari Street 4 Stream Assessment Sites – (a) Upstream; (b) Entrance to Stormwater Pipes near Upstream Site; and (c) Downstream	84
Figure 7-1: Orari Street Stormwater Catchment Model Extent.....	95
Figure 8-1: 2010 1 in 2 yr ARI Rainfall Event (Model Results).....	99
Figure 8-2: Intake at 91 Glen Road.....	101
Figure 8-3: Surcharging pipes and manholes on Forfar Street, Bridge Street, and Leckhampton Court, 1 in 5 yr ARI rainfall event	103
Figure 8-4: Flood depths in South Road and Glen Road during a 1 in 50 yr ARI rainfall event (current land use).....	106
Figure 8-5: Long Section of Stormwater Pipe at South Road / Laing Street Intersection, Current 1 in 10 yr ARI Rainfall Event	107



Figure 8-6: 2010 Predicted Flood Hazard in the Glen Valley, 1 in 100 yr ARI Rainfall Event.....	109
Figure 8-7: 2010 Predicted Flood Hazard in Caversham / Corstorphine, 1 in 100 yr ARI Rainfall Event	109
Figure 8-8: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event	113
Figure 8-9: Sediment contaminant concentrations adjacent to the Portobello Road Outfall (from Ryder, 2005b).....	114
Figure 9-1: Catchment Issues.....	123
Figure 10-1: Risk / Consequence Matrix for Issues Prioritisation.....	125
Figure 11-1: Target Development Process.....	129
Figure 12-1: Sealed manholes, Option O2	147
Figure 12-2: Option O3: Local Upgrades – South Road / Leckhampton Court.....	148
Figure 12-3: Upper Catchment Storage	149
Figure 12-4: Options: South Road Commercial Area	150
Figure 14-1: Upper Catchment Detention Effects – Current 1 in 50 yr ARI Rainfall Event	166



List of Tables

Table ES 1: Orari Street Catchment Issues, Approach and Targets Summary.....	4
Table ES 2: Further Study Recommendations.....	10
Table ES 3: Planning and Education Recommendations.....	10
Table ES 4: Operation and Maintenance Recommendations	11
Table ES 5: Capital Works Recommendations	11
Table 1-1: Phase 2 Catchment Prioritisation.....	16
Table 2-1: Strategic Stormwater Management Objectives	30
Table 2-2: Activity Management Plan Measures and Targets	31
Table 4-1: Pipe Network Age and Length Composition	52
Table 4-2: Asset Criticality Score Criteria.....	56
Table 5-1: Sources of stormwater contaminants	72
Table 5-2: Marine Sediment Guideline Values and Measured Contaminant Levels	76
Table 5-3: Assessment site characteristics.....	79
Table 6-1: Stormwater Quality Consent Monitoring Results – Orari Street Catchment Outfall...	90
Table 6-2: Dunedin Time Proportional Stormwater Monitoring Results, Contaminant Ranges..	90
Table 6-3: Comparison of Orari Street Catchment Stormwater Quality with Other Stormwater Quality Data	90
Table 7-1: Orari Street Model Results – Current Land Use	93
Table 7-2: Orari Street Catchment Model Results – Future Land Use / Climate Change.....	94
Table 8-1: Predicted Nuisance Flooding – up to 1 in 10 yr ARI, 50 mm – 300 mm deep	102
Table 8-2: Modelled flood areas (unconfirmed)	104
Table 8-3: Flood Hazard Rating.....	108
Table 10-1: Issues Prioritisation.....	126
Table 11-1: Orari Street Catchment Management Targets: Stormwater Quantity	134
Table 11-2: Orari Street Catchment Management Targets: Stormwater Quality.....	142
Table 12-1: Stormwater Design Criteria	155
Table 14-1: Option Assessment Criteria and Scoring System.....	162
Table 16-1: Further Study Recommendations	172
Table 16-2: Planning and Education Recommendations	173
Table 16-3: Operation and Maintenance Recommendations.....	173
Table 16-4: Capital Works Recommendations.....	173



Executive Summary

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

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

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

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

The Orari Street stormwater catchment covers an area of approximately 3.4 km² (344 ha), west of the Otago harbour. The catchment is flanked along its north and east edges by four of the 3 Waters Project stormwater catchments; Mason Street, Kitchener Street, South Dunedin and St Clair, from north to south.

Since its first period of development in the mid 1900's, Orari's land use has primarily been a mixture of high and medium density residential land, and 97 % of the catchment is zoned Residential 1. The catchment includes suburbs such as Kenmure, Maryhill and Caversham and is bordered by Roslyn in to the north, Balaclava to the south and South Dunedin to the east. The Caversham Bypass Motorway (State Highway 1) divides the Orari Street catchment.

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). With the exception of possible development of vacant lots, the Orari Street catchment is not expected to undergo significant changes to the existing land use practice types over the next 50 years based on the current understanding of the growth demands on the city and the existing district plan provisions.

The steep terrain at the head and sides of the catchment directs surface water into three main gullies which are found above and surrounding Caversham Valley Road, Corstorphine Road and Glen Road. The topography becomes flatter with low lying areas towards the southeast.



Unlike the majority of the other stormwater catchments discharging to the Otago Harbour, the Orari Street catchment does not include a large flat area adjacent to the harbour, however stormwater is conveyed through the flat South Dunedin and Portsmouth Drive catchments in the main pipeline.

Within the three main stormwater branches, four 'streams' with natural water channels remain, with two of the streams separated by piped sections. These streams are among the more significant of the smaller streams in Dunedin city. The stormwater pipe network also contains many small pipes (< 300 mm diameter), and the three main branches converge at the junction of the South Road and Glen Road into a large pipeline, which continues for 3 km along the alignment of the Caversham Bypass Motorway before running adjacent to Orari Street and discharging to the Otago Harbour via a single outfall.

Structures of note in the catchment are the many watercourse intakes, a split of the main pipeline into four to cross beneath Andersons Bay Road, and 'The Glen Intake', a large intake and screen structure receiving stormwater from the Glen Valley area.

Based on the current forecasts of asset life for stormwater mains, the majority of which have been assigned a theoretical life of 100 years, 82 % of the pipe network in the Orari Street 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 approximately 57 km of water supply pipes within the Orari Street catchment, most of which are less than 200 mm in diameter. The majority of the supply pipes in this catchment are constructed from cast iron. Aged cast iron mains in this catchment cause headloss issues, and the cast iron mains are linked to low pressure, limited fire flows and water quality complaints in the area. The wastewater system within the Orari Street catchment comprises approximately 52 km of wastewater pipeline, approximately 81 % of which are between 150 mm and 300 mm in diameter. There are records of historical wastewater flooding on South Road within this catchment due to high flows within the system. Inflow and Infiltration (I&I) issues in the wastewater system upstream of this catchment, in Corstorphine and Kaikorai Valley areas, contribute to the high flows. However, work has been undertaken to resolve this issue by constructing a new cross connection between the two sewer lines down South Road. Other wastewater upgrades in the areas in question are also being undertaken.

A linked 1 and 2-dimensional (2-D) hydrological and hydraulic model of the Orari Street catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different land use, climate change and storm event scenarios. Confidence in the model output is considered to be low. Because of good correlation with historical flood reports however, 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 Average Recurrence Interval (ARI) rainfall events 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 Orari Street catchment.



Flooding in the catchment is currently an issue, and 'The Glen' (the base of the Glen Valley) is an area known to flood. Modelling indicates that a large proportion of the flooding is overland flow from system restrictions, collecting in low points around the catchment. Stormwater is also predicted to flow out of this catchment and onto 'The Flat' in South Dunedin.

Reports from DCC staff also indicate issues with the watercourse intake screens. This is supported by information gathered during stream assessments, where watercourse maintenance has been highlighted as a potential issue.

Stormwater quality information gathered in the catchment indicates that the levels of all contaminants discharged from the Orari Street catchment outfall are typical of stormwater quality from residential catchments and in some cases, are better. Although variable, heavy metal concentrations have been below detectable levels in a number of samples taken from the outfall.

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

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

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

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



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

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 10 parcels affected by deep flooding during 1 in 2 yr ARI rainfall event; rises to 85 land parcels during 1 in 50 yr ARI rainfall event in current and 99 land parcels in future planning scenarios. Large number of properties affected during extreme climate change scenario. A large amount of deep flooding is predicted to be exterior to buildings (although surveys not yet undertaken).	Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. Enhance understanding of effects of deep flooding, particularly on private property. Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 85 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. > 70 % 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
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater contaminant levels remain unclear, however results to date indicate moderately low contaminant concentrations in stormwater discharge. Poor information on actual effects of stormwater on harbour environment, although not considered significant with respect to this catchment. Lack of data to assess linkages between pipe discharge and harbour environment quality.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. No recorded breaches of the Resource Management Act. Ensure stormwater discharge quality does not deteriorate.	Manage Actively Redesign DCC's monitoring programme to ensure stormwater quality and receiving environment data is collected within a robust framework. Develop method for determining linkages between stormwater management and harbour environment. Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high- contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality. Undertake monitoring to ensure stormwater quality does not deteriorate over time. Incorporate a feedback process to the ICMP if / when monitoring indicates potential adverse effects from stormwater discharges.	Robust city-wide monitoring framework developed and implemented by 2012. Improve confidence in data supporting analysis of stormwater discharge quality and effects on harbour environment, with improved confidence in data by 2013. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Blocking / Maintenance of Intake Structures	Intake structures on a number of open channels (the majority of which are privately owned) are undersized and / or sensitive to blockage, and overland flow from blocked or overflowing screens is exacerbating flooding in critical areas.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Actively Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Work with property owners to ensure screens and intakes are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets in the catchment (in conjunction with city-wide criteria) by 2012. Develop list of key intake structures in Orari Street catchment requiring additional cleaning and maintenance checks by 2013. Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.
Low Confidence in Hydraulic Model	There is low confidence in hydraulic model results in areas where flooding is not validated by photographic or anecdotal evidence. The current hydraulic model is suitable for planning purposes, but not for preliminary design.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	Manage Actively Improve model confidence by seeking flood related information in areas predicted to flood by the model (but unconfirmed). Improve model confidence by undertaking local survey and flow calibration wherever capital works are proposed and preliminary design is necessary.	Improve level of confidence in the Orari Stormwater Hydraulic model to 'moderate' by 2014.



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



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Ongoing Stormwater Discharge	Could exacerbate historical contaminant issues in the harbour. Extent to which this is likely to occur is unconfirmed. Key stakeholder issue. Based on available data, consequence currently believed to be minor.	Improve the quality of stormwater discharges to minimise the impact on the environment. Adopt an integrated approach to water management which embraces the concept of kaitiakitaka and improves the quality of stormwater discharges. > 75 % compliance with stormwater discharge consents. Ensure stormwater discharge quality does not deteriorate.	Manage Passively Consider the cost / benefit of stormwater quality treatment as part of flood mitigation works where practicable. Require source control of stormwater contaminants in new development of high-contaminant generating land uses. Enforce the Trade Waste Bylaw, and educate occupiers of high-risk sites with respect to stormwater discharge quality.	No deterioration of stormwater quality due to land use change or development in the catchment. Implement an education / enforcement programme targeting stormwater discharges from high risk land uses by 2015.
Nuisance Flooding	Nuisance flooding is predicted and confirmed in three main areas; South Road beneath the Motorway over-bridge, in the South Road commercial area, and on the northern part of the Caversham Bypass Motorway. Flooding not significant during small events, but becomes progressively worse with larger events.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Passively Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 0.1 % of catchment surface area predicted to flood during a 1 in 2 yr ARI rainfall event by 2060. > 70 % 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
Low Level of Service in Upper Catchment	Small diameter pipes in the upper reaches of the network only have capacity to convey 1 in 2 yr ARI rainfall events. Overflow causes overland flow and exacerbates flooding in other locations.	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.	> 70 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Overland Flow into the South Dunedin Catchment	Overland flow is predicted to enter the South Dunedin catchment from the South Road commercial area, and Corstorphine area, during large 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 Orari Street catchment on South Dunedin catchment. > 70 % 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
210	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
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	\$ 20 k	3 - 6 months
120	Increase hydraulic model confidence in The Glen Valley, South Road commercial area and around the Caversham Bypass Motorway, via survey, data collection and / or flow monitoring and calibration.	\$ 50 - \$ 100 k	12 months
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	\$ 0	Ongoing

Table ES 3: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.	\$ 0	3 - 6 months
80	Contribute information to a city-wide climate change adaptation plan.	\$ 0	6 - 12 months
80	Develop an emergency response plan to re-route traffic during extreme rainfall events, and identify vulnerable properties.	\$ 0	3 - 6 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	\$ 0	2 months
30	Review flood hazard in South Dunedin catchment, incorporating effects from the Orari Street catchment.	\$ 10 - \$ 20 k	2 months



Table ES 4: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	tba	Ongoing
160	Implement the revised city-wide monitoring framework.	\$ 25 k	Annual
50	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance.	\$ 5 k	2 months
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	\$ 20 k	2 months

Table ES 5: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
210	Undertake local pipe and catchpit upgrades in South Road / Leckhampton Court area.	\$ 200 k	6 months
160	Replace the screen at 91 Glen Road with a design less prone to blockage.	\$ 10 k	1 month
40	Progressively upgrade intakes / culverts in upper network.	\$ 200 k	Ongoing



Part 1

Introduction





1 Introduction

1.1 Background

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

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

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

The objectives of the 3 Waters Strategy are:

- Determine required levels of service for each of the three waters networks;
- Determine capital and operational costs associated with improvements to the three waters networks, including priorities and phasing for investment;
- Develop a greater understanding of the operations of the three waters networks through targeted asset and flow data collection;
- Develop decision support tools including network models;
- Develop Integrated Stormwater Catchment Management Plans; and
- 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 Orari Street Integrated Catchment Management Plan 2010-2060 (ICMP) is part of the 3 Waters Strategy being undertaken by DCC, as described above. This ICMP is one of ten long term plans to be developed to fulfil consent requirements relating to the discharge of stormwater to the Otago Harbour, as well as to provide future direction for DCC's stormwater management at a catchment specific scale.

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

Appendix A contains the short term stormwater discharge consent granted for the Orari Street catchment (via a single outfall on Orari Street). This consent (Consent No. 2002.085), granted in November 2007, is for a period of five years. Condition 12 of the consent states the following:

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

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

The Orari Street stormwater catchment ranked fourth out of the nine catchments scored, indicating a moderately high number of issues in the catchment. This is to be expected, given the large size of the catchment relative to the others. Of note in the prioritisation study were a significant number of pollution incidents, and potential sources of diffuse pollution in the catchment.

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 (Kāi Tahu) considerations	20	100	4	4	4	4	4	4	4	4	3
Environmental	4A	Sensitivity of Receiving Environment	45	10	3	3	3	3	4	3	3	3	1
	4B	Asset condition / age / capacity restraints		25	3	3	3	3	3	3	1	1	3
	4C	Reported Flooding incidents		10	4	2	3	1	2	1	1	3	2
	4D	Reported Water Quality incidents		10	4	2	4	3	1	3	1	0	2
	4E	Presence of point source pollution sources		20	3	2	3	3	1	2	4	4	1
	4F	Presence of diffuse pollution sources		10	3	2	3	3	2	0	5	3	1
	4G	Development proposed within catchment		-	-	-	-	-	-	-	-	-	-
	4H	Sediment generating / erosion areas		10	3	2	2	1	2	1	0	0	2
	4I	Potential for waste / stormwater system interaction		5	4	3	4	2	2	4	1	1	2
Weighted Score:					3.31	2.58	2.17	1.95	1.77	1.77	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 (specific, measurable, achievable, realistic and time-bound) 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 DCC 3 Waters Strategy.

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

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

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

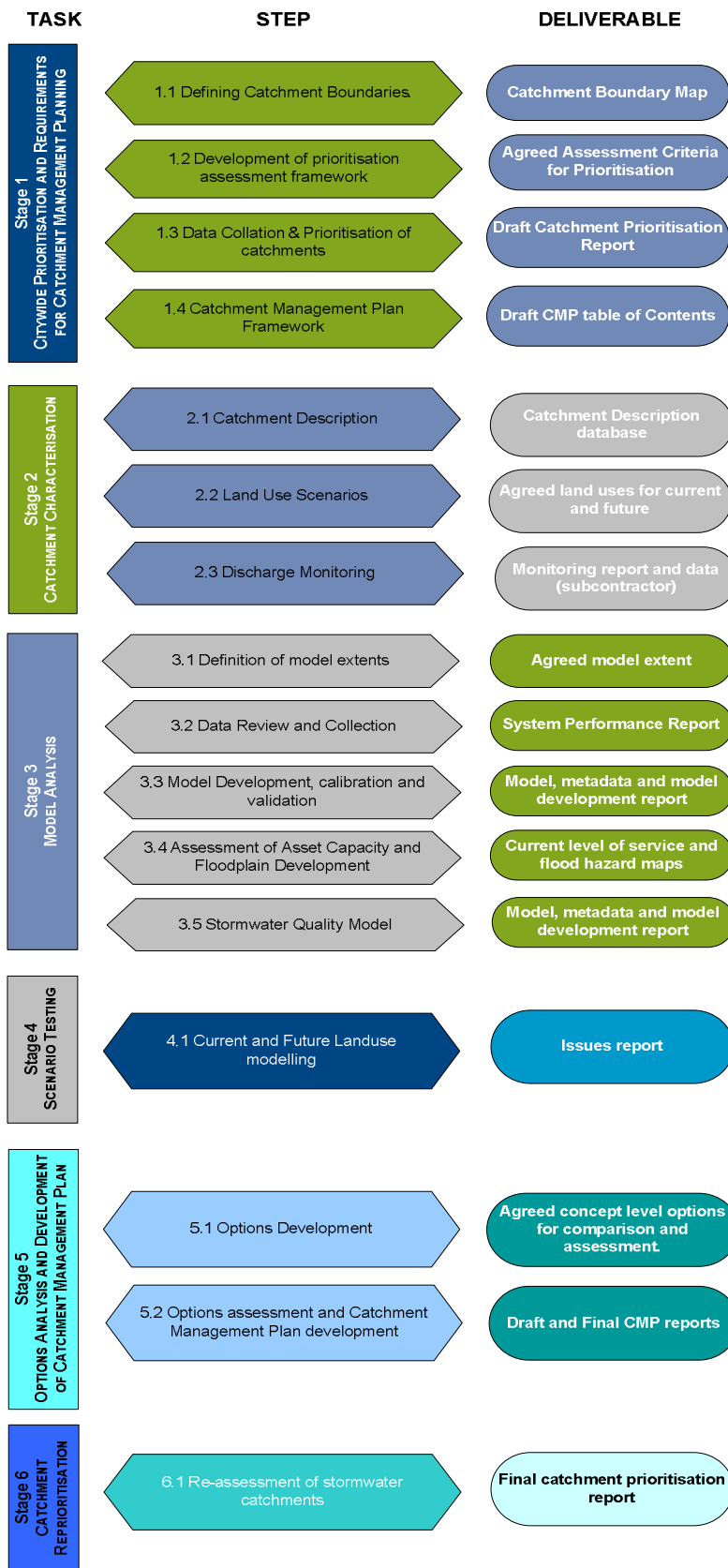


Figure 1-1: Scope of Work

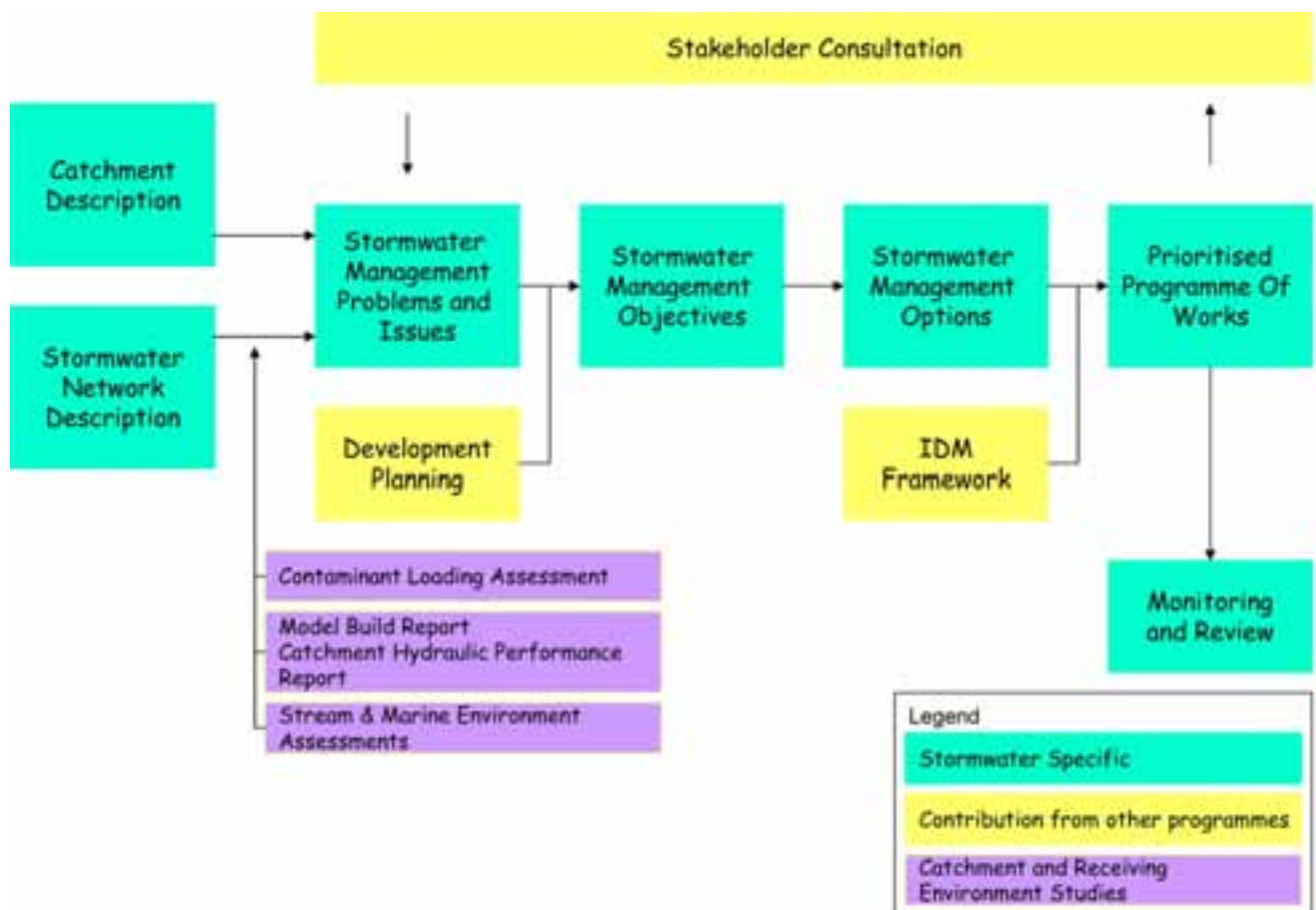


Figure 1-2: ICMP Development Process



2 Planning and Statutory Background

2.1 Planning Framework

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

The influence of each of the key current statutory and non-statutory documents relating to stormwater management and the development of an ICMP are discussed in Sections 2.2 – 2.7. It is important to note that these documents are subject to review and change. Therefore, the ICMP needs to be flexible enough to endure variations to these documents while remaining relevant. In some cases the ICMP may provide direction to these variations.

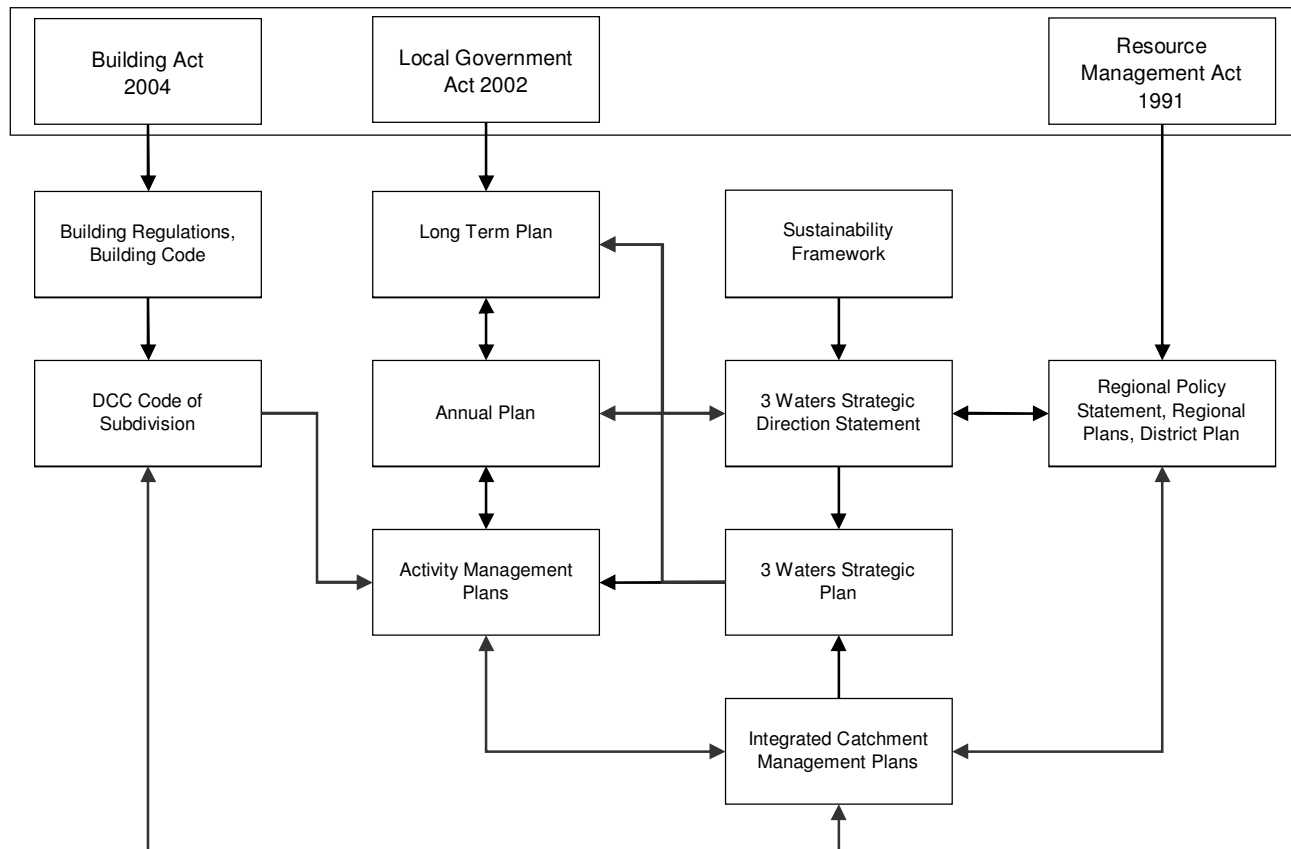


Figure 2-1: Legislative and Planning Document Hierarchies



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; and provide a basis for the accountability of the local authority to the community.”; and to provide an opportunity for participation by the public in decision making processes.”

2.2.2 Annual Plan

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



2.2.3 Performance Measures

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

2.2.4 Trade Waste Bylaw

The DCC Trade Waste Bylaw 2008 regulates the discharge of Trade Waste to a Sewerage System operated by 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 achieved by managing the use of resources, in a manner that allows for people and communities to provide for their social, economic and cultural wellbeing, while sustaining the potential of natural and physical resource to meet the needs of future generations; safeguarding the life supporting capacity of air, water, soil and ecosystems; and avoiding, remedying or mitigating adverse effects of activities on the environment.

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

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

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

- The need to sustainably manage our water resources to meet the needs of future generations;
- The need to preserve the natural character of our coastal environment, wetlands, lakes, rivers and their margins;
- Recognising and providing for the relationship of Māori with their ancestral lands and water;
- The control of the use of land for the purpose of the maintenance and enhancement of the quality of water in water bodies and coastal water;
- The control of discharges of contaminants and water into water;



- The control of the taking, use, damming and diversion of water, and the control of the quantity, level and flow of water in any water body, including:
 - i) The setting of any maximum or minimum levels or flows of water; 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 communities 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 Orari Street catchment discharges into the Otago Harbour, which links with the Pacific Ocean, therefore the NZCPS must be considered when developing and implementing the ICMP. The ICMP provides a detailed assessment of the effects of current land use and development within the Orari Street catchment on the Otago Harbour. It is considered that the ICMP approach is consistent with the holistic nature of the NZCPS, in particular Policy 23(4)(c), and that the stormwater management options considered by the ICMP, such as source control, treatment devices, low impact design, and community education, will ensure that the adverse effects of stormwater runoff on the coastal environment will be avoided, remedied or mitigated.

2.3.2 Marine and Coastal Area Act (2011)

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

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

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

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

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



2.3.3 National Environmental Standards

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

2.3.4 The Otago Regional Policy Statement (1998)

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

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

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

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

2.3.5 The Regional Plan: Coast for Otago

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

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

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



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

2.3.6 The Regional Plan: Water for Otago

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

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

2.3.7 The Dunedin City District Plan

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

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

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

The Dunedin City District Plan also uses land use zoning as a method of regulating activities under DCC jurisdiction. These land uses will play an integral part in determining the quantity and quality of any stormwater runoff. The Orari Street catchment consists of Residential 1 and 2 and Local Activity 1 land use, with a very small area of industrial land use at the base of the catchment. These residential zones are characterised by low site coverage and front and rear yards. Local Activity 1 zone is characterised by site coverage of 70 % or less and a wide range of activities from residential to large scale retail activities are permitted. No industrial or trade activities are permitted to be undertaken in these residential or local activity zones.

Careful consideration will need to be given to these land use zones and any potential changes to the zones when looking at management options under the ICMP, as different land uses produce different stormwater quantities and quality outputs. It may also be that data obtained during the development of the ICMP provides input into future land use zoning within The Dunedin City District Plan.



2.4 Building Act (2004)

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

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

2.5 Civil Defence Emergency Management Act (2002)

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

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

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

2.6 Non Statutory Documents

2.6.1 Kāi Tahu ki Otago Natural Resource Management Plan

Kāi Tahu ki Otago Natural Resource Management Plan (Kāi Tahu Plan) provides a background to Kāi Tahu's resource management issues in the Otago Region. The Kāi Tahu Plan contains management guidelines and objectives relating to freshwater fisheries and coastal resources. Kāi Tahu are particularly concerned with the 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 Kāi Tahu where they are not addressed by the regional or district statutory planning documents, and should ensure that Kāi Tahu are considered as a potentially affected party where appropriate.

2.6.2 Code of Subdivision and Development

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



2.6.3 The Dunedin City Council Sustainability Framework

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

- Affordable: reasonable cost, value for money, today / future costs;
- Environmental Care: clean energy, bio-diversity, safe;
- Enduring: forward looking, whole of life, long term, future generations;
- Supporting People: social connectivity, social equity, quality of life, safe;
- Efficient: using less, creating less waste, smarter use.

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

2.6.4 3 Waters Strategic Direction Statement and 3 Waters Strategic Plan

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

While there are no rules within The Dunedin City District Plan classifying the discharge of stormwater, the ICMP needs to be consistent with 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 Regional Plan: Water for Otago and The Regional Plan: Coast for Otago. The Dunedin City District Plan however, contains methods addressing water quality issues through investigations, monitoring, education, consultation and the creation of management plans such as this ICMP.

Rule 10.5.3: Discharge of stormwater, 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 Orari Street Catchment is unlikely to comply with the conditions of the rule due to the size of the catchment and the likelihood of contaminants having some effect on the receiving environment. Any stormwater discharge would therefore be classified as controlled under Rule 10.5.3.2 and would require a resource consent with ORC exercising its control over matters such as; the location, volume, rate and nature of the discharge.

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

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

Rule 12.4.1 classifies the discharge of stormwater to water as a permitted activity provided that certain conditions are met. These conditions, among others include 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, or floatable or suspended materials or objectionable odours.

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

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

2.8 Objectives of Stormwater Management

2.8.1 Strategic Objectives

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



Table 2-1: Strategic Stormwater Management Objectives

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

2.8.2 Activity Management Plan / LTP Objectives and Targets

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

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

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



Table 2-2: Activity Management Plan Measures and Targets

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

tbc: to be confirmed.



3 Consultation

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

3.1 3 Waters Strategy Consultation- Stakeholder Workshops and Community Survey

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

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

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

Views Relating to Quality

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

Views Relating to Volume

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

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

- Legislative changes, e.g. changing planning or building consents standards to further reduce the impact of new developments on stormwater;
- Passive changes, e.g. increasing the use of swales and soakholes to better manage storm events; using landscaping to reduce the visual pollution of outfalls;



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

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

3.2 Resource Consent Submissions

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

3.2.1 Kāi Tahu Cultural Impact Assessment

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

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

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

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



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

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

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

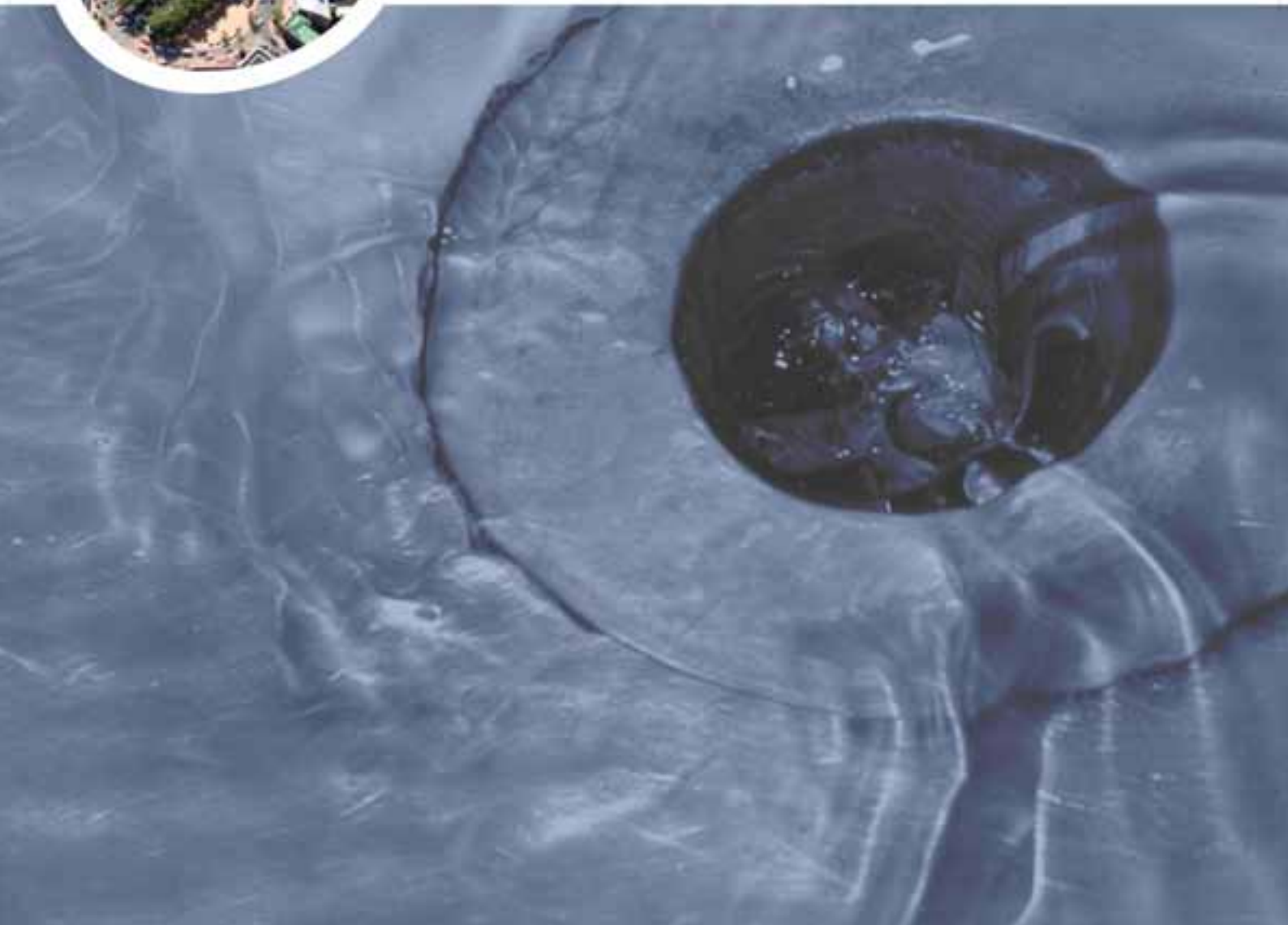
3.3 Annual Plan Submissions

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 so to ensure adequate treatment and filtration of the stormwater prior to it being discharged. The issue of infrastructure capacity was also raised.



Part 2

Baseline





4 Catchment Description

4.1 Catchment Location

Figure 4-1 shows the location of the Orari Street stormwater catchment. The catchment covers an area of approximately 3.4 km² (344 ha), west of the Otago harbour. The catchment lies on a ring of hills that surround Dunedin and primarily consists of residential zoning; typically one or two storey housing surrounded by lawn or garden. Currently 52 % of the catchment is pervious land, and all impervious areas are connected to the stormwater network. The catchment is flanked along its north and east edges by four of the 3 Waters Project catchments; Mason Street, Kitchener Street, South Dunedin and St Clair, from north to south.

Land use in the catchment is predominantly residential, with a small amount of Local Activity 1 to the North (Havelock Street) and East (South Road area). The catchment includes suburbs such as Kenmure, Maryhill and Caversham and is bordered by Roslyn in to the north, Balaclava to the south and South Dunedin on the east.

The Orari Street stormwater system comprises three major network branches (containing both piped and open watercourse sections), which meet near the junction of the South Road and Glen Road, and continue as a large single stormwater main along the alignment of the Caversham Bypass Motorway before running adjacent to Orari Street and discharging to the Otago Harbour via a single outfall.

4.2 Topography and Geology

Figure 4-2 provides a contour map of the Orari Street catchment using 2 m contours. The steep terrain at the head and sides of the catchment directs surface water into the three main gullies which are found above and surrounding Caversham Valley Road, Corstorphine Road and Glen Road. The topography becomes flatter with low lying areas towards the southeast. The head of the catchment has an elevation of approximately 164 m above mean sea level, with most of the catchment lying between 50 m and 150 m above mean sea level. Unlike the majority of the other stormwater catchments discharging to the Otago Harbour, the Orari Street catchment does not include a large flat area adjacent to the harbour, however stormwater is conveyed through the flat South Dunedin and Portsmouth Drive catchments via a 3 km long large sealed stormwater main.

Figure 4-3 shows the geology of the catchment (Bishop and Turnbull, 1996).

The topography of the catchment has been created by volcanic lava flows which occurred in the mid to late Tertiary period, with several volcanic episodes evident in the topographic and geologic maps (Md1e, Md2e and Md3e basalt). The volcanic deposits are very resilient to erosion and weathering, with the rock material typically providing variable infiltration capacity.

Along the Caversham Bypass Motorway there is an area of marine sediments which consist of calcareous sandstone, sandy limestone and minor tuff (Mo). This material would be softer than the basalt, and the old Caversham railway tunnel was built through this material. Near the centre of the catchment, in the east, is a small area of alluvial fan deposits (Q2af) which consist of poorly consolidated and sorted, slightly weathered, fine to bouldery sandstone or gravel, sand and mud.



4.3 Surface Water

The Orari Street catchment stormwater network comprises three main branches, based on the location of historical gullies / watercourses in the undeveloped catchment. There are a large number of open and piped watercourses within the catchment drainage network.

An assessment of four streams 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 4-11 later in this report):

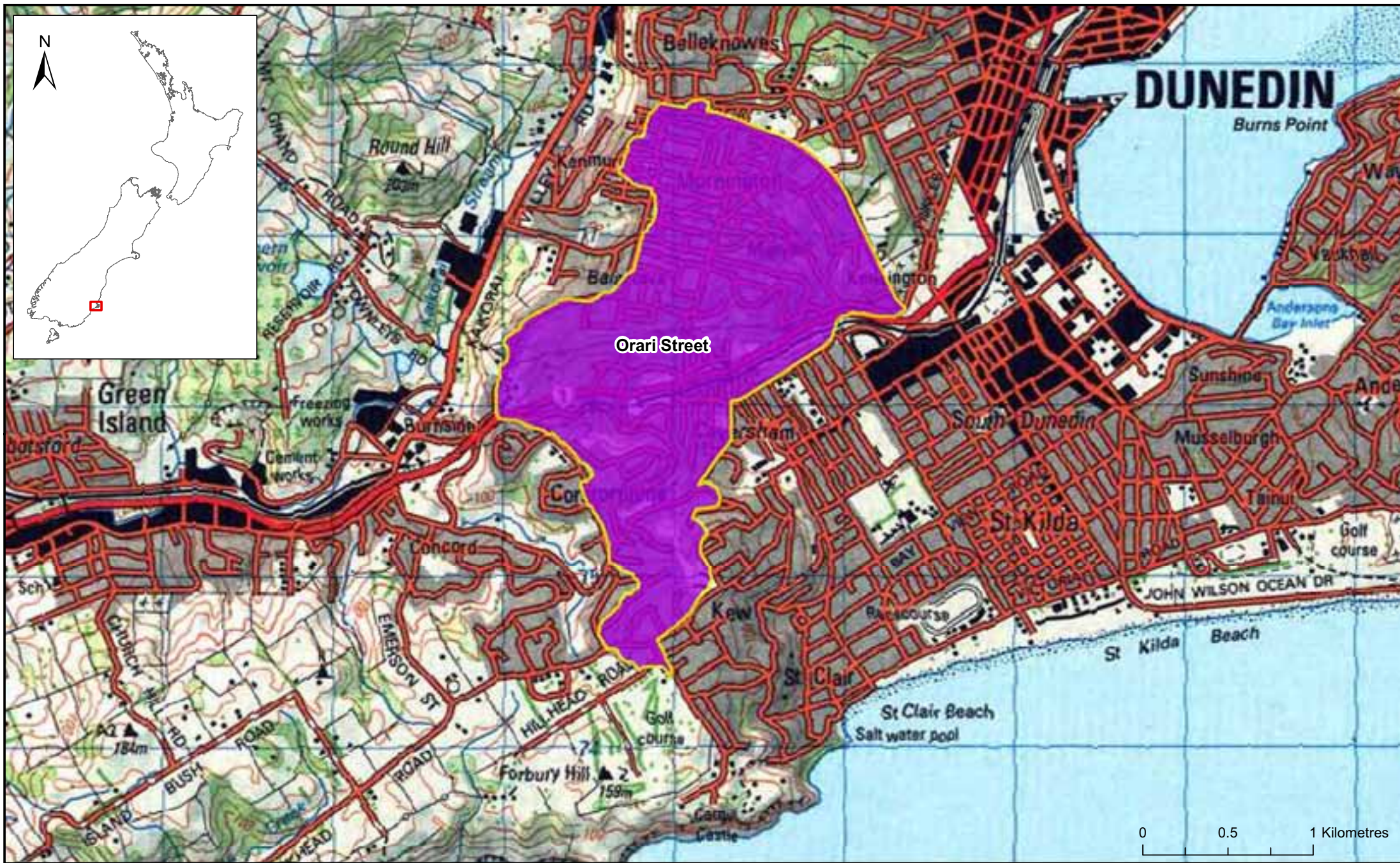
- Stream One – Flowing from south to north, between Dovecote Avenue and Corstorphine Road. The upper reaches of the stream flow from stormwater pipes into a section of open channel and then back into pipes under a school playing field. A stormwater overflow pipe is present towards the upstream end of the open channel with a small rill to convey any overflow into the stream. Towards the lower reaches of the stream the flow from the stormwater pipes under the playing fields enters a natural channel before flowing back into stormwater pipes. There is a debris gate close to the entrance of the stormwater pipes.
- Stream Two – Located in the reserve area just to the north of Caversham Valley Road. The upper reaches of this stream flow in a natural channel before entering stormwater pipes. In comparison to stream one, the land use surrounding this part of the catchment is dominated by farm land and reserve land.
- Stream Three – Flowing north to south between Oakwood Avenue and the Caversham Bypass Motorway. The upstream reaches of this stream flows from stormwater pipes into a natural channel. The stream flows through a culvert under a walkway between Forfar and Oakland Streets. The lower reaches of the stream are in a low gradient area. The stream enters stormwater pipes at the Caversham Bypass Motorway.
- Stream Four – Flowing down the Glen Valley, between Glenpark Avenue and Haywood Street. The upper reaches flow in a semi-natural channel which is adjoined by drainage pipes from residential properties. The middle and lower reaches of the stream flow in a natural channel before entering stormwater pipes.

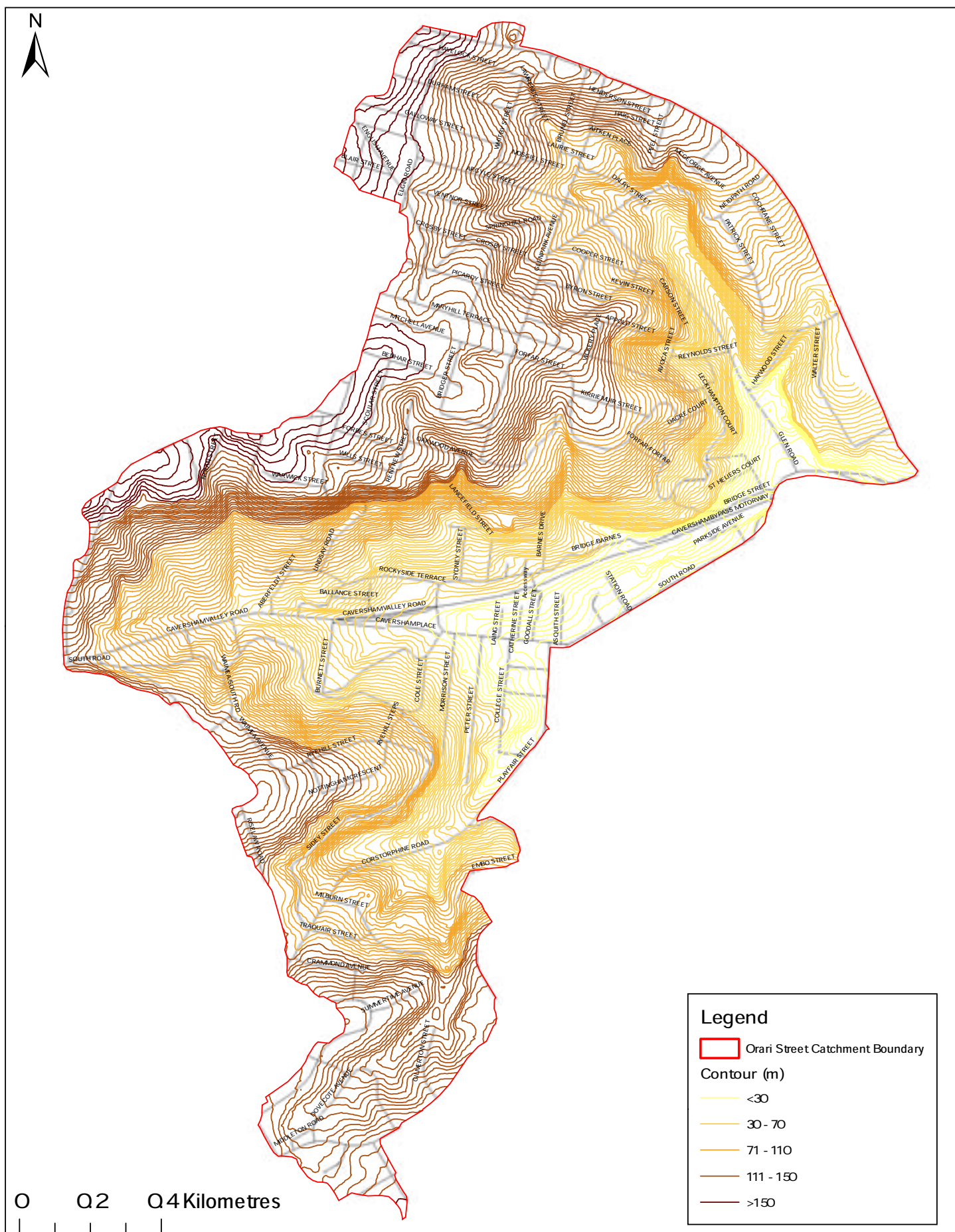
4.4 Groundwater

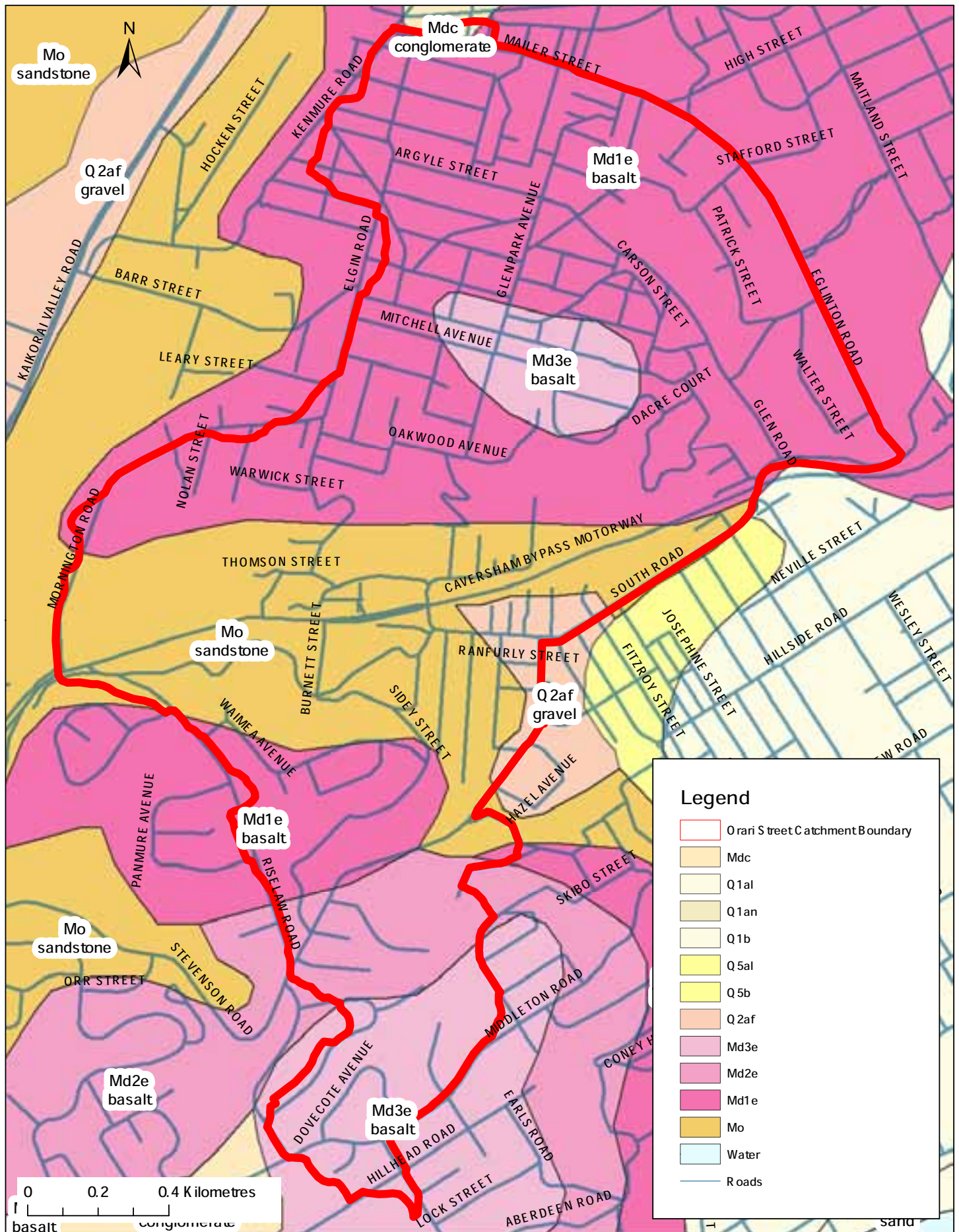
There is limited information relating to groundwater surface levels in the Orari Street catchment, and over much of the Dunedin urban area adjacent to the harbour. ORC do not currently require groundwater monitoring in the area for consent purposes. However, based on the site geology, a conceptual understanding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

The basalt which makes up the majority of the catchment may contain a fractured rock groundwater system. However, as there are no wells drilled in the catchment area, it is difficult to ascertain the extent of any fractured rock groundwater. Nevertheless, water that infiltrates the basalt is expected to move vertically down through fractures until it intercepts the quaternary groundwater system. Similarly, the infiltration properties of the sandstone material would be variable, depending on fractures in the rock.

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







	Dunedin 3 Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-3 Orari Street Catchment Geology Map	DISCIPLINE Stormwater	Status: Final		
				Scale: 1:10 000	Plot Date: Sep 2011	
				Drawn By: CO	Approved: HS	
				Checked: JH	Date: Sep 2011	
				Job No: 42173227	Map No: Figure 4-3	Revision: -



4.5 Land Use

4.5.1 Historical and Current Land Use

After intense growth of what is now the 'city centre' of Dunedin during the late 19th century, demand for new land spread the development into the surrounding areas, creating new suburbs. Since its first period of development in the mid 1900's, land use in the Orari Street catchment has primarily been a mixture of high and medium density residential land, and 97 % of the catchment is zoned Residential 1, (refer Figure 4-4).

The Orari Street catchment includes all or parts of the suburbs of Mornington, Maryhill, Caversham, Balaclava and Corstorphine, and small parts of Kenmure and Kensington.

Prior to the development of the majority of the Orari Street catchment, the Caversham suburb was established in the 1850s and is located on the western edge of Dunedin's central plain. The suburb was founded by a wealthy pioneer, William Valpy, and quickly grew during the gold rush of the 1860s due to proximity to transport routes. By the end of the 19th century the suburb was heavily industrialised and the population included many skilled and semi-skilled trades people. Caversham is now predominantly residential.

The Dunedin cable tramway system connected Maryhill to Dunedin from 1855 to 1955 and the line was known as The Big Dipper. The Old Caversham railway tunnel runs between Kaikorai Valley and Caversham; construction of this tunnel commenced in 1871, and the line was opened in 1873. The tunnel was in service until 1910, when the replacement dual-line tunnel (on the southern side of Caversham Valley Road) was commissioned. The suburb of Corstorphine, in the south-west of the catchment, contains a substantial amount of state housing built between 1930 and 1960.

State Highway 1 divides the Orari Street catchment. Caversham Valley Road and the Caversham Bypass (constructed in the 1970s) form part of the state highway, linking the one way system through the centre city with the Dunedin Southern Motorway. New work on the highway will see the residential section (Caversham Valley Road) widened.

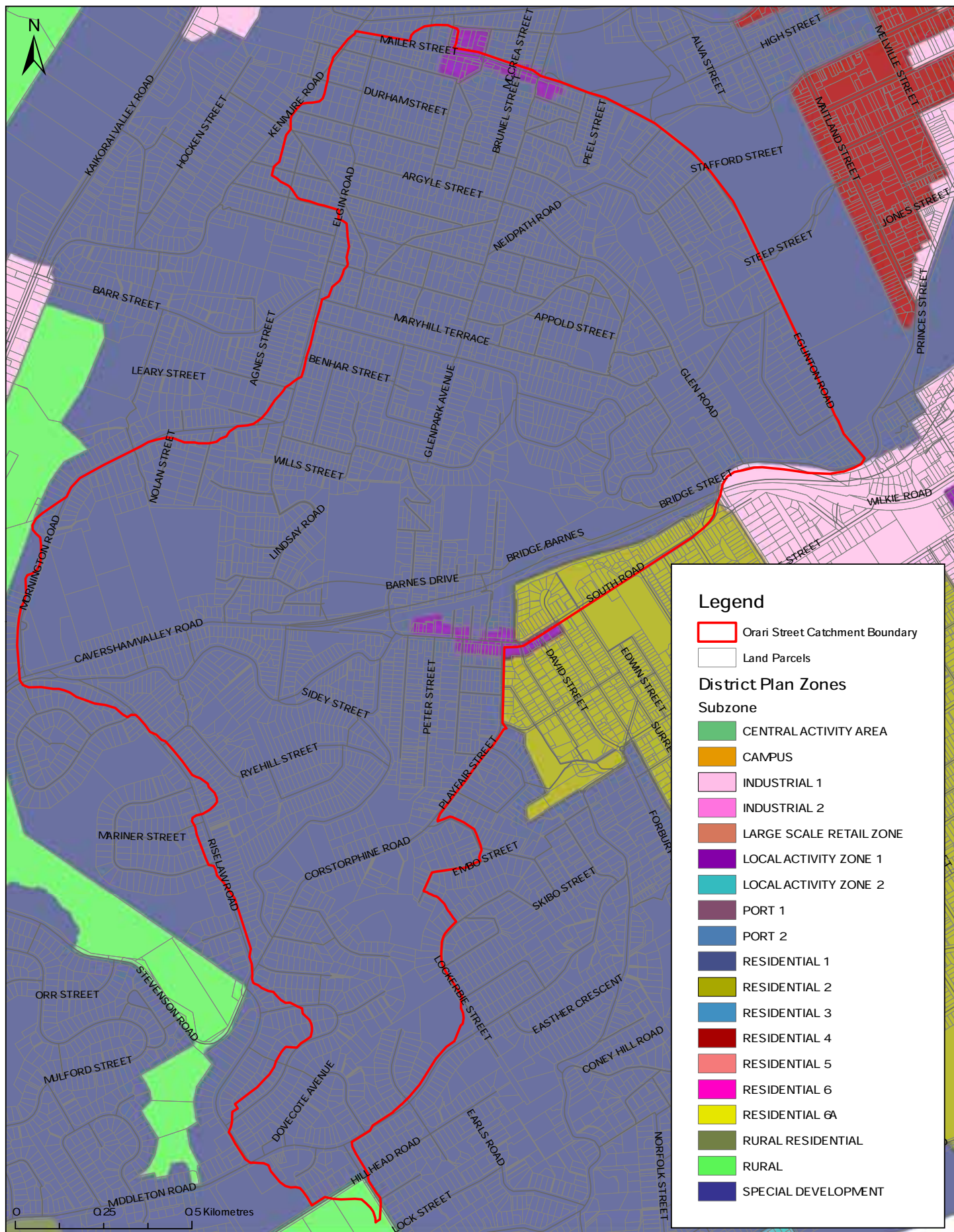
Hill slopes to the north of the motorway retain tree cover, providing a break in the imperviousness usually associated with residential land use.

4.5.2 Cultural and Heritage Sites

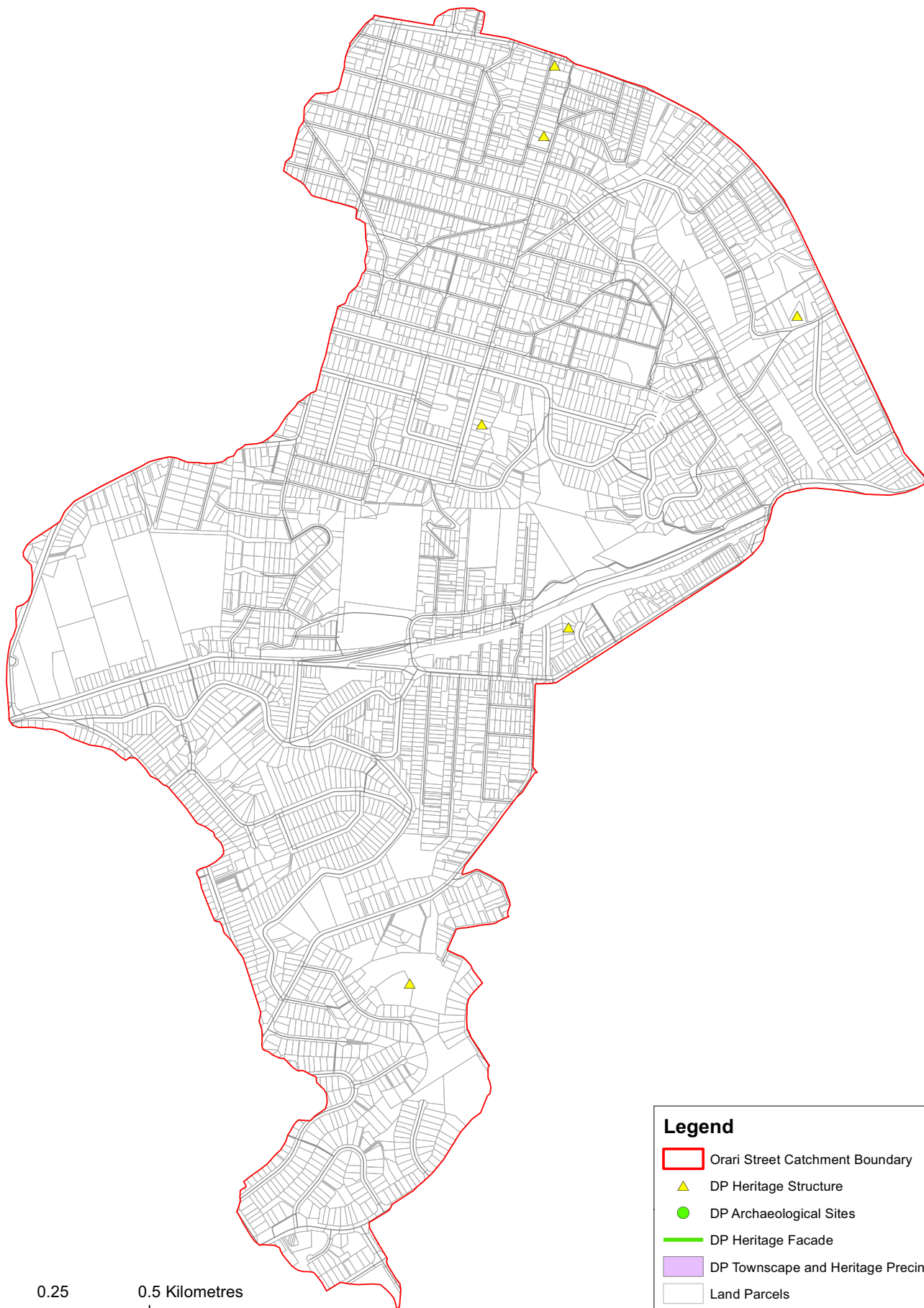
According to DCC records of significant archaeological and heritage sites within Dunedin city, Heritage structures are scattered throughout the Orari Street catchment, however, there are no archaeological sites or heritage precincts recorded in the District Plan.

Heritage structures in the catchment comprise houses, the Mornington Presbyterian Church and a former post office. Locations of these structures are shown in Figure 4-5.

There is some anecdotal evidence citing the hilltop area known as Lookout Point, in the suburb of Caversham, as a burial place (Opus, 2010). However, there are no conclusions regarding the presence of kiwi in this location and consultation with iwi would be required to provide further information on this site and clarify any heritage issues associated with the location. Kāi Tahu have been identified as a key stakeholder. It should be noted that coastal and freshwater environments hold particularly high values for Kāi Tahu. Māori cultural values, along with those of other stakeholders throughout Dunedin's community, are discussed in Section 3.3.



  	Dunedin 3 Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-4 Orari Street Catchment Land Use Zones	DISCIPLINE Stormwater	Status: Final		
				Scale:	1:10,000	Plot Date: Sep 2011
				Drawn By:	CO	Approved: HS
				Checked:	JH	Date: Sep 2011
				Job No:	42173227	Mbp No: Revision: Figure 4-4 -



Legend

- Orari Street Catchment Boundary
- ▲ DP Heritage Structure
- DP Archaeological Sites
- DP Heritage Facade
- DP Townscape and Heritage Precinct
- Land Parcels

0 0.25 0.5 Kilometres



**Dunedin 3
Waters
Strategy**

ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-5

**Orari Street Catchment
Archaeological and Heritage Sites**

DISCIPLINE

Stormwater

Status: Final		
Scale: 1:10,000	Plot Date: Sep 2011	
Drawn By: CO	Approved: HS	
Checked: JH	Date: Sep 2011	
Job No: 42173227	Map No: Figure 4-5	Revision: -



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 Orari Street catchment. However, other than the short-term catchment discharge consent detailed in Section 1.2, there are no other significant resource consents granted relating to stormwater management.

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

A number of District Plan Designations exist within this catchment. Some are for transport purposes and include the existing Main South Railway and State Highway 1, both of which run through the centre of the catchment. There are also a number of primary schools scattered through the catchment, and a DCC reservoir located on Glenpark Avenue.

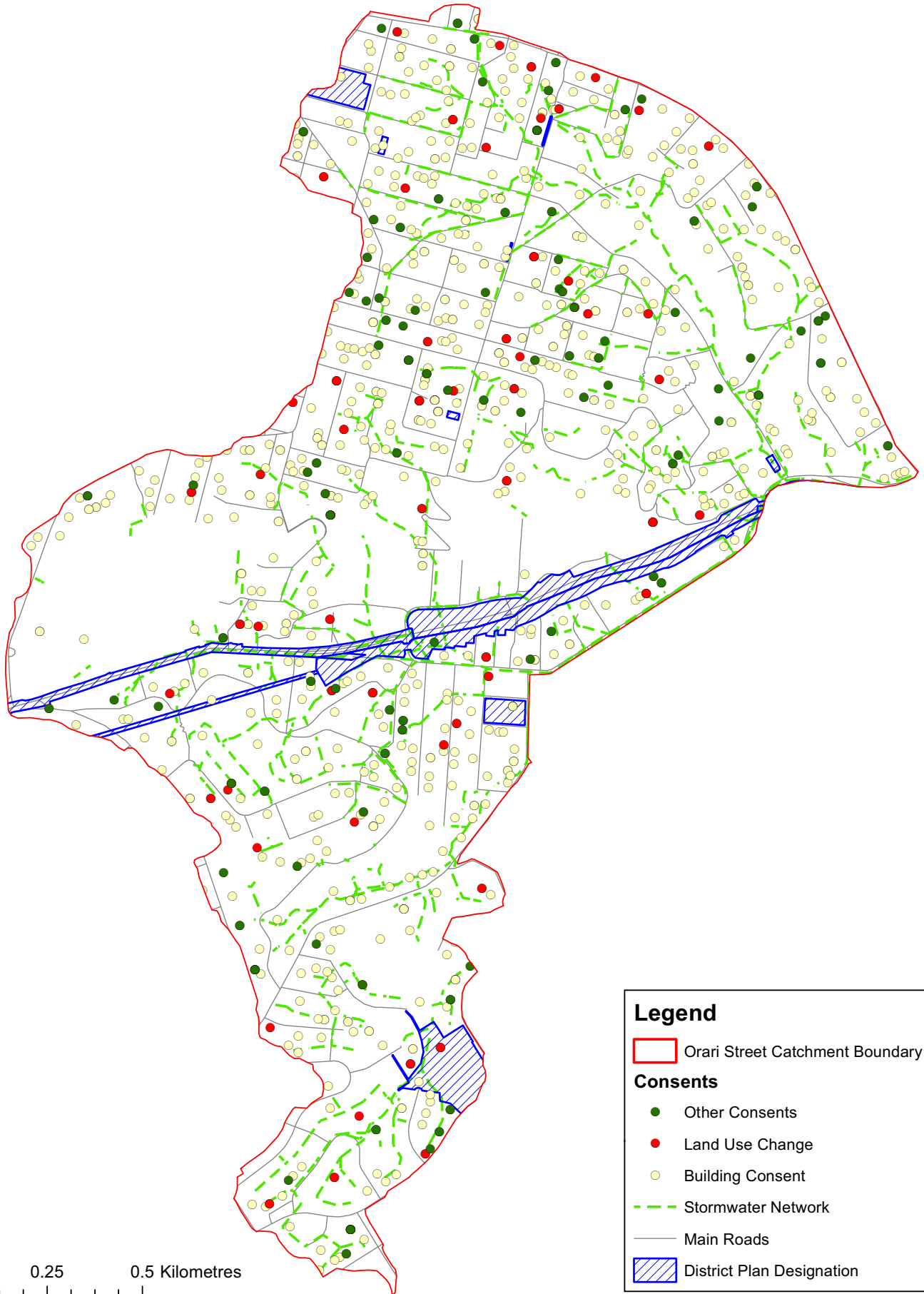
Figure 4-6 provides the location of the resource consents granted by DCC and District Plan Designations within the Orari Street catchment.

4.5.4 Contaminated Land

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

There are a number of reclamation sites in the catchment, however further details relating to these sites were unavailable at the time of writing this plan. There is a small area of reclaimed land on the harbour front in the eastern-most section of the catchment, and a service station site listed as contaminated between the motorway and South Road. There has been a service station on this site since the 1930's and currently the regional council status of this site is "managed". It is noted that soil sampling undertaken in 2000 complied with Tier 1 Ministry for the Environment (MfE) Oil Industry Guidelines.

Figure 4-7 provides the location of the known contaminated land sites within the Orari Street catchment.



Legend

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



URS



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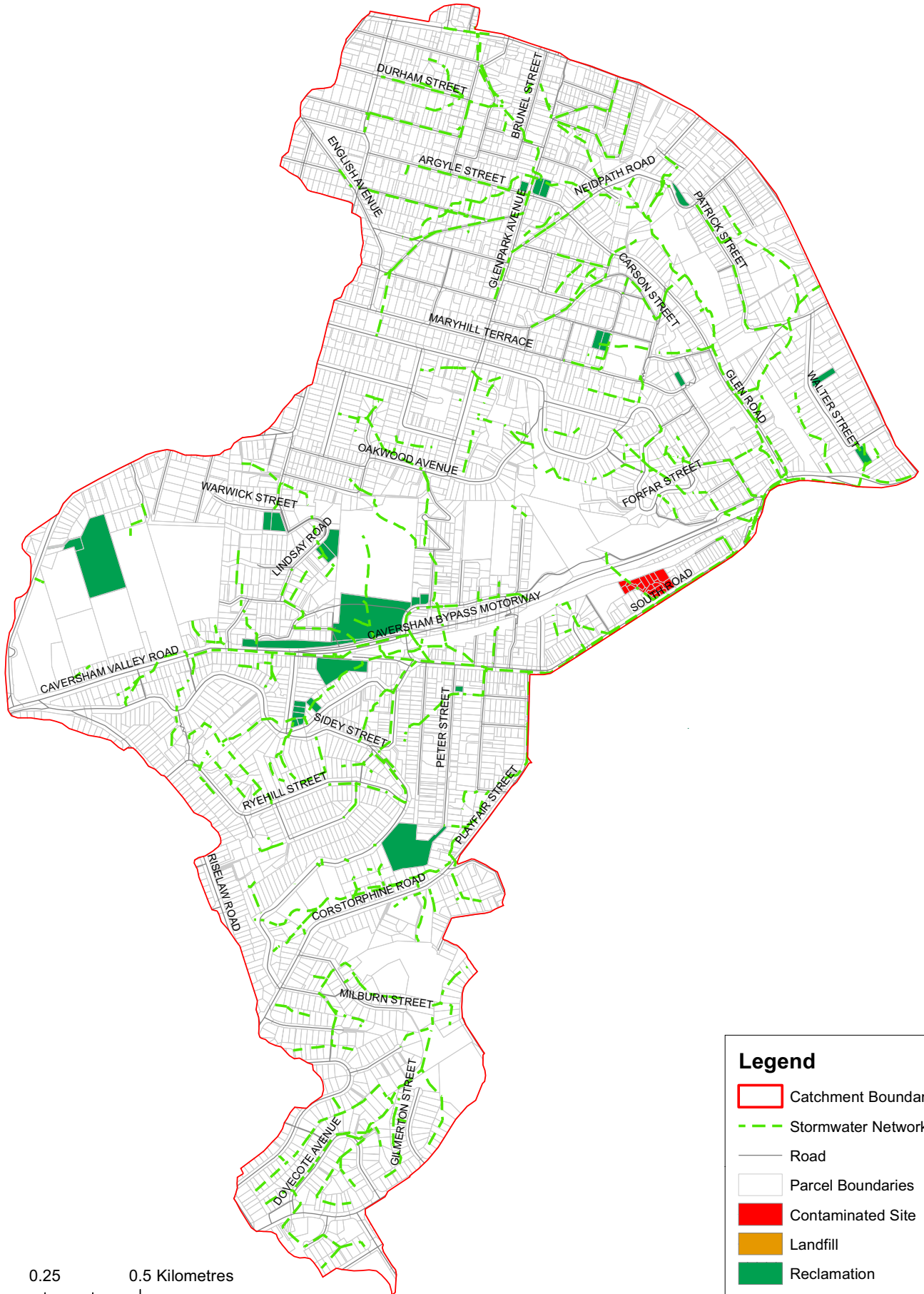
ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-6

**Orari Street Catchment Recent
Consents and Designations**

DISCIPLINE
Stormwater

Status: Final		
Scale:	1:10,000	Plot Date: Sep 2011
Drawn By:	CO	Approved: HS
Checked:	JH	Date: Sep 2011
Job No:	42173227	Map No: Figure 4-6
		Revision: -



0 0.25 0.5 Kilometres

Legend

-  Catchment Boundary
-  Stormwater Network
-  Road
-  Parcel Boundaries
-  Contaminated Site
-  Landfill
-  Reclamation



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Waters
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ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-7

**Orari Street Catchment
Contaminated Land Sites**

DISCIPLINE
Stormwater

Status:	Final		
Scale:	1:10,000	Plot Date:	Sep 2011
Drawn By:	CO	Approved:	HS
Checked:	JH	Date:	Sep 2011
Job No:	42173227	Map No:	Figure 4-7
		Revision:	-



4.5.5 Future Land Use

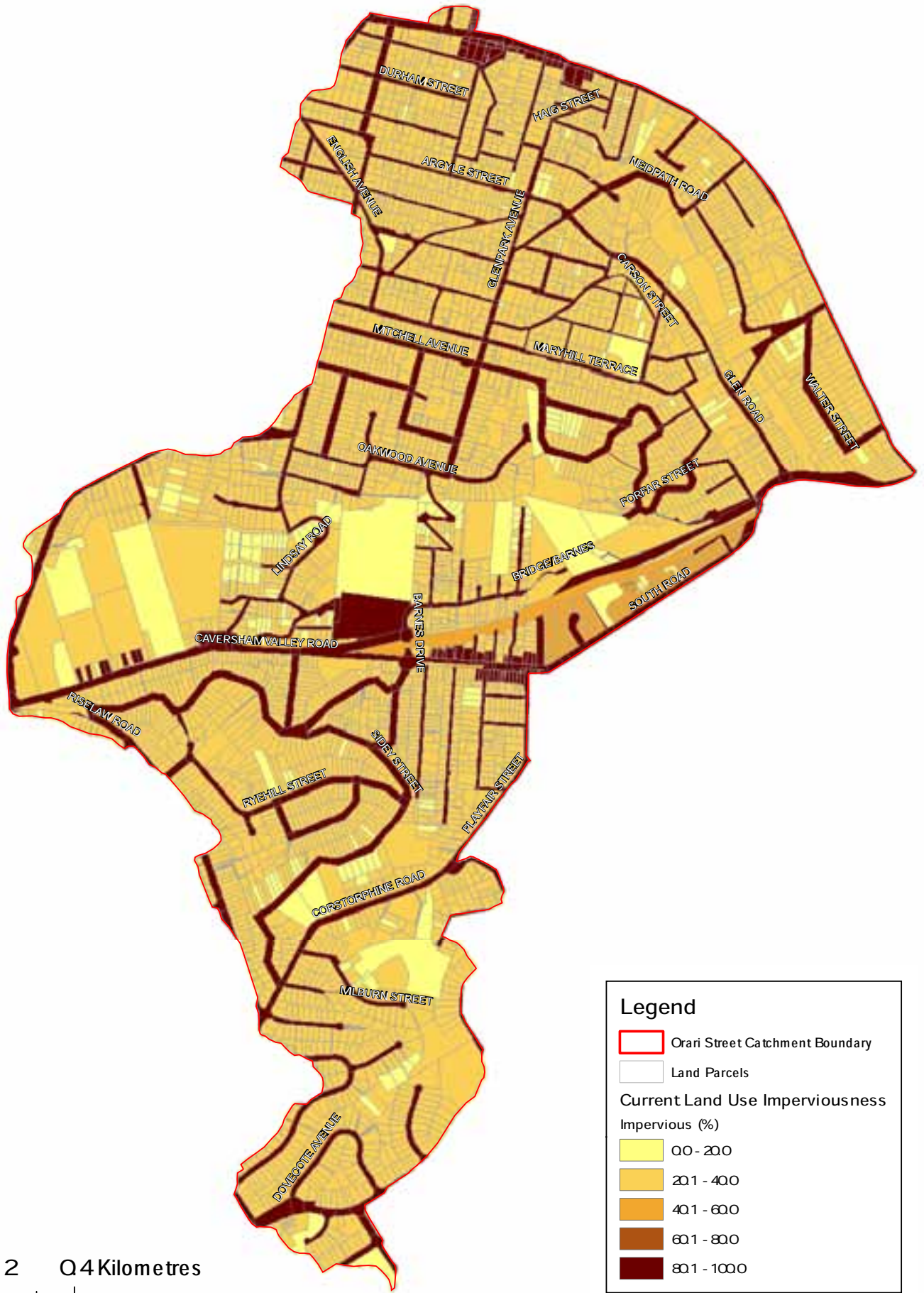
Three future land use scenarios are being considered within the DCC 3 Waters Strategy along with the current situation. The scenarios are; 2008 (current), 2021, 2031 and 2060. For the purposes of stormwater modelling, the 2031 scenario contains the maximum allowable imperviousness for each zone, consistent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

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

4.6 Catchment Imperviousness

Figure 4-8 provides a map of current imperviousness for the Orari Street catchment (refer Appendix B for calculation methods). The land use for 98 % of the catchment is zoned for residential purposes as Residential 1. Housing in this zone typically has lower site coverage than other residential zones, with the district plan estimating site coverage of approximately 25 %. The imperviousness study calculated that Residential 1 zones typically had a total imperviousness of approximately 39 %, of which about 23 % was estimated to be houses and driveways (with the remainder representing areas such as unconnected paving etc). Residential 2 areas around South Road are estimated to have a higher imperviousness (approximately 58 % total). Some land parcels in the Orari Street stormwater catchment to the north of State Highway 1 have lower imperviousness, due to the undeveloped bush clad nature of the terrain.

There are a number of vacant lots in the Orari Street catchment; due to the zoning, these can potentially be developed in the future. It is not anticipated that the currently occupied sites will experience significant change in imperviousness into the future.



Legend

- Orari Street Catchment Boundary
- Land Parcels
- Current Land Use Imperviousness
- Impervious (%)
- 00 - 20.0
- 20.1 - 40.0
- 40.1 - 60.0
- 60.1 - 80.0
- 80.1 - 100.0



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ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-8

Orari Street Catchment
Current Imperviousness

DISCIPLINE

Stormwater

Status: Final		
Scale:	1:10 000	Plot Date: Sep 2011
Drawn By:	CO	Approved: HS
Checked:	JH	Date: Sep 2011
Job No:	42173227	Map No: Figure 4-8
		Revision: -



4.7 Stormwater Drainage Network

4.7.1 Network Description

Figure 4-11 provides details of the stormwater network in the catchment, based on DCC GIS data.

In general the Orari Street catchment stormwater system can be split into three major network branches, which in turn are made up of an intricate network of smaller sub-branches comprising a number of piped and open watercourses. These branches come together in a large pipeline, approximately at the junction of the South Road and Glen Road, and continue along the alignment of the Caversham Bypass Motorway before running adjacent to Orari Street and discharging to the Otago Harbour via a single outfall. Approximately 20 m inland of the outfall is an obsolete stormwater pump station that has been inoperative for several years.

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

- Orari Street catchment outfall – a tidally influenced outfall at the end of Orari Street, fitted with a flap valve.
- Sediment wall in main stormwater pipe – a 1 m high sediment wall is understood to exist approximately 200 m upstream of the outfall, however the regularity of cleaning of the sediment trap was unknown.
- Andersons Bay Road crossing – to provide clearance beneath Andersons Bay Road, the Orari pipeline splits into two, and then four smaller pipes to cross beneath the road. These four pipes then merge into a single pipe of the same shape and dimensions of the upstream pipe.
- ‘The Glen Intake’, near the intersection of Glen Road and South Road – this intake is a concrete basin structure, approximately 12 m wide, with a 2 m high weir and debris screen. The weir contains two 150 mm diameter low flow pipes, and an adjustable weir section. Figure 4-9 provides a photograph of the Glen Intake. Immediately downstream of the intake structure is a 1500 mm square box culvert.
- Intake at 91 Glen Road – an intake structure located on private property at 91 Glen Road experiences regular blocking; site visits indicate that flooding on part of the property occur regularly.

Figure 4-10 provides the frequency distribution of the pipe diameters in the Orari Street catchment. As can be seen, most of the pipes in the catchment are relatively small, and the majority of the pipes in the catchment have a diameter of between 150 mm and 300 mm.



Figure 4-9: Glen Intake Structure, Including Weir and Screens

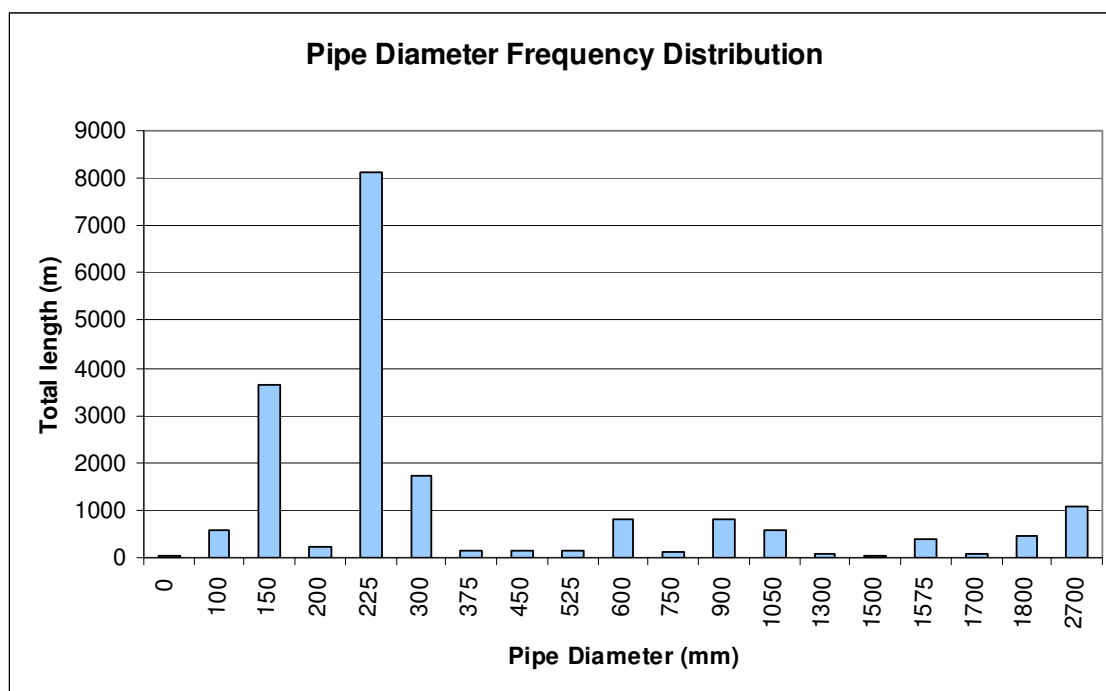
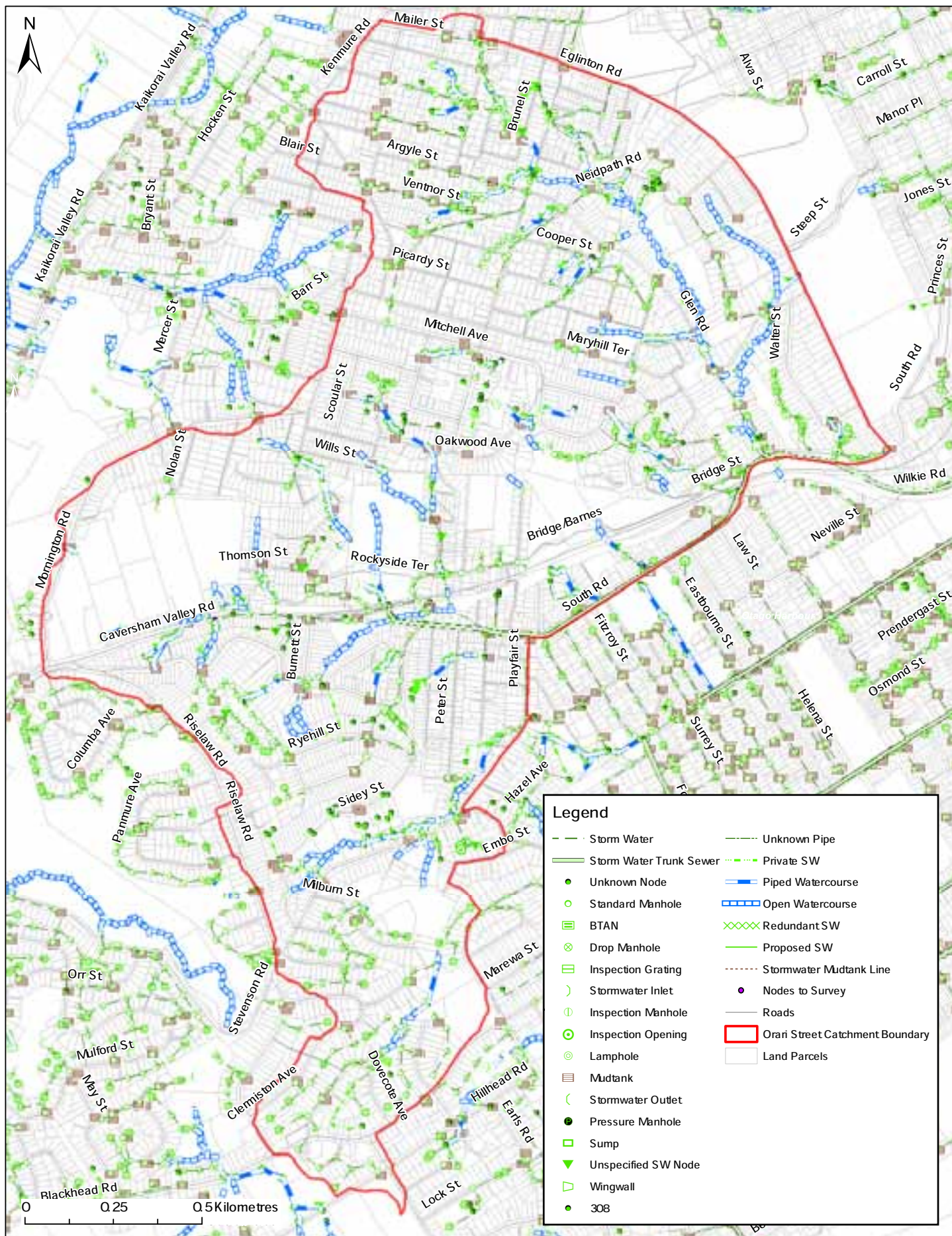


Figure 4-10: Pipe Diameter Frequency Distribution



	Dunedin 3 Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-11 Orari Street Catchment Stormwater Drainage Network	DISCIPLINE Stormwater	Status: Final		
				Scale: 1:10,000	Plot Date: Sep 2011	
				Drawn By: CO	Approved: HS	
				Checked: JH	Date: Sep 2011	
				Job No: 42173227	Map No: Figure 4-11	Revision: -



4.7.2 Network Age

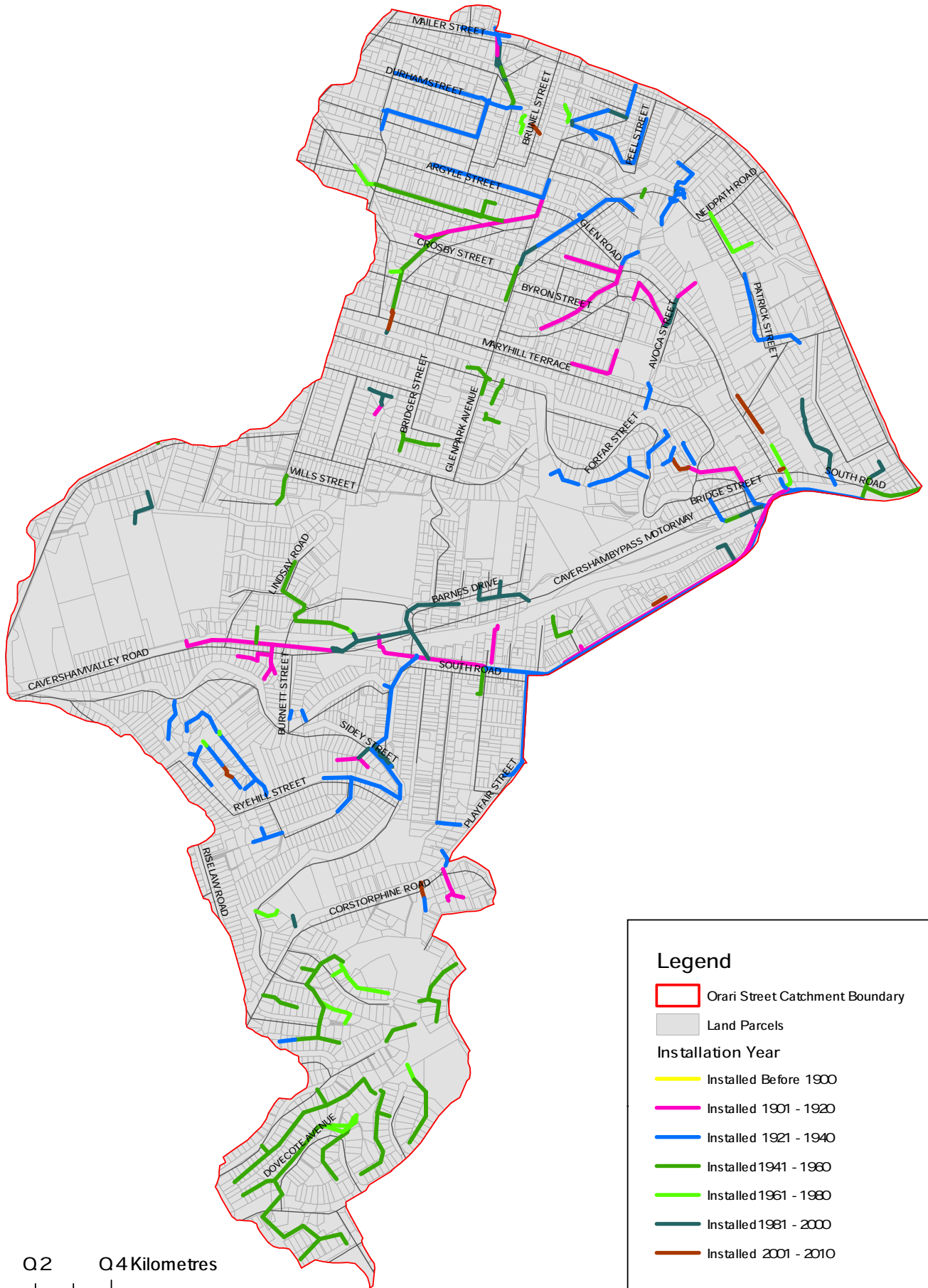
Table 4-1 below provides a breakdown of pipe age in the Orari Street catchment. Figure 4-12 provides a map of pipe age based on location.

The data shows that the majority of the pipework in the Orari Street catchment was laid in the mid-1900s, and as such will still be the original infrastructure. The stormwater network in the Corstorphine area is newer than the rest of the catchment, and was installed in the 1940s and 1960s, most likely as part of the state housing scheme.

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, 82 % 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 4-1: Pipe Network Age and Length Composition

Installation Date	Approximate Age	Number of Pipelines	Length of Pipe (m)	% of Pipe Length
Installed 1900 or before	> 110 years	0	0	0
Installed 1901 to 1920	90-110 years	67	3537	17
Installed 1921 to 1940	70-90 years	214	8031	39
Installed 1941 to 1960	50-70 years	137	5242	26
Installed 1961 to 1980	30-50 years	44	1156	6
Installed 1981 to 2000	10-30 years	82	1968	10
Installed 2001 to 2009	< 10 years	19	404	2



Legend

- Orari Street Catchment Boundary
- Land Parcels
- Installation Year**
- Installed Before 1900
- Installed 1901 - 1920
- Installed 1921 - 1940
- Installed 1941 - 1960
- Installed 1961 - 1980
- Installed 1981 - 2000
- Installed 2001 - 2010

0 0.2 0.4 Kilometres



Dunedin 3
Waters
Strategy

ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-12

Orari Street Catchment
Pipe Network Ages

DISCIPLINE
Stormwater

Status:	Final		
Scale:	1:10,000	Plot Date:	Sep 2011
Drawn By:	CO	Approved:	HS
Checked:	JH	Date:	Sep 2011
Job No:	42173227	Map No:	Figure 4-12
		Revision:	-



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 4-2 summarises the first cut version used for stormwater assets as of November 2010. Note that stormwater intakes were rated slightly differently to remaining assets, with 20 % of the weighting assigned to cost and 20 % to each of the four wellbeings, given that the consequences of failure of an intake would be largely localised in nature due to area flooding.

Figure 4-13 shows a map of the Orari Street catchment, with criticality and wellbeing locations identified. This map shows pipe criticality only. Pipe condition assessment (via closed circuit television (CCTV)) is currently being undertaken throughout the city on selected pipes, however to date no information is available on pipes in the Orari Street catchment.

There are a small number of 'wellbeing' locations identified in the Orari Street catchment, however the maximum pipe criticality assigned to the stormwater network is 2; these pipes are either in the area of the Caversham Bypass / South Road intersection, due to proximity to the Caversham Bypass, Sidey Park and South Road, or near the Glen Road intake structure, due again to proximity to South Road (a bus route, considered a 'minor social' wellbeing location).



Table 4-2: Asset Criticality Score Criteria

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

Criticality 1 = Not Critical

Criticality 5 = Very Critical



0 0.15 0.3 Kilometres



Legend	
Stormwater Criticality	
Total Criticality Score	
1	
2	
3	
Social Minor Location	
Social Major Location	
Economic Minor Location	
Environmental Major Location	
Cultural Location	
Economic Major Location	
Orari Street Catchment Boundary	



Dunedin 3
Waters
Strategy

ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 4-13

Orari Street Catchment
Stormwater Network Criticality

DISCIPLINE

Stormwater

Status: Final		
Scale:	1:10,000	Plot Date: Sep 2011
Drawn By:	CO	Approved: HS
Checked:	JH	Date: Sep 2011
Job No:	42173227	Map No: Figure 4-13
		Revision: -



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

4.7.5 Operational Issues

Discussions were held with DCC Network Management and Maintenance personnel during the catchment walkover (8 July 2009) in order to identify known operational issues or locations of historical flooding. Further discussions were held during a workshop with DCC Water and Waste Business Unit staff in November 2010. Discussions highlighted the following issues:

- Overtopping of inlet screen at 91 Glen Road, resulting in overland flow – also poor screen performance.
- Flooding on South Road, near the Glen Road intake structure (refer Figure 4-14).
- The open channel behind the South Road commercial area requires a screen.
- Flooding of the property on the corner of South Road and Laing Street has occurred in the past.
- The hydraulic bottleneck (925 mm diameter pipe, leading to a 525 mm diameter pipe) on Barnes Drive (north of the motorway) has resulted in issues.
- Drainage around the Caversham Bypass Motorway will be re-designed as the motorway upgrades take place.
- No known issues in the Corstorphine area. Macbeth Street is a low point.

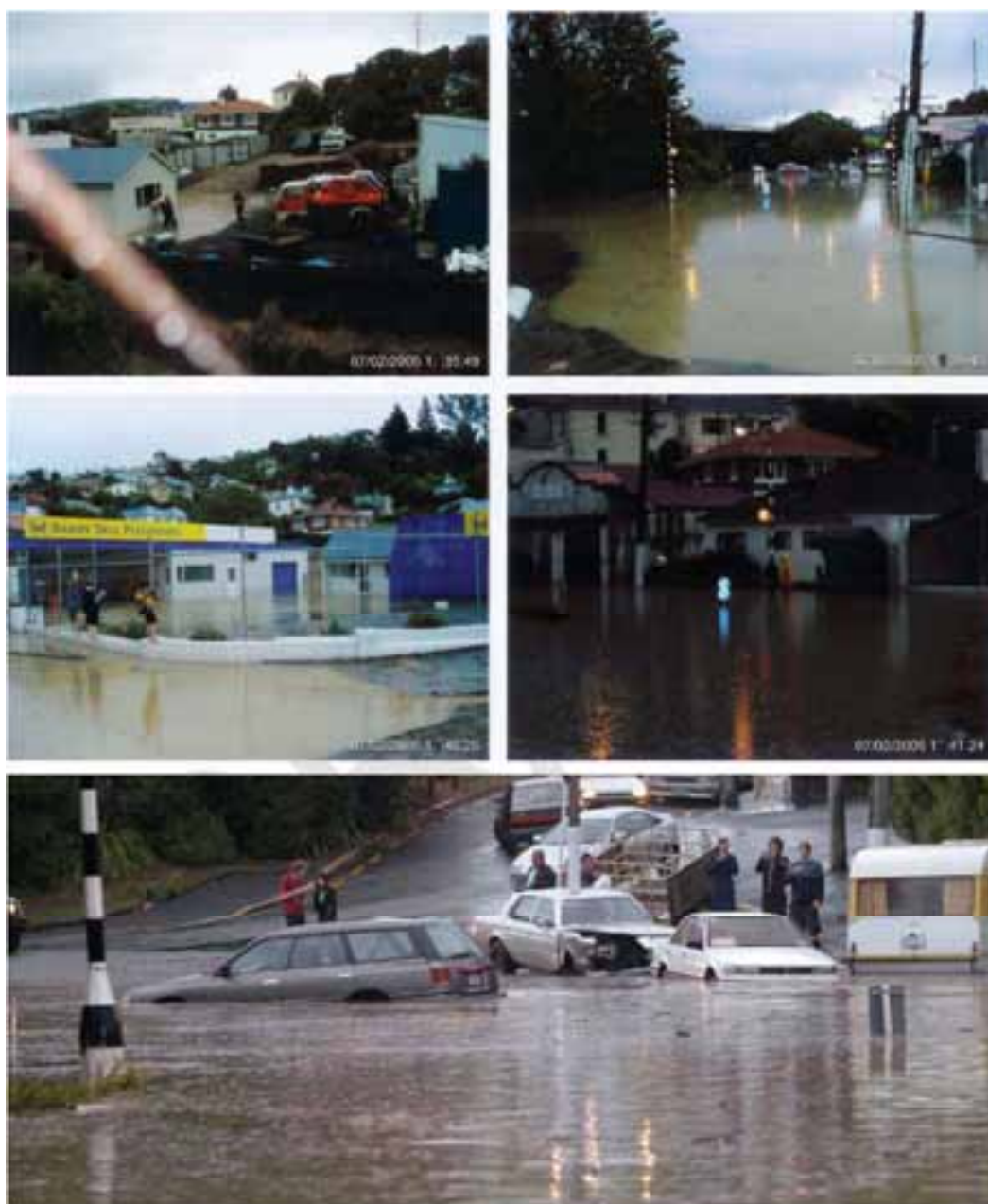


Figure 4-14: Flooding on South Road, near the Glen Road Intake Structure, February 2005

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 Management and Maintenance team that during autumn months heavy rainfall can result in blocked catchpits or inlet screens regardless of how well maintained they are. Failure to remove silt and gravel from the catchpits can also lead to siltation and hence capacity reduction of the pipe network; siltation has been identified as an issue in some areas of Dunedin by the Network Management and Maintenance team, and this is currently being investigated as part of a city-wide CCTV programme.

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



Network Management and Maintenance

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

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

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

Transportation Operations

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

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

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

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

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

The cleaning and maintenance of stormwater structures in the road is currently perceived by Water and Waste Business Unit Network Management and Maintenance team to be inadequate. DCC have concerns that the cleaning and maintenance contract is not specific enough and therefore the stormwater structures within the roads are not maintained to a satisfactory standard.



Community and Recreation Services

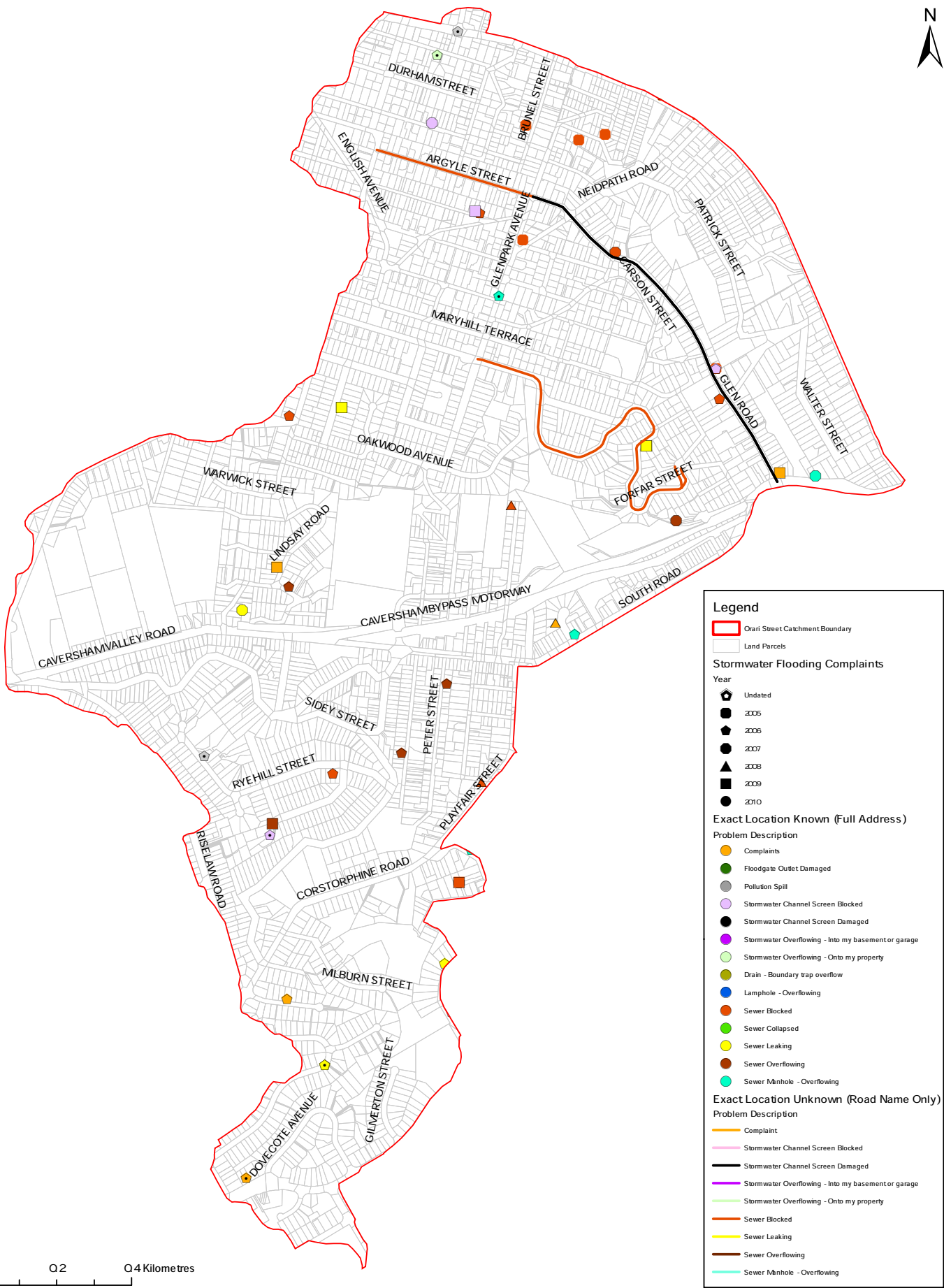
The maintenance and cleaning of stormwater structures located within parks and reserves, other than those listed under Network Management supervision, are the responsibility of CARS.

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

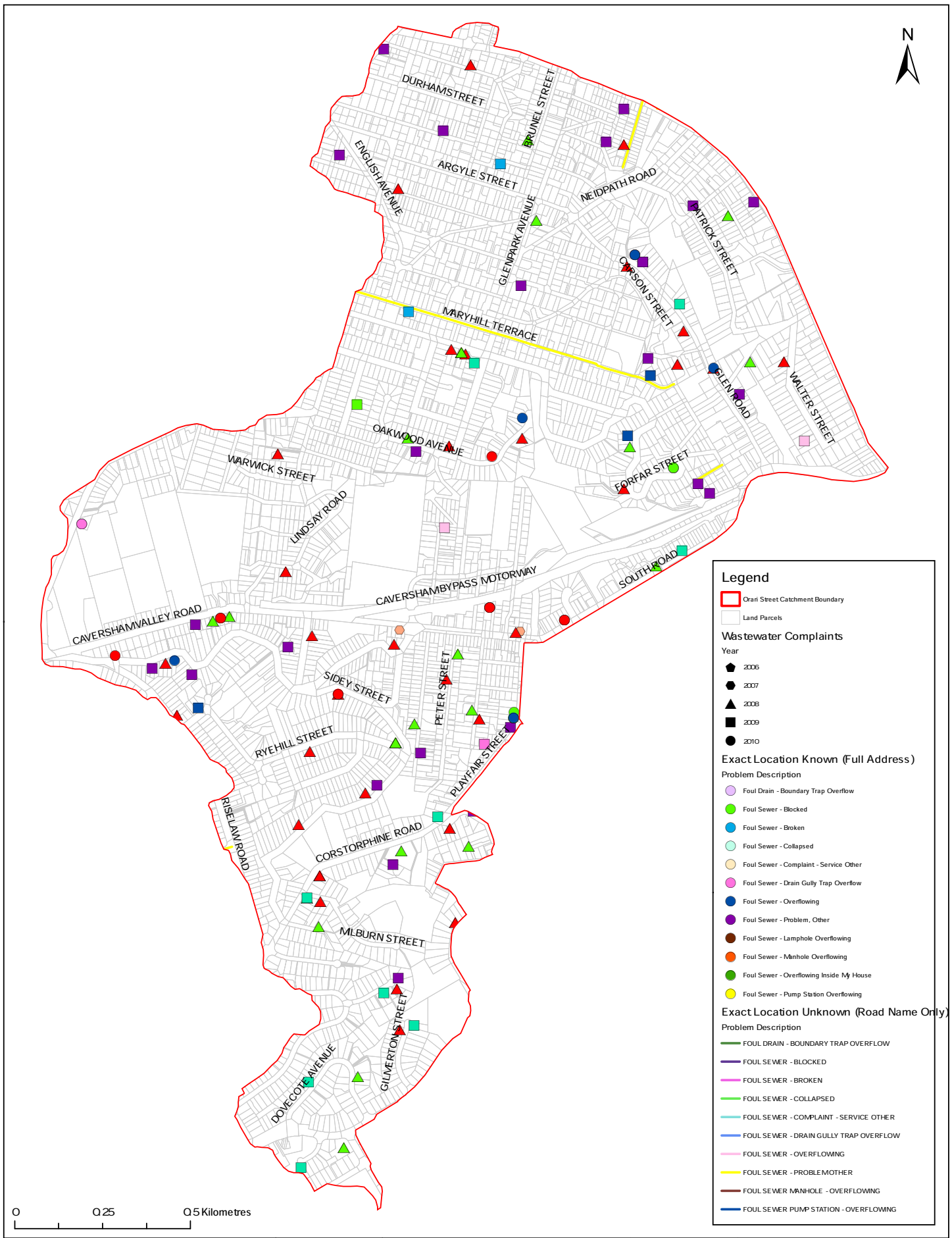
4.8 Customer Complaints

Based on DCC customer complaints information collated between 2005 and 2010, there were 58 recorded stormwater complaints in the Orari Street catchment that relate to blockages, leakages or overflows, or that are unspecified. Five of these have imprecise locations and could only be identified by road name. A map of stormwater complaints is provided as Figure 4-15. Stormwater flooding complaints are generally scattered around the catchment, however a larger number have been recorded in the Glen Valley area, both at the upper reaches of the sub-catchment, and along Glen Road and Forfar Street.

Wastewater customer complaints information compiled between 2005 and 2010 (Figure 4-16) shows a relatively large number of complaints in the Orari Street catchment. These complaints are, however, fairly evenly distributed across the catchment, and do not highlight any particular areas of concern with respect to stormwater management. The wastewater investigations undertaken as part of the 3 Waters Strategy study indicate that records of historical wastewater flooding on South Road within this catchment are due to high flows within the system, transferred from upstream catchments.



  	Dunedin 3 Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-15 Orari Street Catchment Reported Stormwater Flooding	DISCIPLINE Stormwater	Status: Final		
				Scale: 1:10,000	Plot Date: Sep 2011	
				Drawn By: CO	Approved: HS	
				Checked: JH	Date: Sep 2011	
				Job No: 42173227	M/p No: Figure 4-15	Revision: -



 	Dunedin 3 Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-16 Orari Street Catchment Reported Wastewater Flooding	DISCIPLINE Stormwater	Status: Final		
				Scale: 1:10,000	Plot Date: Sep 2011	
				Drawn By: CO	Approved: HS	
				Checked: JH	Date: Sep 2011	
				Job No: 42173227	M/p No: Figure 4-16	Revision: -



4.9 Water and Wastewater Systems

Figure 4-17 provides a layout of the 3 waters networks in the Orari Street catchment.

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

4.9.1 Water Supply System

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

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

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

The water for the Orari Street catchment is supplied from the Epsilon Street and Glenpark Avenue reservoirs. The southern part of the zone is fed from the Lookout Point PRV, supplied from Mount Grand WTP. There are approximately 57 km of water supply pipes within the Orari Street catchment, ranging from 15 mm to 475 mm in diameter, most of which are less than 200 mm in diameter. The majority of the supply pipes in this catchment are constructed from cast iron.

The Orari Street catchment falls within the Corstorphine and Epsilon water supply zones. Aged cast iron mains in this catchment cause headloss issues, and the cast iron mains are linked to low pressure, limited fire flows and water quality complaints in the area. Leakage in the catchment is difficult to assess as there is a suspected flow through the zone boundary into the Intermediate zone.

Some low pressures and fire flow issues have been identified in the catchment, and focussing renewals in the area is recommended.

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.



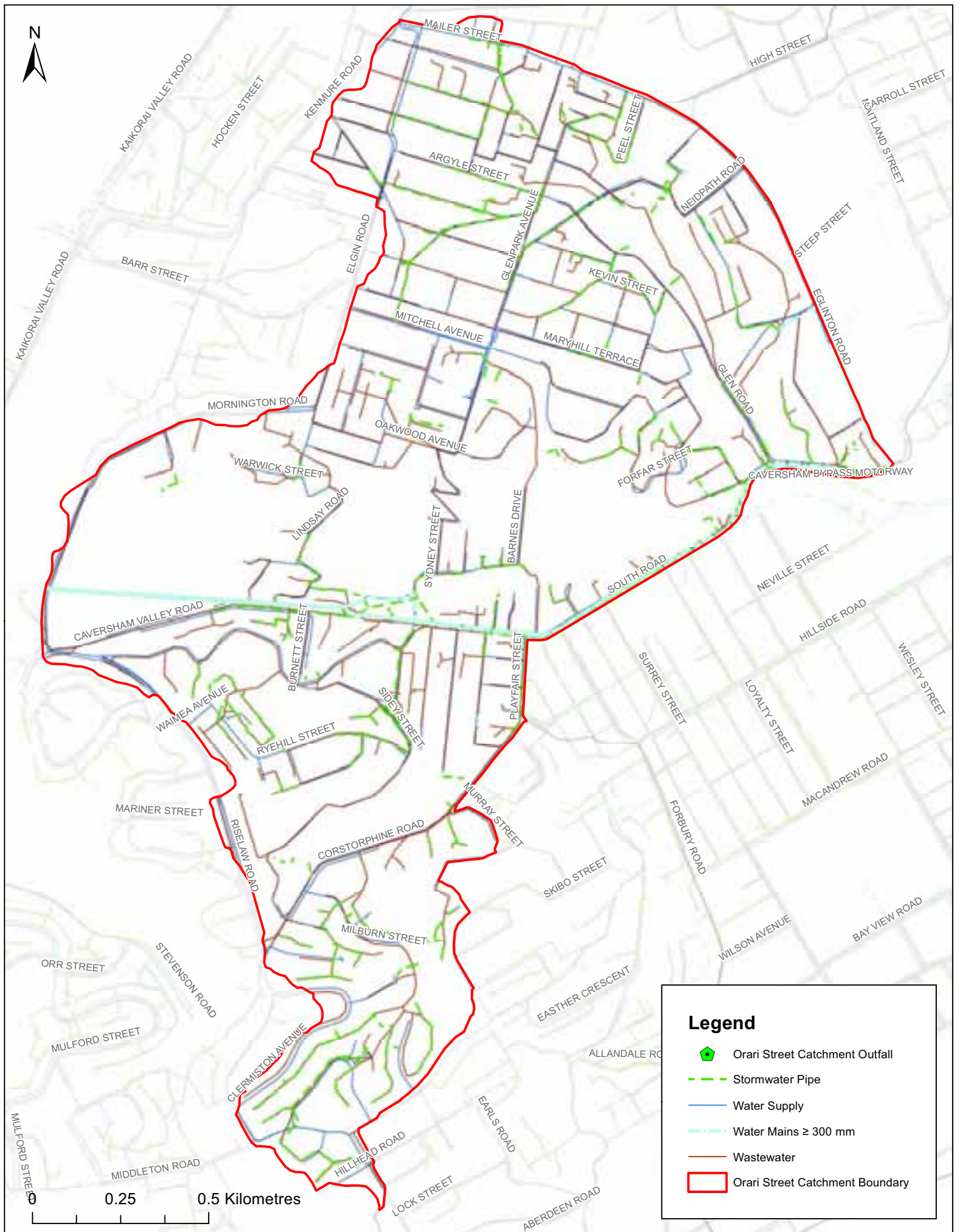
The Dunedin city wastewater system collects wastewater from commercial, industrial and residential customers in Dunedin city. It is split into three distinct schemes, the Dunedin Metropolitan Scheme, the Mosgiel Scheme and the Green Island Scheme.

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

The system within the Orari Street catchment comprises approximately 52 km of wastewater pipeline, approximately 81 % of which are between 150 mm and 300 mm in diameter.

Flows from Corstorphine and Balaclava are directed to a trunk main along South Road which conveys flows through South Dunedin to the MIS.

There are records of historical wastewater flooding on South Road within this catchment due to high flows within the system. I&I issues in the wastewater system upstream of this catchment, in Corstorphine and Kaikorai Valley areas, contribute to the high flows. However, this issue is being addressed via a new cross connection between the two sewer lines down South Road, recommended as a result of the 3 Waters Strategy Project investigations.



 	Dunedin 3 Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 4-17 Orari Street Catchment Three Waters Network	DISCIPLINE Stormwater	Status: Final		
				Scale:	1:10,000	Plot Date: Sep 2011
				Drawn By:	CO	Approved: HS
				Checked:	JH	Date: Sep 2011
				Job No:	42173227	Map No: Figure 4-17 Revision: -



5 Receiving Environment

This section identifies and describes the stormwater receiving environments for the Orari Street catchment, both freshwater and marine. 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.

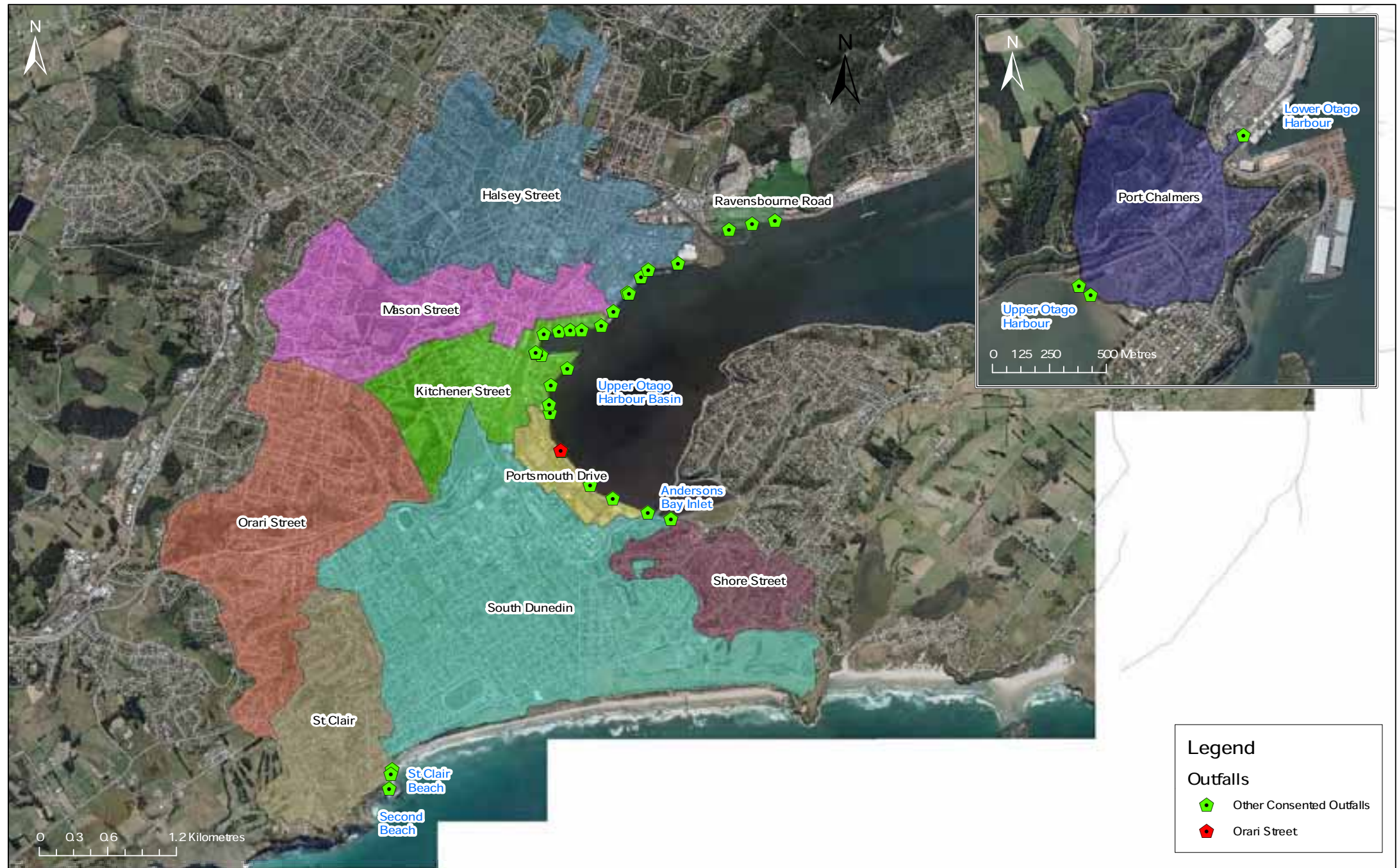
Part 3 of this report identifies and analyses the effects that specific current stormwater management practices are considered to be having on the receiving environment of the catchment. Where the effects are considered to be unacceptable, options for avoiding remedying or mitigating the effects are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

The stormwater network in the Orari Street catchment discharges directly to the marine environment at the eastern shore of the Otago Harbour basin via an outfall located approximately 75 m northeast of the intersection of Orari Street and Portsmouth Drive (Figure 5-1). The location of the outfall, relative to other DCC stormwater outfalls and the Otago Harbour receiving environment, is shown in Figure 5-2.

There are four natural streams in the Orari Street catchment, the locations of which are indicated in Figure 5-4. 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: Orari Street Stormwater Catchment Outfall



Legend

Outfalls

- ▮ Other Consented Outfalls
- ▮ Orari Street

Created with SRI ArcGIS

	Dunedin 3Waters Strategy	ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN Figure 5-2 Orari Street Catchment Marine Receiving Environment	DISCIPLINE Stormwater	<table><tr><td>Drawn:</td><td>MM</td><td colspan="2">Status: Final</td></tr><tr><td>Checked:</td><td>HES</td><td>Scale: 1:30,000</td><td>Plot Date: Sep 2011</td></tr><tr><td>Approved:</td><td>HES</td><td>Job. No: 42173227</td><td>Map No: Figure 5-2</td></tr><tr><td>Date:</td><td>Sep 2011</td><td></td><td>Revision: -</td></tr></table>	Drawn:	MM	Status: Final		Checked:	HES	Scale: 1:30,000	Plot Date: Sep 2011	Approved:	HES	Job. No: 42173227	Map No: Figure 5-2	Date:	Sep 2011		Revision: -
Drawn:	MM	Status: Final																		
Checked:	HES	Scale: 1:30,000	Plot Date: Sep 2011																	
Approved:	HES	Job. No: 42173227	Map No: Figure 5-2																	
Date:	Sep 2011		Revision: -																	



5.1 Marine Receiving Environment

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

- Biological monitoring: Macroalgae, epifauna and infauna are surveyed at low tide from four sites; two within 20 m and two a minimum of 50 m from each outfall monitored. Shellfish and octopus are collected from within 20 m of the confluence of the stormwater outfall and waters edge at low tide; and fish (variable triplefins) are collected within 50 m of the stormwater outfalls. The flesh of the animals is then analysed for heavy metals and polycyclic aromatic hydrocarbons (PAHs).
- Sediment monitoring: Replicate samples are collected from the top 20 mm of sediment within 20 m of each outfall monitored. The sediment is analysed for a suite of contaminants including heavy metals, bacteria and PAHs. In addition to the annual sampling, sediment is also analysed from four transects across the centre of the upper harbour, every 5 years.
- Stormwater monitoring: Stormwater grab samples are taken from a number of outfalls, within 1 hour of the commencement of a rain event greater than 0.5 mm, in an attempt to capture the first flush stormwater. The stormwater is then analysed for a suite of contaminants. Stormwater quality is discussed further in Section 6.

There have been a number of studies carried out to establish the condition of the Otago Harbour receiving environment. A study of Dunedin's marine stormwater outfalls was completed in 2010 by Ryder Consulting (Ryder, 2010a), for the purpose of assessing the current quality of the receiving environments and the potential effects of stormwater on the environments. This study comprises an assessment of the stormwater, sediments, and ecology in the vicinity of the major outfalls within the harbour using sites and methods generally in accordance with those carried out for the annual monitoring. The results of this study were compared with past surveys and historical data in order to determine the condition of the harbour receiving environment.

The following reports are provided for reference in Appendix C:

- Ryder (2010a). Ecological Assessment of Dunedin's Marine Stormwater Outfalls.
- Ryder (2010b). Compliance Monitoring 2010. Stormwater Discharges from Dunedin City.
- Ryder (2010c). Dunedin Three Waters Strategy Stream Assessments.
- Ryder (2009). Compliance Monitoring 2009. Stormwater Discharges from Dunedin City.
- Ryder (2008). Compliance Monitoring 2008. Stormwater Discharges from Dunedin City.
- Ryder (2007). Compliance Monitoring 2007. Stormwater Discharges from Dunedin City.
- Ryder (2006). Remediation of Contaminated Sediments off the South Dunedin Stormwater Outfall: A proposed course of action.



- Ryder (2005a). Characterisation of Dunedin's Urban Stormwater Discharges & Their Effect on The Upper Harbour Basin Coastal Environment.
- Ryder (2005b). Spatial Distribution of Contaminants in Sediments off the South Dunedin Stormwater Outfall.

5.1.1 Upper Harbour Basin

The upper harbour basin is a highly modified environment as a result of reclamation, road works and dredging activities (Smith, 2007). Stormwater is received from the greater Dunedin urban area and surrounding rural catchments and discharged via outfalls into the Otago Harbour at a number of locations, shown in Figure 5-2.

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

A study by Smith and Croot (1993), describes the circulation of water in the Otago Harbour as being dominated by the tide and inputs of heavy rainfall (see Figure 5-3). Smith and Croot (1993) report that flushing times in the harbour are hard to establish as heavy rainfall has a dramatic effect on dilution displacement of the water in the upper harbour. Harbour flushing times, therefore, may vary and be greatly reduced during rainfall events.

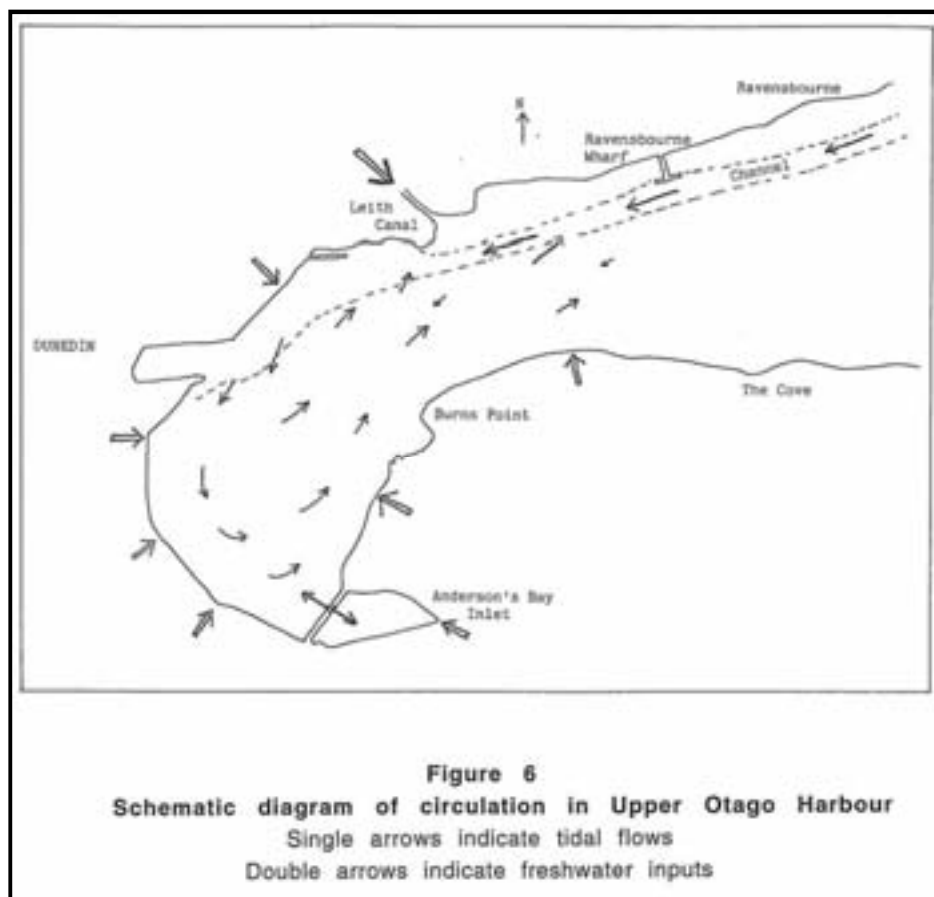


Figure 5-3: Circulation of Water in the Upper Otago Harbour (from Smith and Croot, 1993)



5.1.2 Recreational and Cultural Significance

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

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

5.1.3 Harbour Ecology

The resource consent associated with the outfall of the Orari Street catchment has conditions requiring biological monitoring. This includes the monitoring of epifauna, infauna and macroalgae, as well as sampling of cockle and octopus flesh.

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. The diversity of benthic flora and fauna is generally accepted as a reasonable indicator of environmental health. The presence of pollution tolerant species, and an absence of pollution intolerant species, can be used to indicate contamination. However, significant amounts of data are required to link the presence or absence of indicator species with contamination. Table 5-1 below provides typical sources of urban stormwater contaminants.

Several large outfalls discharging stormwater from other urban and industrial catchments exist within approximately 500 m of the Orari Street catchment outfall. Due to the proximity of the outfalls and the common receiving environment it is difficult to distinguish between the potential effects of any particular catchment. Additionally, the harbour ecology is likely to be affected by a number of other factors including other discharges and freshwater input to the harbour (for example the Water of Leith) and historical sediment contamination from sites such as the city gasworks, operational in the South Dunedin catchment up until the 1980s.



Table 5-1: Sources of stormwater contaminants

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

The results of the biological monitoring for consent requirements (2007 to 2010) can be summarized as follows:

- **Macroalgae:** The monitoring results indicate that macroalgal percentage cover at sites at 20 m and greater than 50 m from the Orari Street catchment outfall was, on average, sparse between 2007 and 2009. There was a notable difference in the 2010 results where percentage cover at the outfall was seen to be much higher.
- **The diversity of macroalgae** at all sites near the Orari Street catchment outfall was found to be quite poor in 2007 with a maximum of three species found at any site. The monitoring results from 2008-2010 showed a slightly higher diversity, with a maximum of seven species recorded. Between 2008 and 2010 the macroalgal cover was dominated by red algae.
- **Epifauna:** The monitoring results indicate that epifauna abundance was reasonably sparse at all of the Orari Street catchment outfall sampling sites in 2007. The abundance has been found to improve each year and the 2010 monitoring results indicate a moderate abundance of epifauna at the sites surveyed at the outfall.



- The diversity of epifauna has been found to be variable. In some years, a higher diversity was observed at sites 20 m from the outfalls; in others, diversity was higher at the sites greater than 50 m from the outfall. The 2010 monitoring results concluded that, in general, moderate diversity could be observed. Overall, there was no significant change in epifauna diversity observed between 2007 and 2010 and there was no significant difference between the diversity at sites 20 m from the outfall and sites greater than 50 m from the outfall.
- Infauna: The monitoring results 2007-2010 indicate that the infauna was generally dominated by polychaete worms and amphipods at all sites surveyed at the Orari Street catchment outfall. The results from 2010 showed a general increase in the abundance of infauna in comparison with monitoring undertaken 2007-2009, there was however, still some variability between the sites and replicate samples taken.
- The diversity of infauna species has not changed significantly between 2007 and 2010 at sites at 20 m from the outfall. At the sites greater than 50 m from the outfall however, there was a significantly higher diversity found in 2010 than in previous monitoring years.
- Cockle and Octopus Flesh: The concentration of heavy metals measured in cockle flesh between 2007 and 2010, have remained well below the New Zealand accepted food guidelines levels for shellfish flesh (ANZ Food Standards Code 2002; NZ Food Regulations 1984). No fish sampling is undertaken at these locations.
- Faecal coliform levels measured in cockle flesh have fluctuated between years. In 2007 and 2009 faecal coliforms were below detectable limits. The highest levels observed to date were recorded in 2008. The 2010 results indicate moderate levels in cockle flesh samples from near the outfall.
- The PAH levels in cockle flesh, measured between 2007 and 2010, were found to be considerably lower than other sites within the harbour. There are no specific guidelines for PAHs in shellfish flesh for New Zealand.
- The overall size of cockles has not changed significantly from year to year. However, cockles at this site (and the other sites monitored) are much slower growing than at prime cockle sites further down harbour.
- The concentration of contaminants in octopus flesh, sampled between 2007 and 2010, were in general below the New Zealand accepted food guidelines levels. In 2007 however, cadmium levels measured in the digestive gland of a single specimen were found to be higher than the food guideline levels. Arsenic levels, measured in all the specimens collected between 2007 and 2010, were consistently higher than levels measured in shellfish from the same locations.

The fluctuations in analysis presented above show that the monitoring period has not yet been sufficient to determine any clear trends in the state of the ecology in the receiving environment.

The benthic and infaunal communities in the vicinity of the outfalls assessed in this catchment show moderate abundance and diversity. This is unlikely to be attributed to any single outfall or catchment. Animals present are typical of other soft bottom intertidal areas in the upper harbour basin.

The 2010 monitoring report notes that, whilst not pristine, the upper harbour and the communities associated with the intertidal areas adjacent to the major stormwater outfalls appear not to be



undergoing any significant further degradation as a result of the stormwater inputs during the monitoring period (2007-2010).

5.1.4 Harbour Sediments

The resource consent associated with the outfall from the Orari Street catchment has a sediment monitoring requirement. Sediments have been collected from sample sites less than 20 m and greater than 20 m from the outfall. As noted above, the influence of other urban stormwater discharges, and discharges from a variety of other activities, both current and historical, are also expected to be evident in harbour sediments at this location, and throughout the upper harbour.

The upper harbour bed has been classified, in general, as muddy sands / sandy muds, with varying proportions of fine gravels (Ryder, 2005b). The harbour bed at the Orari Street catchment outfall generally consists of fine silt and sand with a reasonable abundance of organic matter content (e.g. decaying leaves and twigs) (Ryder, 2010b).

A range of historic data is available regarding contamination levels within harbour sediments, including sediments near the Orari Street catchment outfall. However, historic values should be viewed with caution as sampling in previous years may have used different protocols and sediments may have been collected from different substrate depths and by different methods.

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

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

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

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

The monitoring results presented in Table 5-2 show that overall the levels of metals measured in the sediment in 2010 was lower than the most of the levels measured in other monitoring years.



However, it is difficult to identify contaminant trends due to high levels of variability over the four year monitoring period for most contaminants.

There have been some samples, in some monitoring years, that have shown contaminant levels to be above the ANZECC low and high trigger values. However, for most contaminants these have been isolated occurrences that do not appear to indicate any trend at the site for any particular contaminant. In addition, the results of the 2010 monitoring do not show contaminant levels in any samples to be above ANZECC low trigger values, with the exception of PAH from samples close to the outfall. PAHs have been consistently above the ANZECC low trigger value for all samples taken, throughout to monitoring rounds, at the near outfall site.

The 2010 monitoring report noted that, for all outfalls monitored harbour wide, whilst copper, lead, nickel and zinc levels were generally elevated in the sediments in previous years, overall there was a general reduction in the concentration of these contaminants in sediments at most sites monitored that year, with the exception of Wickcliffe Street. However, ANZECC low trigger values were still found to be exceeded by lead, zinc and PAHs at the majority of the sites. This appears to be somewhat true of the Orari outfall in that the concentration of contaminants in these sediments has reduced in the 2010 results compared with previous results. However, only PAHs are above the ANZECC low trigger values. Studies done near the South Dunedin outfall (Ryder, 2005b) indicated that high PAH levels in harbour sediments adjacent to Portsmouth Drive were as a result of direct discharge from the highly trafficked road. It is also likely that contamination from the city gasworks (also likely to be PAH contamination) is present in this area.

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		Orari Street Catchment Outfall					Comment
			< 20 m				> 20 m	
	Low	High	2007	2008	2009	2010	2010	
Arsenic (As)	20	70	18.6	4.3	20.0	5.0	3.1	All samples at or below ANZECC low trigger value.
Cadmium (Cd)	1.5	10	63	0.1	0.9	0.2	0.096	One isolated exceedence of high trigger value, all other results below low trigger.
Chromium (Cr)	80	370	0.3	16.0	37.0	16.3	11.7	All samples at or below ANZECC low trigger value.
Copper (Cu)	65	270	25	13	61	11	6.1	All samples at or below ANZECC low trigger value.
Nickel (Ni)	21	52	23.6	8.1	16.0	8.0	5.1	One isolated exceedence of low trigger value, all other results below low trigger.
Lead (Pb)	50	220	12.8	39	120	35	13.5	One isolated exceedence of low trigger value, all other results below low trigger.
Zinc (Zn)	200	410	68	130	680	157	73	One isolated exceedence of high trigger value, all other results below low trigger.
PAHs	4	45	10.2	12.6	28.3	9.3	0.730	All samples near outfall exceed low trigger value.
Enterococci*	-	-	< 2	8	23	< 3	24	Very low concentrations.
Faecal coliforms*	-	-	23000	4	33	33	17	Very low concentrations except 2007 result.

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

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

KEY:



Exceeds Low ANZECC Trigger Value

Exceeds High ANZECC Trigger Value



5.2 Freshwater Receiving Environment

An assessment of the streams located within selected Dunedin stormwater catchments was completed in 2010 by Ryder Consulting (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 Orari Street catchment have been receiving stormwater from urban development (both diffuse and concentrated) since the mid 1900s; as a result, DCC's stormwater collection network has evolved around these natural flow corridors. The Orari Street catchment contains some of the more significant streams studied as part of the 3 Waters Strategy Project.

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.

Four streams with natural channels were identified as suitable for assessment in the Orari Street catchment. A total of seven sites were assessed in June 2010. The locations of the streams and assessment sites are shown in Figure 5-4.

Only one site was selected for surveying in one of the streams (Orari Street 2), with two sites (upstream and downstream) being surveyed in the other streams (Orari Street 1, 3 and 4).



Figure 5-4: Freshwater Receiving Environment

5.2.1 Habitat Characteristics

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



Table 5-3: Assessment site characteristics

Characteristic	Orari Street 1 - Upstream	Orari Street 1 Downstream	Orari Street 2	Orari Street 3 - Upstream	Orari Street 3 – Downstream	Orari Street 4 - Upstream	Orari Street 4 – Downstream
Length	100 m	40 m	80 m	30 m	40 m	50 m	80 m
Channel width	1-3 m	1.0 - 2.0 m	1.0 m	1.0 m	1.0 m	1 – 2 m	2 – 4 m
Channel depth	1-30 cm	2 - 30 cm	5 - 40 cm	1 - 20 cm	2 – 30 cm	2 - 20 cm	5 - 40 cm
Bank height	0.5 - 1.0 m	0.5 - 1.0 m	1.0 m	0.5 m	0.5 - 1.0 m	0.5 - 2.0 m	0.5 - 1.5 m
Bank stability	Moderate	Moderate	Moderate, some reinforcing	Moderate	Moderate	High with artificial banks	Moderately high
Wetted width	0.2 - 1.0 m	0.5 m	0.5 m	0.5 m	0.5 m	0.5 - 1.0 m	0.5 - 1.0 m
Dominant riparian vegetation	Residential gardens, with some taller trees.	Grassed lawns, forest canopy and ivy.	Trees, blackberry, ivy, weed species.	Canopy of trees, groundcover of climbers.	Large trees, broadleaf, climbers and blackberry.	Gardens, grass, pine, ivy.	Forest, blackberry, weeds, pasture grass.
In-stream features	Runs with shallow riffles and some deeper pools.	Runs, shallow, fast flowing riffles and some deeper pools.	Shallow riffles, with runs and pools.	Shallow riffles, with runs and pools.	Runs with some riffles and pools.	Shallow riffles and drops, some runs and pools.	Shallow riffles and runs, with pools.
Bed substrate	Fine sediments and gravels.	Gravels and cobbles, with some sections of clay-like substrate.	Clay-like bedrock substrate, with some sediments, gravels and cobbles.	Cobbles with some clay-like substrate and gravels.	Clay-like substrate and cobbles with some fine sediment.	Cobbles, boulders and some bedrock and concrete.	Cobbles with boulders and bedrock.
Other	Woody debris - sparse. Leaves - common.	Woody debris and leaves – common. Some moss.	Some woody debris and moss. Leaves – common.	Woody debris and leaves –common. Some moss.	Woody debris, moss and leaves – common.	Moss – abundant. Leaves – common.	Moss and leaves – abundant. Woody debris – sparse.



Orari Street 1 Upstream

The upper reaches of this stream flow from stormwater pipes into a natural channel, before re-entering pipes under the playing fields of the primary school. The assessment site is located in the open section downstream of the stormwater pipe outlet. Land use in the catchment is predominately urban residential.

The stream is contained within a gully with no public access and is not generally visible from adjacent roads so no amenity values were identified. Refer Figure 5-5.

Orari Street 1 Downstream

The lower reaches of this stream flow from stormwater pipes under the playing fields of a primary school into a deeply incised and narrow natural channel behind residential properties before flowing back into stormwater pipes. Land use in the catchment is mainly urban residential.

Amenity values are limited because the stream channel is behind private property and there is overhanging vegetation. Refer Figure 5-5.



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



Orari Street 2

This stream flows in a natural channel behind the residential properties and DCC land on Caversham Valley Road before entering stormwater pipes. The assessment site was located next to the Caversham Valley Forest Reserve. Land use in the catchment is zoned as residential, but dominated by farmland in the upper reaches, with urban and reserve land near the assessment site.

Amenity values of the stream are limited to views from public areas, which are restricted to short sections of public road. Refer Figure 5-6.



Figure 5-6: Orari Street 2 Stream – (a) Assessment Site; and (b) Entrance to Stormwater Pipes



Orari Street 3 Upstream

The upstream reaches of this stream flow from stormwater pipes into a natural channel between Forfar Street and Oakland Street. A public walkway crosses the stream at the downstream end of the assessment site (refer Figure 5-7). The stream is culverted at this point. Land use in the catchment is predominately urban residential.

Amenity values are likely restricted to views from the walkway, as access to other areas is limited.

Orari Street 3 Downstream

The middle reaches of this stream have a steep gradient, which flattens when the stream flows from dense forest into open DCC reserve land. See Figure 5-7. Land use is dominated by urban residential and the reserve. Given that access to the stream is limited (apart from in the reserve), amenity values will also be limited.



Figure 5-7: Orari Street 3 Stream Assessment Sites – (a) Upstream; (b) Downstream; and (c) Entrance to Stormwater Pipes near Downstream Site



Orari Street 4 Upstream

The upper reaches of this stream are in a highly modified channel behind residential properties on Glen Road and Dalry Street. Drainage pipes from residential properties enter the channel throughout the assessment site (Figure 5-8). Land use is predominantly urban residential.

Amenity values are likely to be restricted to views from the public road.

Orari Street 4 Downstream

The middle and lower reaches of this stream flow in a natural channel behind residential properties on Glen Road and Patrick Street (see Figure 5-8). Land use is mainly urban residential. Amenity is limited because the stream is located in a gully behind residential properties.



Figure 5-8: Orari Street 4 Stream Assessment Sites – (a) Upstream; (b) Entrance to Stormwater Pipes near Upstream Site; and (c) Downstream



5.2.2 Water Quality

The pH level in the streams at all seven 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.

Dissolved oxygen levels were low at the three upstream sites (Orari Street 1, 3 and 4 upstream), but were especially low at Orari Street 1 upstream (at 74.3 %) which was below the minimum standard of 80 % (which is used to protect trout in lowland river environments). 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.

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

- **Aquatic Plants:** Macrophytes were present in small areas at the upstream site of Orari Street 1. Low levels of algal cover were seen with generally only thin algal mats or films present on larger substrate surfaces. Small patches of filamentous green algae were seen at the upstream site of Orari Street 1.



- **Macroinvertebrates:** A total of 29 different taxa were observed within the Orari Street streams. The average number of taxa per sample was below the national average of 14 (as determined in a nation-wide survey by Quinn and Hickey 1990).
- **Macroinvertebrate communities** were dominated by *Potamopyrgus antipodarum* snails, oligochaete worms, amphipods and isopods. High quality scirtid beetles were also present throughout the catchment. The highest macroinvertebrate abundance was in the Orari Street 1 and 3 catchments. Orari Street 1 contained high abundance of Phreatoicid isopods at the upstream site, while the downstream sites at both Orari Street 1 and 3 contained high abundances of the threatened isopod *Austriodonta benhami*.
- **Macroinvertebrate community health index scores** were generally low throughout the catchment. They were indicative of a 'poor' quality habitat (using narrative terminology of Stark and Maxted 2004) at Orari Street 1 upstream and Orari Street 4 upstream and downstream sites. Community health scores at Orari Street 2 and both Orari Street 3 sites were indicative of 'fair' quality habitat. Orari Street 1 downstream was the highest in the catchment and was indicative of 'good' quality habitat.
- **Fish:** No fish were caught or observed in the Orari Street 1 and 4 catchments. A single kokopu was found at Orari Street 2, and multiple healthy kokopu were found at the downstream site of Orari Street 3. The presence of adults and juveniles indicates that the population is self sustaining.

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.

Habitat and ecosystem quality was generally good throughout the catchment. However, Orari Street 1 upstream and Orari Street 4 upstream were of particularly poor quality with 'poor' abundance of invertebrates and fish, as well as 'poor' riparian vegetation and in-stream cover. The habitat and ecosystem of the Orari Street 3 upstream site was of particularly good quality, with most stream features of 'good' quality, a 'good' abundance of invertebrates, and an 'excellent' abundance of fish.

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

Whilst the stream quality is not good when compared to a pristine, wilderness environment, the quality of streams in the Orari Street catchment vary, but are in general as to be expected for modified urban streams. The presence of features of interest in the Orari Street 3 upstream stream indicates a good quality for a modified urban stream.

Orari Street 1 upstream site appears to be in particularly poor condition, however the quality of the stream environment improves downstream. Orari Street 4 site is also in poor condition, particularly the upstream site. Only Orari Street 3 upstream site had 'excellent' fish habitat, however given the highly modified nature of the stream environment, and the number of fish barriers in the system, it is not surprising that the remainder of the streams provide a poor fish habitat. With the exception of Orari Street 1 upstream, water quality in the streams was consistently 'good', indicating that stormwater quality is not producing a highly degraded aquatic environment.



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

Feature	Orari Street 1		Orari Street 2	Orari Street 3		Orari Street 4	
	Upstream	Downstream		Upstream	Downstream	Upstream	Downstream
Riparian vegetation	Poor	Good	Good	Good	Good	Poor	Good
Bank stability	Good	Good	Good	Good	Good	Excellent	Good
Flow variability	Good	Good	Good	Good	Good	Good	Excellent
Bed substrate	Poor	Good	Good	Poor	Poor	Good	Excellent
In-stream cover	Poor	Good	Poor	Good	Good	Poor	Good
Water quality	Poor	Good	Good	Good	Good	Good	Good
Invertebrates	Poor	Excellent	Good	Good	Excellent	Poor	Poor
Fish	Poor	Poor	Good	Excellent	Poor	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 Orari Street catchment based on the information available.

6.1 Stormwater Quality Monitoring

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

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

Monitoring of the stormwater quality at the outfall has been carried out by Ryder Consulting Ltd. Several rounds of monitoring have been completed to date; 2007, 2008, 2009 and 2010. A 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 Orari Street catchment outfall, which is undertaken via a grab-sampling technique, providing a 'snapshot' of stormwater quality during a storm event.

Table 6-2 shows the results of the time proportional sampling in Dunedin. 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, however many contaminants have been below detectable levels in at least two of the four samples.

The results of the 2010 monitoring indicate, in general, slightly higher levels of contaminants than the previous year (although with the exception of TSS and zinc, values still appear low when compared to other sites sampled in Dunedin and elsewhere). Across the four sampling years however, the results do not clearly show any trends and therefore it is difficult to determine any deterioration or improvement in the quality of the stormwater being discharged from this catchment.

E.coli and faecal coliforms have fluctuated over the four monitoring years. However, all results are within the typical range for urban stormwater for faecal coliforms (1,000 – 21,000 MPN/100 ml) (Metcalf & Eddy, 1991). The presence of FWAs within the stormwater can be an indication of human waste contamination within the stormwater, but FWA concentrations are not particularly high. This indicates that the fluctuations in E.coli are not likely to be related to wastewater inputs. FWAs may also be present in low concentrations from other activities such as vehicle washing.

Zinc and copper appear to be within or below the range typically observed from this type of catchment when compared with stormwater data from the variety of sources listed in Table 6-3.

Lead concentrations in the stormwater remain very low when compared with stormwater data from other catchments in Table 6-3.



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

Year	Contaminant												
	pH	As	Cd	Cr	Cu	Ni	Pb	Zn	TSS	Oil and Grease	FWA	E.Coli	Faecal Coliforms
		g/m ³									µg/l	MPN/100ml	cfu/100ml
2007	7.8	BDL	BDL	BDL	BDL	BDL	BDL	BDL	28	BDL	BDL	50	80
2008	7.4	BDL	BDL	0.0032	0.014	0.0033	0.023	0.22	77	11	0.005	6000	7000
2009	8.1	0.032	BDL	BDL	BDL	BDL	BDL	0.031	16	BDL	0.11	210	210
2010	7.1	0.00149	0.000164	0.00183	0.0096	0.00108	0.00015	0.3	130	BDL	0.052	1700	3500

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 Orari Street Catchment Stormwater Quality with Other Stormwater Quality Data

Contaminant (g/m ³)	Time Proportional Dunedin	Christchurch Recommended Provisional Mean Values ¹	Pacific Steel, Auckland ²	Brookhaven Subdivision ³	Australian Stormwater Mean ⁴	Urban Highway, USA ⁵	New Zealand Data Range ²	Orari Street 2010
	Residential / Industrial	Christchurch	Industrial	Residential	Australian sites	Highway	Urban	Residential
TSS	8 - 330	33 - 200	124	5 - 49	164	142	-	130
Zinc	0.05 - 2.50	0.40	2.80	0.003 - 0.260	0.910	0.329	0.09 - 0.80	0.3
Copper	BDL - 0.23	0.05	0.08	0.002 - 0.031	0.08	0.054	0.015 - 0.110	0.0096
Lead	BDL - 0.087	0.075	0.23	0.003 - 0.007	0.25	0.4	0.06 - 0.19	0.00015

BDL = below detection limit

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



7 Stormwater Quantity

7.1 Introduction

A linked 1 and 2-dimensional hydrological and hydraulic model of the Orari Street catchment and stormwater network was developed to replicate the stormwater system performance, and to predict flood extents during a number of different scenarios. Two modelling reports were produced for DCC; the '*Orari Street Model Build Report*' (URS, 2011a), and the '*Orari Street Catchment Hydraulic Performance Report*' (Opus, 2011), and the information presented in this Section is sourced from these reports. Figure 7-1 provides a diagram of the model extent.

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

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

The model relied in the most part on DCC GIS and Hansen (asset 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 estimated based on the calibrated model built for the pilot catchment, South Dunedin, and adjusted during calibration.

A single flow monitor was installed in the catchment, just downstream of The Glen Intake. Unfortunately, due to flow conditions at the site, flow data from this monitor was unreliable, and the model was unable to be calibrated using this information. The model was validated, however, as it provides a good correlation between predicted and anecdotal flooding for the February 2005 rainfall event, an event which caused significant flooding in some parts of the catchment.

Confidence in the model output is considered to be low due to the inability to achieve calibration, however the model has been 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. A recommendation has been made to undertake additional flow monitoring in the catchment in order to calibrate the model in the future.

7.2 Model Results

Fourteen scenarios representing different land use, rainfall, climate change and tide combinations have been modelled. Table 7-1 and 7-2 provides 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: Orari Street Model Results – Current Land Use

Hydraulic Performance Measure	ARI	Current Land Use
Percentage of manholes predicted to overflow	1 in 2 ¹ yr	6.7
	1 in 5 yr	17.5
	1 in 10 yr	30.3
Number of land parcels with flood depth potentially ≥ 300 mm ²	1 in 2 ¹ yr	10
	1 in 5 yr	26
	1 in 10 yr	50
	1 in 50 yr	85
	1 in 100 yr	98
Estimated flood extent (% of catchment area with flood depth ≥ 50 mm) ³	1 in 2 ¹ yr	0.1
	1 in 5 yr	0.2
	1 in 10 yr	0.8
	1 in 50 yr	2.0
	1 in 100 yr	2.5
Modelled percentage (by number) of pipes surcharging	1 in 2 ¹ yr	40.8
	1 in 5 yr	56.8
	1 in 10 yr	70.0
Percentage of manholes predicted to be close to overflowing (free water level within 300 mm of cover)	1 in 2 ¹ yr	3.9
	1 in 5 yr	6.3
	1 in 10 yr	6.3

¹ 1 in 2.33 year event (mean annual flood)

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

³ Includes areas flooded outside the catchment boundary



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

Hydraulic Performance Measure	ARI	Planning Scenario				
		2031			2060	
		Growth Only	Mean Climate Change	Extreme Climate Change	Mean Climate Change	Extreme Climate Change
Percentage of manholes predicted to overflow	1 in 10 yr	31.0	33.0	35.8	36.0	39.7
Number of land parcels with flood depth potentially ≥ 300 mm ¹	1 in 10 yr	52	58	64	63	73
	1 in 50 yr		97		99	
	1 in 100 yr					130
Estimated Flood Extent (% of catchment area with flood depth ≥ 50 mm) ²	1 in 10 yr	0.9	1.0	1.2	1.2	1.7
	1 in 50 yr		2.4		2.6	
	1 in 100 yr					3.9
Modelled percentage (by number) of pipes surcharging	1 in 10 yr	72.3	75.9	76.5	76.5	78.0
Percentage of manholes with free water level within 300 mm of cover	1 in 10 yr	6.1	7.1	7.3	7.7	7.3

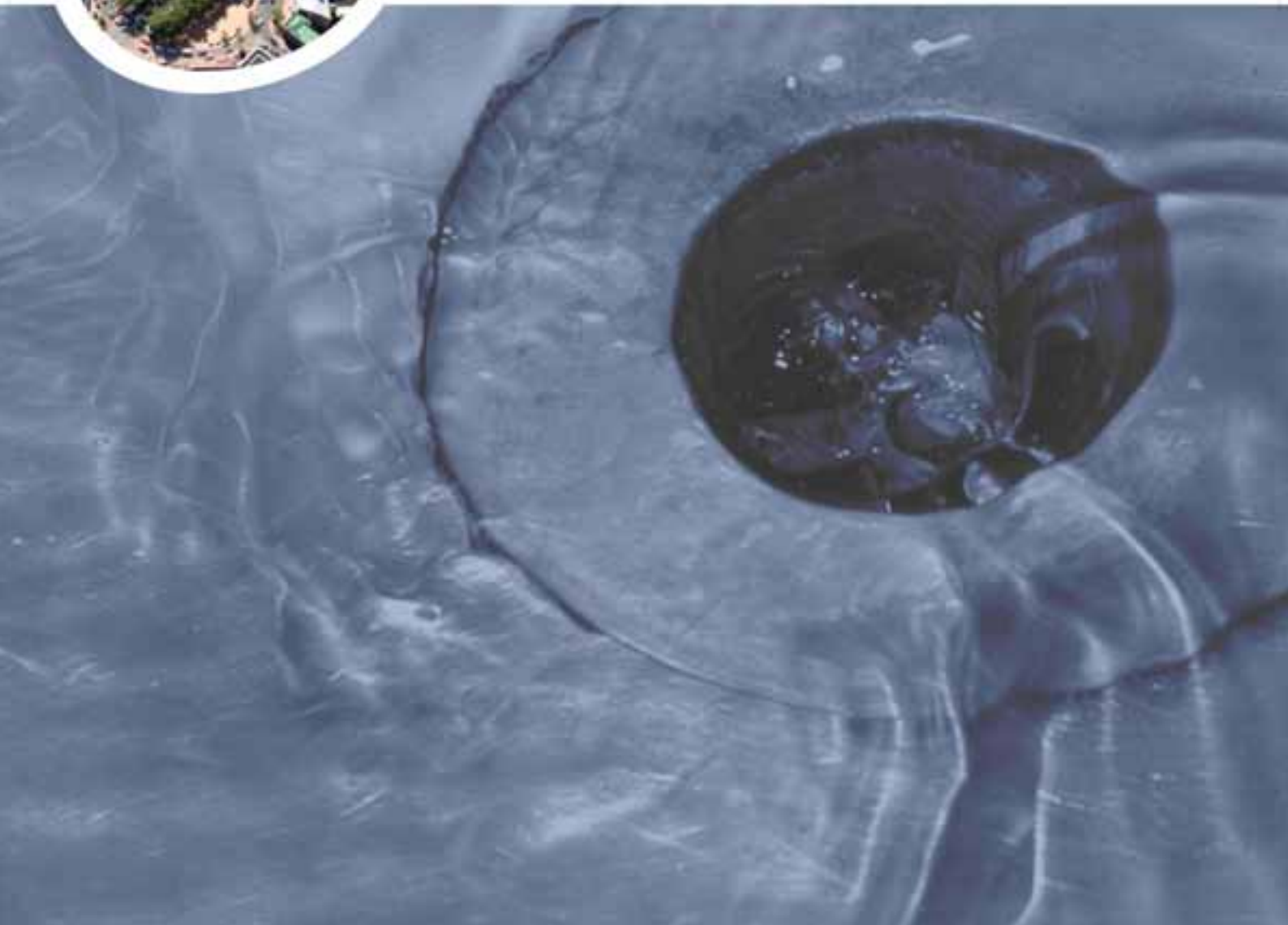
¹ On all or part of a land parcel, or against a building void in the 2-D surface

² Includes areas flooded outside the catchment boundary



Part 3

Analysis





8 Assessment of Environmental Effects

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

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

8.1 Stormwater Quantity

8.1.1 Benefits of the Stormwater Network

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

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

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

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

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



8.1.2 Stormwater Quantity Effects

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

Each planning scenario modelled used a range of assumptions which are outlined in Section 7. The Orari Street stormwater model failed to calibrate according to the specified criteria and it is suspected that the presence of supercritical flow and / or a hydraulic jump at or near the flow monitor location contributed to erroneous data measurements or flow conditions that the InfoWorks model was unable to replicate.

Consequently the level of confidence in the model, which contains a high percentage of interpolated or assumed data, is low. A relatively good correlation between anecdotal and predicted flooding during an historic event, however, provides validation of the model and a reasonable sense of confidence in the outputs, suitable for broad assessment and planning purposes.

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

Because of the 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 DCC Network Management and Maintenance staff. Unconfirmed model outputs of significance can be used to focus future modelling and investigation work in the catchment. DCC staff have been able to confirm moderate to significant flooding under the Caversham Bypass Motorway bridge at South Road and at the intersection of South Road and Laing Street. Flooding in South Dunedin near the boundary of the Orari Street catchment is also a known issue.

Flooding and system performance predicted by the model, however, could only be partly validated through actual reported historical higher level events, i.e. 1 in 10 yr ARI upwards. Actual flood depth information for those events was not recorded.

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 indicates that approximately 70 % of the modelled network in the Orari Street stormwater catchment can accommodate flows from a 1 in 10 yr ARI rainfall event; although these pipes may be surcharged, manhole overflow is not predicted.

Many of the small diameter pipes in the upper reaches of the network, however, can only convey small rainfall events, e.g. a 1 in 2 yr ARI rainfall event. This can result in manhole overflow, and overland flow down the steep upper catchment. Figure 8-1 shows pipe and manhole surcharging in the northern part of the catchment; the area most affected by this issue.

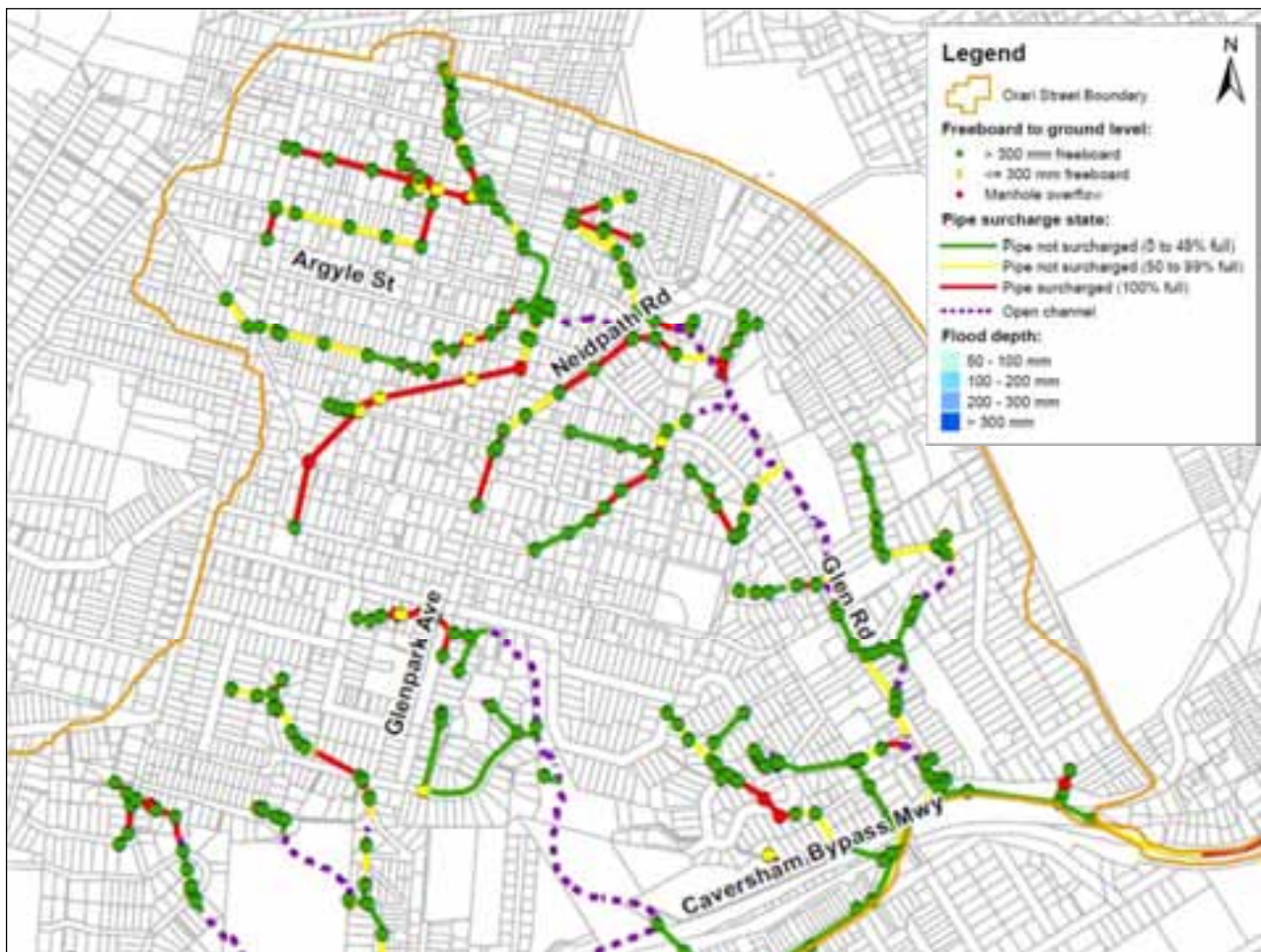


Figure 8-1: 2010 1 in 2 yr ARI Rainfall Event (Model Results)

The capacity of several key intake structures and conveyance channels in the catchment may be limited, causing restrictions during extreme rainfall events, resulting in flows overtopping the structures.

During the 1 in 10 yr ARI synthetic rainfall event, many of the manholes along the main pipeline from the outfall up to the Glen Intake are predicted to “surcharge”. In some locations the hydraulic grade line exceeds ground level during that event, however, the pipe is designed to flow under pressure in order to increase capacity as all associated manholes are sealed, and should not overflow.

Despite a reasonably good level of service catchment-wide, overflow from a small number of manholes appears to be ponding in specific areas; flood depths exceeding 300 mm are predicted on 50 properties during the 1 in 10 yr ARI rainfall event, and 10 properties during a 1 in 2 yr ARI rainfall event. Predicted surface water flooding (to a depth greater than 50 mm), during the 1 in 100 yr ARI rainfall event, affects 2.5 % of the catchment area. Deep flooding is discussed below in Section 8.1.4.2. It should be noted, however, that a number of properties with flooding on part of their land parcel contain a watercourse, and in reality, flooding only extends a small distance from the channel, which is often in a gully at the base of the property. This applies in particular to a number of properties on Glen Road. Similarly, predicted flooding adjacent to the Caversham Bypass Motorway affects a number of land parcels which are open space.



Analysis of tidal influence on the system indicates that during a 1 in 10 yr ARI rainfall event, a MHWS tide has an influence on the network capacity up to the Glen Intake and as far as Law Street on South Road. A pump station originally installed to pump stormwater from the outfall during high tides has been decommissioned.

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.

Orari Street Catchment Outfall

The flap gates modelled at the Orari Street catchment outfall operated as expected during the design rainfall events with respect to tidal influence and the operation of the outfall main under pressure. When a flap gate is installed, while tidal ingress is prevented, the pressure required to lift the flap valve and discharge stormwater during a storm events creates an influence upstream, particularly when the stormwater line leading to the outfall is relatively flat, as is the case in the Orari Street catchment.

Sediment Wall in Trunk Line

The sediment wall modelled in the trunk line just downstream of Andersons Bay Road performed as expected during the design rainfall events. The pipe is surcharged during all events, and as such, the only noticeable effect from the wall is a large increase in the hydraulic grade line at this location. This does not result in overflow here or upstream, however, as the system is sealed some distance upstream.

Bifurcation at Andersons Bay Road

The main Orari Street catchment pipeline splits into four to run beneath Andersons Bay Road. The model predicts minimal losses at the bifurcation during all events and the splitting of flows is approximately equal across all pipes.

The Glen Intake

The model indicates that the Glen Intake possesses capacity to manage the 1 in 10 yr ARI rainfall event, with and without climate change effects. Overtopping does not occur until a 1 in 50 yr ARI rainfall event, under current scenarios modelled.

The level of service of the intake reduces during the 1 in 10 yr ARI event with extreme climate change in the 2060 scenario, although not significantly. These results imply that the intake, as modelled, is designed to accommodate approximately a 1 in 50 yr ARI event (current and future scenarios).

Intake at 91 Glen Road

The intake at 91 Glen Road overflows during all of the 1 in 50 yr ARI and 1 in 100 yr ARI events modelled, and to a lesser degree during the 1 in 10 yr ARI events. Figure 8-2 illustrates the screen both (i) free of debris; and (ii) approximately half blocked by leaves and litter.

The modelled events did not include simulated blockage of the screen which would further exacerbate overflows. A sensitivity analysis on the partial blockage of this structure was therefore conducted. Results indicate a significant increase in the depth of flooding at the intake when



blocked, while the extent of flooding on site increases only slightly. The volume of overflow is significant, however, resulting in an increase in the depth and velocity of surface flows down Glen Road.



Figure 8-2: Intake at 91 Glen Road

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 MHSW 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, community complaints, and observations made on the catchment walkovers. As discussed above, this evidence has been strongly relied upon in the Orari Street catchment to validate flooding predictions by the uncalibrated hydraulic model. In a number of instances, predicted flooding has been unconfirmed by anecdotal evidence; in the instances where predicted flooding is significant, further investigation, monitoring and modelling may be required prior to developing solutions.

The flood hazard maps cannot be fully relied on to depict secondary flow paths and flooding extent due to possible inaccuracies within the data set used to develop the ground model. 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.

The Glen Valley is one of the first locations to show surface flooding during low frequency events, which is mainly caused by intake structure overflows and undersized pipes in the upper reaches of the sub-catchment.

Overflows in the southeast of the catchment (in the Corstorphine / Caversham area) are predicted to cross over into the South Dunedin catchment during large rainfall events. While flooding in the South Dunedin catchment is a common occurrence, DCC Network Management and Maintenance staff are unaware of flooding issues in the Corstorphine / Playfair Street area of the Orari Street catchment. Flooded land parcel calculations discussed below include areas outside of the Orari Street catchment.



A number of areas have been assigned 'significant' or 'extreme' flood hazard ratings, relating to the depth or velocity of flood water estimated at that location.

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.

Table 8-1 presents the most significant locations affected in the Orari Street stormwater catchment during events up to a 1 in 10 yr ARI rainfall event; the identification of these locations is based on model outputs combined with confirmation from customer complaints and / or DCC Network Management and Maintenance staff. Figure 8-3 below shows the surcharging manholes contributing to nuisance flooding (and subsequently deep flooding) beneath the Caversham Bypass Motorway bridge.

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

Location	Description	Predicted Cause	Minimum Rainfall Event (ARI yr)
South Road	Low to moderate flooding across South Road at the base of Glen Road, and beneath the Caversham Bypass Motorway bridge.	Inadequate capacity and bottleneck in local network resulting in overflows and hence overland flow from Forfar Street, Bridge Street and Leckhampton Court.	1 in 5
South Road commercial area	Low to moderate flooding between Barnes Drive over-bridge and Laing Street. Escalates to overland flow entering South Dunedin catchment.	Under-sized local network resulting in overflow from manhole on South Road near Laing Street.	1 in 5
Caversham Bypass Motorway	Low to moderate flooding on Barnes Drive affecting the northern lanes of the motorway for approximately 300 m, east of the Barnes Drive intersection.	Hydraulic bottleneck on Barnes Drive resulting in manhole overflow and overland flow towards motorway.	1 in 5



Figure 8-3: Surcharging Pipes and Manholes on Forfar Street, Bridge Street, and Leckhampton Court, 1 in 5 yr ARI Rainfall Event

Additionally, the model predicts that a number of areas may experience nuisance flooding in small events (and consequently more severe flooding in larger events), as described in Table 8-2 below. The most significant flooding (in terms of depth and area affected) identified by the model but not confirmed anecdotally, is flooding from the Corstorphine area. This flooding is predicted to enter the South Dunedin catchment, and may contribute to reported flooding in the west of this catchment.



Table 8-2: Modelled Flood Areas (Unconfirmed)

Area	Location	Predicted flooding
The Glen Valley	Durham and Lawrence Street	Low to moderate flooding along most of stormwater branch from bottom of Durham Street to main Glen Valley watercourse at 26 Dalry Street.
	Maryhill Terrace to Glenpark Avenue	Low to moderate flooding from 17 Maryhill Terrace along Springhill Park to Glenpark Avenue.
	Neidpath Road	Moderate to significant flooding from 104 Glenpark Avenue along 80 and 106 Neidpath Road.
	Ventnor Street and Argyle Street	Low to moderate flooding near the vicinity of 43 - 46 Ventnor Street and 52 Argyle Street due to overflow of manholes and undersized pipes.
	Aiken Place	Low flooding near the vicinity of 10 - 12 Aitken Place due to overflow of manholes due to undersized pipes and low gradients.
	Reynolds Street	Low to moderate flooding near the junction of Reynolds Street and Glen Road due to overflow of intake at 82 Glen.
Central: North and West of Caversham Motorway	Renfrew Street	Low to moderate flooding along Renfrew Street and Oakwood Avenue due to manholes overflowing, i.e. undersized pipes.
	Railway corridor near South Road and Caversham Place	Low to moderate flooding near 114 Caversham Valley Road, and along South Road (between Nos. 378 and 522) due to; overflows from surrounding areas, surcharging manholes and intake restrictions.
Southern: South of South Road	Corstorphine Road	Low to moderate flooding at 10 and 29 Corstorphine Road, due to transition from open to piped watercourse. Becomes deep flooding during a 1 in 50 yr rainfall event, flowing overland into the South Dunedin catchment.



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.

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

During the 1 in 50 yr ARI events modelled, up to 85 properties in the Orari Street catchment are predicted by the model to experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the 2060 land use during a 1 in 50 yr ARI event could result in 99 properties experiencing flooding on part of their parcel to depths greater than 300 mm. It should be noted, however, that it is uncertain whether this flooding is likely to enter habitable floors, as no floor level survey has been undertaken, and a number of parcels are only predicted to experience flooding on part of the parcel. For example, a number of land parcels are predicted to experience deep flooding along the watercourse route running from the top of the Glen Road sub-catchment. Many of these parcels, however, have large sloping sections with the watercourse confined to a gully at the rear of the property; flood hazard is likely to be low in these instances, and habitable floor flooding unlikely.

Flood depths exceeding 300 mm are predicted on 50 properties during the 1 in 10 yr ARI rainfall event, and 10 properties during a 1 in 2 yr ARI rainfall event.

The most significant locations, which have been confirmed by DCC Network Management and Maintenance staff, or through customer complaints, are as follows:



South Road / The Glen – Significant deep flooding is predicted across South Road, from a combination of overland flows from the Forfar Street / Leckhampton Court area, and overland flows running down Glen Road. This predicted flooding is supported by information from DCC staff, photographs, and flood complaints on South Road, Bridge Street, Forfar Street and Glen Road. Model results indicate that the Glen intake structure is able to accommodate flows up to the 1 in 50 yr ARI rainfall event. Tidal influence is restricting opportunities for ponded stormwater to enter the main stormwater pipeline to the outfall, at low points near the motorway over-bridge. Drainage back into the Glen Road intake from ponding areas occurs, but is limited due to topography. Figure 8-4 below shows the flood depths estimated during this event; the effects of high speed flows and flood depth are discussed further in Section 8.1.4.3: Flood Hazard.

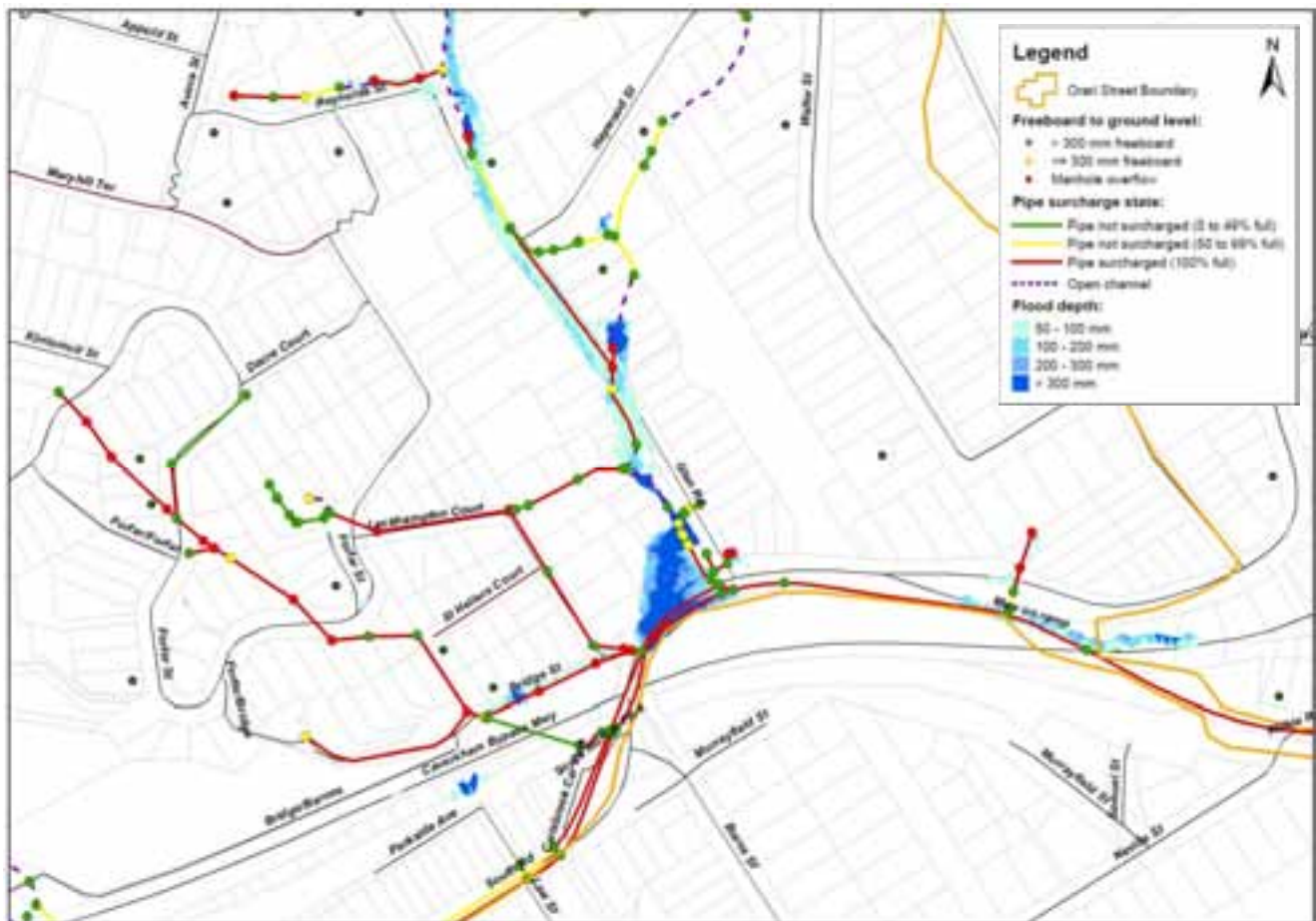


Figure 8-4: Modelled Flood Depths in South Road and Glen Road during a 1 in 50 yr ARI Rainfall Event (Current Land Use)



South Road commercial area – Flooding at some locations near the South Road / Laing Street intersection is predicted to occur due to overflows from a manhole in the centre of South Road opposite Laing Street, with predicted deep flooding in the railway corridor and on a property near the corner of South Road / Laing Street (confirmed by DCC Network Maintenance staff to flood in the past). The network at this location receives flows from both the north and the west of the catchment. Flooding in this area is predicted to get progressively worse with larger rain events, and ultimately modelled overland flow enters the South Dunedin catchment. Figure 8-5 provides a long section of the stormwater pipeline in this area, indicating the point of overflow.

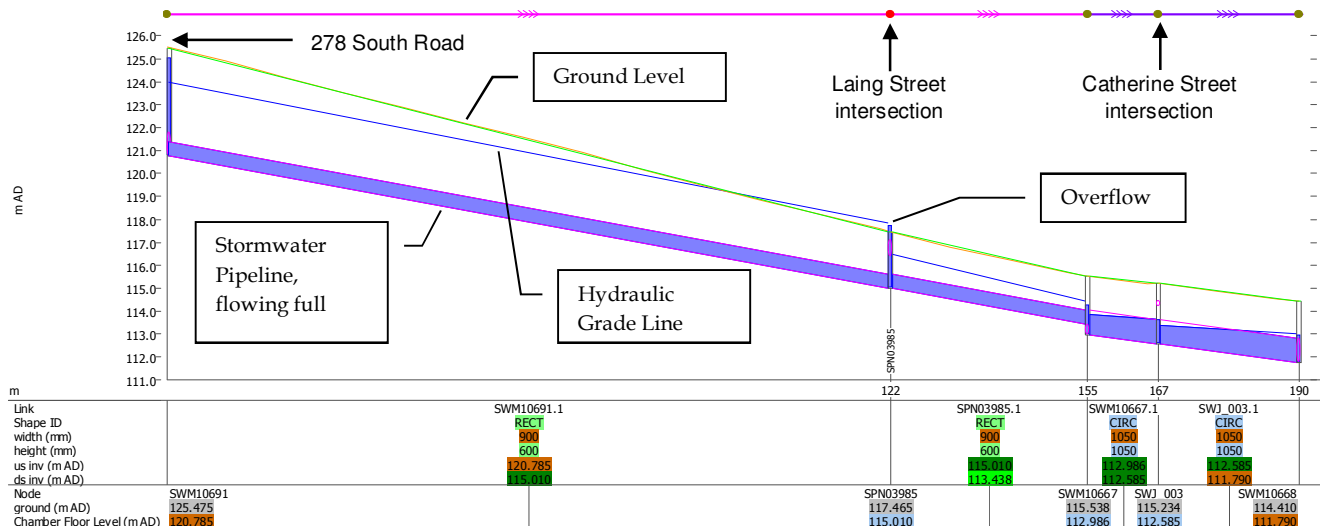


Figure 8-5: Long Section of Stormwater Pipe at South Road / Laing Street Intersection, Current 1 in 10 yr ARI Rainfall Event

Glenpark Avenue / Mitchell Avenue – the model predicts that due to an intake restriction following a short section of open channel, three properties are at risk of habitable floor flooding in this area.



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 8-3 below.

Table 8-3: 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.

As with the majority of flooding scenarios, the emergency planning modelling identifies the Glen Valley and the properties / streets to the southeast of the catchment such as Corstorphine Road, South Road and Playfair Street, as being the most at risk of deep and / or fast surface flooding, commanding hazard ratings of ‘significant’ to ‘extreme’ during the 2060, 1 in 100 yr ARI rainfall event extreme scenario. The worst predicted ponding appears to be the depression on South Road, just south of the Glen Intake. As discussed above, areas of significant or extreme flood risk through the Glen Valley are often within the watercourse gully.

Figure 8-6 below displays the current flood hazard rating in the northern part of the Orari Street catchment. The flooded area at the base of Glen Road, and on South Road is validated by photographs taken during the large storm event in February 2005 (Figure 4-14).

Figure 8-7 displays modelled flooding and flood hazard ratings during the current planning scenario in the southern part of the Orari Street catchment; while the flooding in the Corstorphine area has not been confirmed, flooding on South Road, and in South Dunedin has.

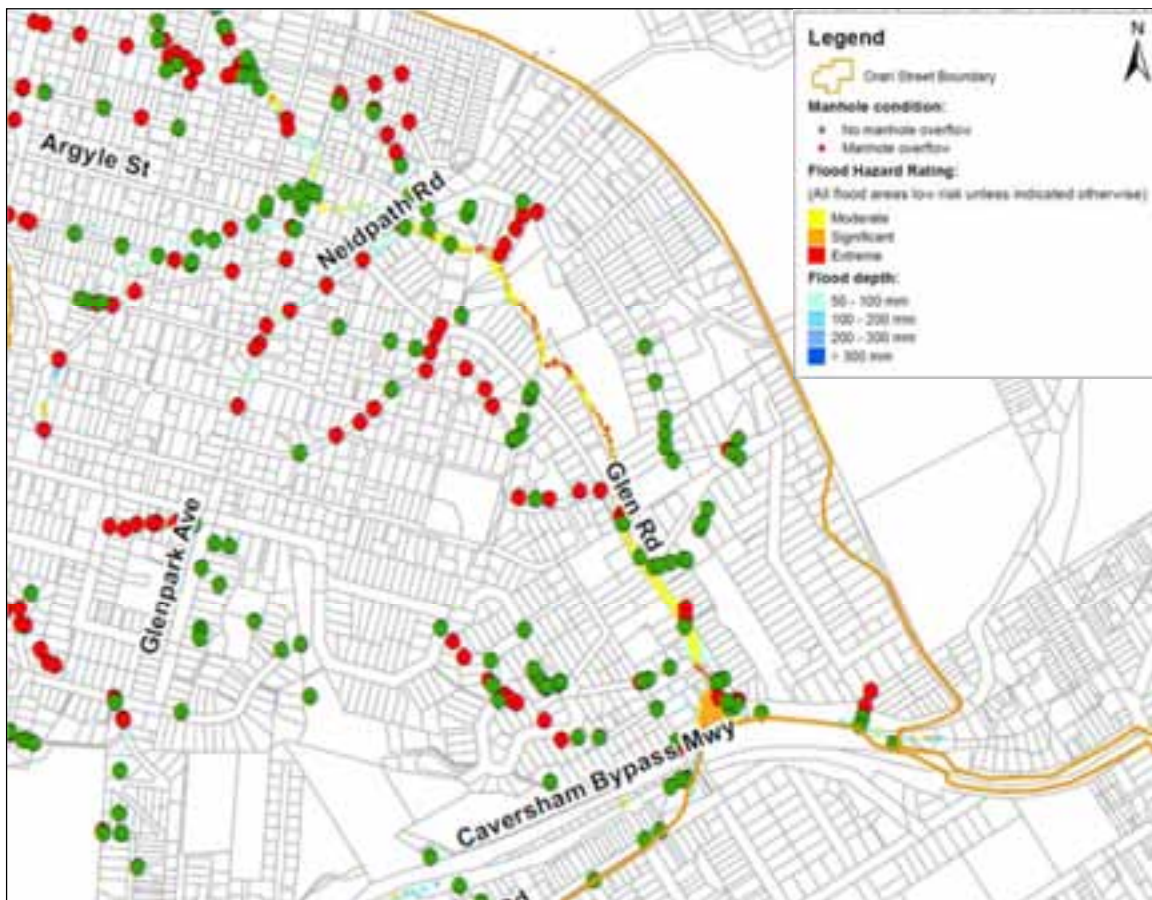


Figure 8-6: 2010 Predicted Flood Hazard in the Glen Valley, 1 in 100 yr ARI Rainfall Event

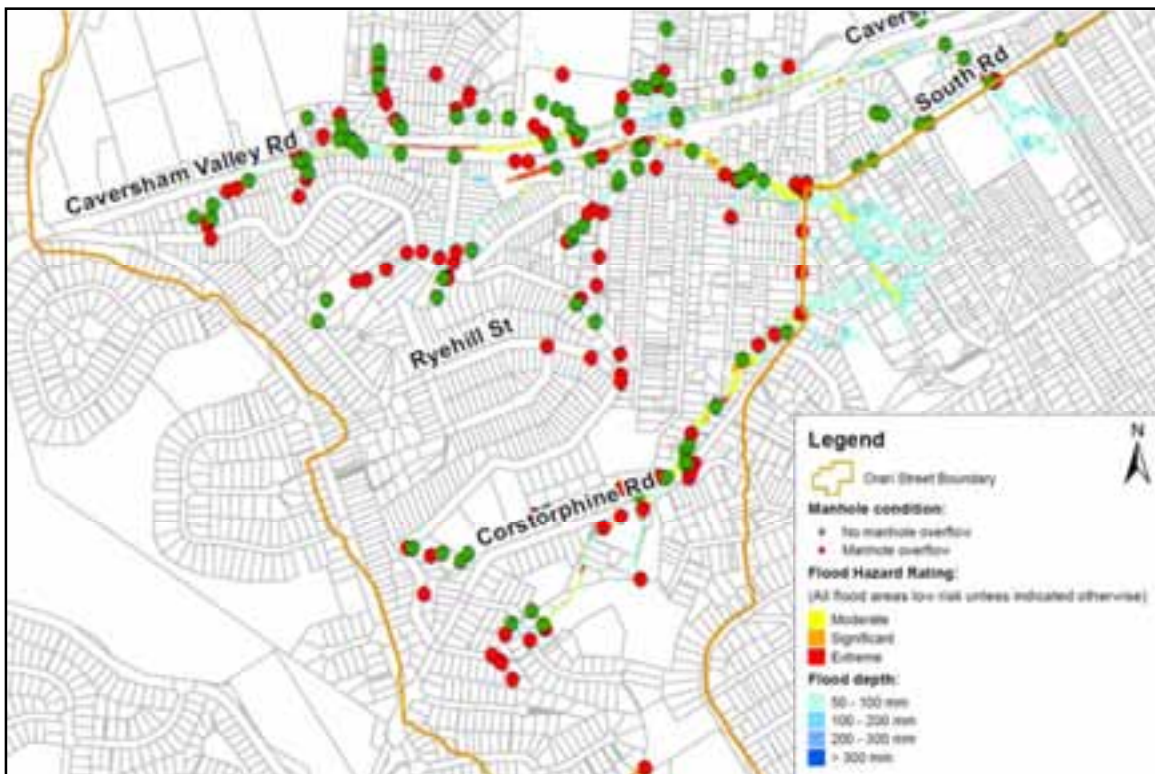


Figure 8-7: 2010 Predicted Flood Hazard in Caversham / Corstorphine, 1 in 100 yr ARI Rainfall Event



Other localised flood hazard areas also exist, particularly in the vicinity of some of the Orari Street intakes such as those on Corstorphine Road, Mitchell Avenue, Neidpath Road and Glen Road. These intakes are of concern as they are located near multiple residences and the predicted hazard ratings can be 'extreme' in spots.

8.1.5 Network Age, Operation and Maintenance

The model predictions (supported by customer complaints in the area) highlight that surface water drainage in some parts of the upper reaches of the network are undersized. Particularly, lateral pipes with a diameter of 225 mm to 300 mm are unable to cope with relatively small events of 1 in 2 and 1 in 5 yr ARI in the upper catchment of the Glen Valley area. The majority of these pipes were laid between 1901 and 1940, and the DCC pipe renewals programme provides an opportunity to inspect and potentially renew these pipes in the near future; new pipes would be designed to convey the 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 (DCC, NZTA) 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.

Intakes and culverts at Glen Road, South Road, Neidpath Road and Glenpark Avenue / Mitchell Avenue locations in particular seem to be undersized or sensitive to blockage when receiving drainage water from open channels during a 1 in 5 and 1 in 10 yr ARI events. 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.

Glen Road (≥ 350 mm flood depth) and South Road (≥ 350 mm flood depth) will most likely experience temporary road closures during events greater than a 1 in 50 yr ARI Rainfall Event. Emergency services and public transport services will have to divert to other access options. Other routes around the predicted flooding locations exist however, and flooding is not expected to last for long periods of time.



8.1.7 Summary of Effects of Stormwater Quantity

- Confidence in the Orari Street stormwater model is low, due to a failure to calibrate, and a high percentage of interpolated or assumed data. Validation was achieved via anecdotal information regarding a number of reported incidents, however, and the model is suitable for planning purposes. Confirmation of some model predictions will be required, and further survey, monitoring and modelling will be necessary prior to preliminary design.
- DCC staff have been able to confirm moderate to significant flooding under the Caversham Bypass Motorway bridge at South Road and at the cross roads of South Road and Laing Street.
- The current level of service for the network in this catchment varies across the catchment, but is approximately equivalent to a 1 in 10 yr ARI rainfall event.
- Many of the small diameter pipes in the upper reaches of the network, (particularly the Glen Valley), can only convey small rainfall events, e.g. a 1 in 2 yr ARI rainfall event. The age of these pipes indicates that they may progressively require renewal within the next 30 years.
- Nuisance flooding is predicted and confirmed in three main areas; South Road beneath the motorway over-bridge, in the South Road commercial area, and on the northern part of the Caversham Bypass Motorway. Flooding in these three main areas becomes progressively worse during larger rain events.
- Flood depths exceeding 300 mm are predicted on 10 properties during the current 1 in 2 yr ARI rainfall event, and on 50 properties during the 1 in 10 yr ARI rainfall event.
- During the 1 in 50 yr ARI events modelled, up to 85 properties experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the 2060 land use during a 1 in 50 yr ARI event could result in 99 properties experiencing flooding on part of their parcel to depths greater than 300 mm.
- 'Significant / extreme' flood hazard during large (1 in 100 yr ARI) rainfall events is predicted in a number of areas; particularly on South Road at the base of the Glen Valley due to deep water, and on Glen Road due to fast flowing water. Other pockets of flood hazard are scattered throughout the catchment.
- During large rainfall events, overland flow is predicted to enter the north-west corner of the South Dunedin catchment.
- Intakes structures and culverts on Glen Road, South Road, Glenpark Avenue and Corstorphine Avenue locations in particular seem to be undersized when receiving drainage water from open channels, some during events as small as a 1 in 5 yr ARI events. Some of these screens are particularly sensitive to blockage, and DCC staff have indicated screen performance is an issue in this catchment.



8.2 Stormwater Quality

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

- A large number of the samples taken have contained contaminant levels below detectable levels, with all metals except zinc being below detectable limits in at least two of the four samples taken.
- The levels of all contaminants in the stormwater from the outfalls in this catchment are typical of stormwater quality from similar catchments and in some cases, better.
- With the exception of zinc and TSS, all levels measured have been low throughout the monitoring period, however most contaminant levels have fluctuated over the monitoring period so it is difficult to determine any deterioration or improvement in the quality of the stormwater from this catchment.
- Sampling data does not indicate presence of a wastewater overflow in the catchment.

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

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

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

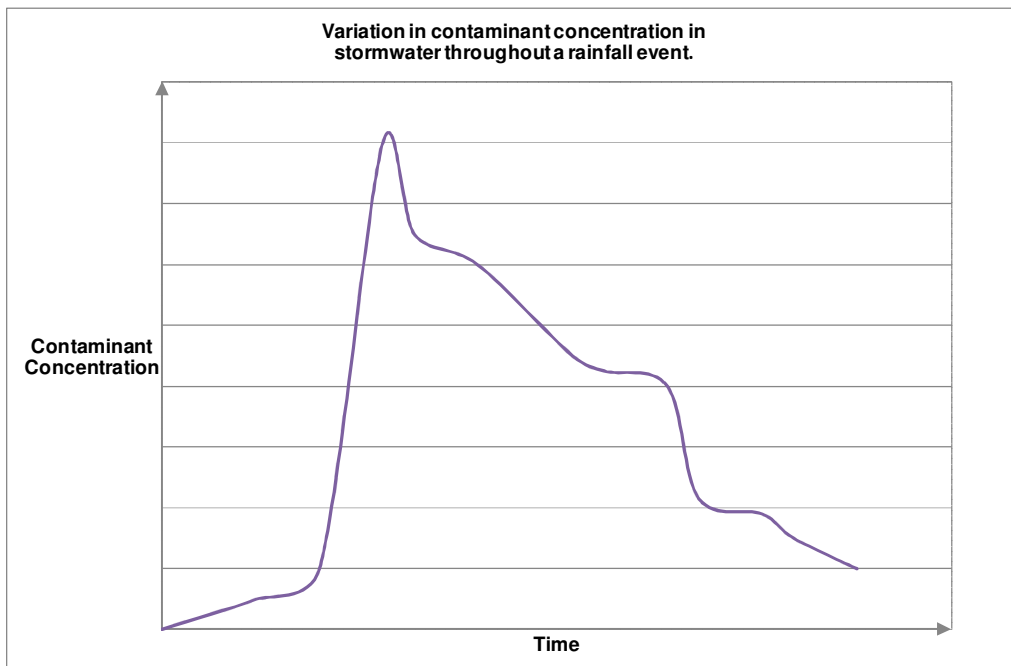


Figure 8-8: Concentration of Contaminants in Stormwater for Duration of a Rainfall Event
(Based on time-proportional sampling carried out in Dunedin)

8.2.1 Harbour Water Quality

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

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

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

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

8.2.2 Harbour Sediment Quality

Contaminants in urban stormwater entering the marine environment potentially pose a risk to the health of marine organisms, primarily through the accumulation of the contaminants in marine sediments. Contaminants in the stormwater adhere to suspended particles and sediments in the



marine environment and accumulate in the marine bed. High levels of contaminants within the sediments may result in adverse impact on marine flora and fauna which come into contact with those sediments.

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

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

8.2.2.1 Orari Street

The contaminant levels within the sediments adjacent to the Orari Street catchment outfall are discussed in detail in Section 5. To summarise, four years of sampling information has been reviewed, and the levels of contaminants in the marine sediments sampled across the monitoring years was generally low, particularly in 2010, with reductions from the 2009 sampling results for all contaminants. Apart from a few isolated exceedences, only PAH regularly exceeded the ANZECC (2000) low trigger values for the near outfall sampling site. As identified in Section 5, high PAH levels in sediments adjacent to Portsmouth Drive and the Portobello causeway could be associated with high traffic volumes on those roads, or the disused gas works in South Dunedin. Figure 8-9 below shows PAH data collected up to 300 m from the South Dunedin outfall. The Orari Street catchment outfall is approximately 900 m from the South Dunedin outfall, however traffic volumes along Portsmouth Drive near the Orari Street catchment outfall would be the same as at the locations monitored.

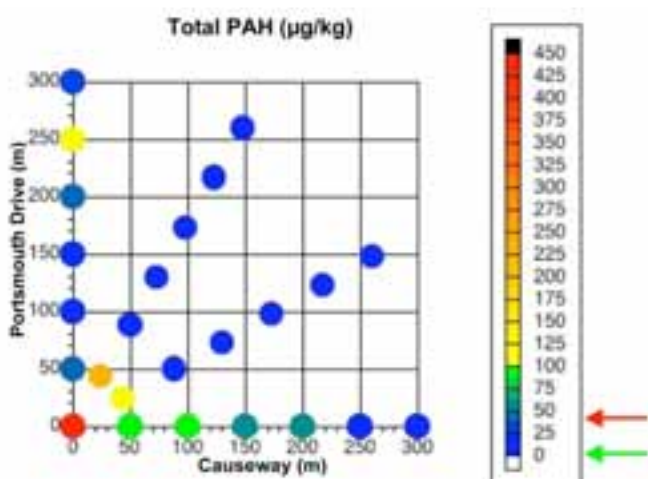


Figure 8-9: Sediment contaminant concentrations adjacent to the Portobello Road Outfall (from Ryder, 2005b)

In 2010, the levels of contaminants observed at the more distant sampling site, were less than the near outfall sampling site for all contaminants measured apart from enterococci.



The reduction in sediment contaminant levels observed in 2010 may suggest that some of the contamination measured is a result of historic sediment contamination. However, further rounds of monitoring would be required to observe any trends.

The sediment contamination adjacent to the Orari Street catchment outfall, measured in 2010, was low and the concentration of contaminants monitored in the stormwater discharging from this outfall was not significant and below levels typical for a catchment of this nature. Further to the information on PAH levels near the roadways, monitoring data at the outfall also may suggest that alternative sources are contributing to sediment contamination; monitoring results from previous years, for example, during 2007 and 2009, indicated higher concentrations of some contaminants in sediments, when contaminants in stormwater quality samples were below detectable limits.

It is possible that the current stormwater discharges from the Orari Street catchment are contributing to the contaminant levels in the sediments. It remains unclear however, in the absence of baseline data or a control site for comparison, the extent to which sediment contamination is as a result of historic land uses and activities within the catchment, or adjacent catchments, and what proportion can be attributed to current stormwater discharges. Further study is required to ascertain any temporal trends in marine sediment quality.

8.2.2.2 Harbour-Wide

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

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

Further monitoring of the sediments harbour wide is required to better understand the levels of contamination and establish whether any long term trends exist. It should be noted that the Orari Street catchment is adjacent to the head of the harbour, which is a high energy environment, with sediments likely to be regularly re-suspended by wave action.

8.2.3 Marine Ecology

The resource consent for the stormwater discharges from this catchment requires that cockles and octopus are sampled and flesh analysed for contaminants. The biological monitoring results to date do not indicate significantly high levels of contaminants within the samples and where applicable (for lead and cadmium), concentrations have been consistently below the maximum levels (MLs) as outlined in Australia New Zealand Food Standards Code (2004). The results indicate that the cockle and octopus communities at this location are not being exposed to significantly high levels of contaminants.

Historical data and the results of biological monitoring carried out harbour wide for DCC stormwater consent compliance indicate that, in general, a reasonably low diversity amongst the benthic and infaunal communities is likely to be symptomatic of a large proportion of the upper harbour basin. The general lack of diversity may be attributable to anthropogenic influences, including stormwater quality, but other factors such as freshwater inputs and exposure at low tide may also be contributing



to the ecological health observed. It is not therefore possible to clearly link ecological health with stormwater quality.

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

The contaminant levels measured in the sediments adjacent to the Orari Street catchment outfall were variable across the monitoring period. They were however, generally low. In addition, the quality of stormwater from the Orari Street catchment outfall was found to be typical for a catchment with this type of land use and no contaminant levels were found to be significantly high. This corresponds with the cockle and octopus sampling results and suggests that the stormwater is not having an adverse effect on ecological health. However, it should be noted that octopus sampled in this location are likely to have a range and will be influenced by contaminants in the harbour marine environment outside of the Orari Street catchment and the biological communities generally will also be influenced by contamination from sources other than stormwater. Therefore, whilst the ecological health at this location was not found to be poor, it is difficult to draw any parallels between the ecology and the contaminants.

The biological monitoring results to date, harbour-wide, show that, whilst not pristine, the upper harbour and the communities associated with the intertidal areas adjacent to the major stormwater outfalls (including the Orari Street catchment outfall) appear not to be undergoing any significant further degradation as a result of the stormwater inputs during the monitoring period (2007-2010).

8.2.4 Freshwater Habitat Quality

There are four streams in the Orari Street catchment. The stream habitat health, assessed in 2010, varied depending on the stream and sampling location.

Habitat and ecosystem quality was generally good throughout the catchment. However, Orari Street 1 upstream and Orari Street 4 upstream were of particularly poor quality with 'poor' abundance of invertebrates and fish, as well as 'poor' riparian vegetation and in-stream cover. The habitat and ecosystem of the Orari Street 3 upstream site was of particularly good quality, with several stream features of 'good' quality and good ecology. Water quality was also found to be good throughout the sampling sites with the exception of the Orari Street 1 upstream site.

The streams are located within an urban residential area. They run through a mixture of private land, school grounds, road reserve and DCC reserve land and alternate between modified natural channel and stormwater pipes. Most of the catchment is developed, so water entering the stream will consist of runoff from hardstand areas (such as roads and driveways where contaminants such as heavy metals accumulate), lawns and gardens. A spring is thought to exist in the upper reaches of the Glen Valley, near Haig Street (DCC Network Maintenance staff comment).

Surrounding land use significantly affects the quality of a stream. Investigations by Auckland Regional Council (ARC) found that the quality of urban streams is related to the density of urban development and that in the Auckland region urban stream quality was consistently poor in streams with a contributing catchment imperviousness of greater than 25 %. (ARC, 2004). Although Dunedin has many different environmental characteristics relating to urban streams, the relationship between imperviousness and stream quality may still apply. The contributing sub-catchments to the streams assessed in the Orari Street catchment are typically lower density urban residential, and have an imperviousness of approximately 40 %, but typically ranging between 20 % and 40 %. This suggests



that the quality of the streams assessed in the Orari Street catchment are as to be expected, or in the case of the Orari Street 2 and 3 streams in particular, reflects the lower imperviousness, with the streams being of relatively good quality for an urban stream.

The sampling sites at Orari Street 1 upstream, and Orari Street 4 (upstream and downstream) are of a lower quality and are either highly modified, sourced solely from stormwater, or flow through residential properties. The poor quality observed may be due to stormwater input, although water quality was only found to be poor at the Orari Street 1 upstream site. It is therefore likely, particularly in the case of the Orari Street 4 stream, that the management of the channels is contributing to the poor quality of the streams. Inappropriate management of the private reaches of the channel, such as the removal of riparian vegetation, modifications to the banks and channel during cleaning and maintenance, or surface runoff containing contaminants from gardens would contribute to a poor state of the stream habitat and ecology. This therefore highlights the need for suitable management of the streams to maintain the in-stream quality and protect the ecological values.

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

8.2.5 Freshwater Ecology

The aquatic ecology within the streams in this catchment ranged from excellent to poor, with the quality of the fish communities being the 'poorest' ecological indicator measured. The variability in ecology observed at the different sampling sites may be attributable to the variation in stormwater inputs to each sampling site, but it is likely that physical factors also strongly influence the in-stream ecology. The extent of piping and vicinity of piping to the sampling sites and potential blockages of some piped areas by debris which could impede fish passage. In addition, the quality of the physical habitat will play an important role in the health of the ecological communities within the stream.

For example, the best fish values were observed at the Orari Street 3 upstream sampling site where twelve banded kokopu were found. This included juvenile through to mature fish. This indicates that there are no barriers to fish passage further downstream in the catchment and in the stormwater system. No fish were caught or observed in the Orari Street 1 and 4 catchments, despite the presence of large areas of suitable habitat at both downstream sites (undercut banks and pool habitat). This may suggest that fish passage is obstructed, which may be from the large amount of litter, debris and leaves observed during sampling blocking the piped sections of these streams. This highlights the need for suitable maintenance of these sections of the channel.

Generally the water quality in the streams was found to be good. Where poor ecology was recorded at the sampling sites this corresponds with observed poor quality of one or more physical features of the site. This would suggest that the physical habitat of the streams may be influencing the quality of the ecological communities within. As described in Section 8.2.1 above, a poor physical habitat could be attributed to a number of factors.

8.2.6 Culture and Amenity

The harbour is an important area for recreation with a number of boat clubs and tourism operators in the area. A decline in the quality of the harbour environment could adversely impact on recreational activities. Limited amenity values have been identified for catchment streams, however a number of them have potential visual amenity values, with views and access available from public roads.



The harbour has been used historically by Kāi Tahu and their descendents and the discharge of stormwater and associated contaminants has the potential to offend Kāi Tahu values and beliefs. The historic decline of harbour quality has been noted by Kāi Tahu. These adverse impacts are associated with effects on the spiritual value of water, mahika kai, aquatic biota and water quality. Stormwater quality in the Orari Street catchment does not appear to be particularly poor.

Poor quality stream environments could, however degrade the spiritual value of the watercourses. Amenity value of 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 harbour continues to deteriorate significantly or that the quality of stormwater from the Orari Street catchment is significantly contributing to any deterioration of the harbour. The monitoring does not indicate the presence of a wastewater contribution to the discharged stormwater from this catchment. The watercourse environments are potentially at risk from further degradation due to lack of management and / or maintenance.



8.2.7 Summary of Effects of Stormwater Quality

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

- The levels of all contaminants in the stormwater from the outfall in this catchment are typical of stormwater quality from similar catchments and in some cases, are better. Although variable, heavy metal concentrations have been below detectable levels in a number of samples taken from the outfall.
- Most sediment contaminant levels sampled within 20 m of the Orari Street catchment outfall are below the ANZECC (2000) sediment guideline low trigger values, except for PAH, which may be linked to the highly trafficked Portsmouth Drive – a main transport route running along the western border of the Otago Harbour adjacent to the Orari Street outfall.
- All sediment contaminant levels sampled beyond 20 m from the outfall are below the ANZECC (2000) trigger values.
- The biological sampling results suggest that the stormwater discharge from this catchment is not having an adverse effect on ecological health.
- The stormwater discharge may be contributing to the contaminant levels in the sediments. However, the current contaminant levels in the stormwater and sediment from this catchment are relatively low. Further study may be able to identify whether any sediment contamination is historic or from other sources.
- Harbour water quality is not currently monitored. Monitoring would allow comparison with ANZECC (2000) marine water quality guidelines and allow a link to be established between stormwater discharge quality and harbour water quality.
- Harbour-wide, levels of key contaminants in the sediments were found to be slightly lower in 2010 than previous monitoring years. Further monitoring is required to better understand the contamination levels and establish any long term trends.
- Freshwater habitat and ecology varied between and within the four streams sampled in the catchment. The poor results in some areas may be attributable to the physical quality of the habitats surveyed. Whilst stormwater may be contributing to poor stream quality in one location, it is likely that a poor physical habitat, and inadequate management and / or maintenance of the streams is a significant contributing factor in others.
- The harbour and watercourses have important cultural values and the harbour is an important area for recreation. The results of investigations do not indicate that harbour quality is continuing to deteriorate as a result of the quality of stormwater from this catchment.
- 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 Orari Street catchment, and prioritised for action. These are discussed below. Section 10 following prioritises these issues, and the remainder of this ICMP involves target setting and development of options to manage the stormwater from this catchment. Figure 9-1 presents the key issues for the Orari Street catchment.

9.1 Stormwater Quantity Issues

9.1.1 Low Confidence in Model

Model predictions indicate flooding (of varying depths) at a number of locations not supported by community complaints, DCC records or DCC staff past experience. Further information is required to validate these results.

9.1.2 Low Level of Service in upper catchment

Many of the small diameter pipes in the upper reaches of the network, (particularly the Glen Valley), can only convey small rainfall events, e.g. a 1 in 2 yr ARI rainfall event. This results in overland flow down the steep catchment, accumulating in low lying areas.

9.1.3 Nuisance Flooding

Nuisance flooding (between 50 mm and 300 mm deep) is predicted and confirmed in three main areas; South Road beneath the Motorway over-bridge, in the South Road commercial area, and on the northern part of the Caversham Bypass Motorway. In all instances, this nuisance flooding becomes progressively worse during larger rain events.

9.1.4 Deep Flooding (Current and Future Scenarios)

Deep Flooding (> 300 mm deep) is predicted on 10 land parcels during the current 1 in 2 yr ARI rainfall event, and on 50 land parcels during the current 1 in 10 yr ARI rainfall event.

During the 1 in 50 yr ARI events modelled, up to 85 properties experience flooding on part of their parcel to depths greater than 300 mm for the current land use. Mean climate change and the 2060 land use during a 1 in 50 yr ARI event could result in 99 properties experiencing flooding on part of their parcel to depths greater than 300 mm.

Deep flooding is not expected to threaten building interiors on a large number of the land parcels affected, as flood depths are often confined to gullies at the rear of properties. The main areas affected are South Road beneath the Motorway over-bridge, in the South Road commercial area, and on the northern part of the Caversham Bypass Motorway.

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

‘Significant / extreme’ flood hazard during large (1 in 100 yr ARI) rainfall events is predicted in a number of areas throughout the catchment, but particularly on South Road at the base of the Glen Valley due to deep water, and on Glen Road due to fast flowing water. Other pockets of flood hazard are scattered throughout the catchment, driven by catchment topography.

9.1.6 Overland Flow into the South Dunedin Catchment

During large rainfall events, overland flow is predicted to enter the north-west corner of the South Dunedin catchment.



9.1.7 Blocking / Maintenance of Intake Structures

A number of intake structures in the catchment are not regularly inspected by DCC as many are on private land, where maintenance is the responsibility of the landowner). Maintenance of these structures is critical to the optimal operation of the hydraulic network.

Overflows from the intake structure at 91 Glen Road are highly sensitive to blockage of the screen. Overflows travel down Glen Road.

An open channel and intake structure behind the South Road commercial area is in poor condition, and predicted hydraulic issues in this area will be exacerbated by poor maintenance of this channel and structure.

9.1.8 Network Maintenance

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

9.2 Stormwater Quality Issues

It is clear that within the harbour there is historical sediment contamination likely to be from a combination of the stormwater outfall and other sources. Harbour-wide, there is potential for ongoing contamination of the sediment from stormwater, however the results are ambiguous and it has not been possible to establish a causal link from available data.

At the Orari Street catchment outfall, sediment data collected over a four year period indicated low levels of contaminants (when compared with ANZECC sediment quality guidelines) for all contaminants except for PAHs, which were present in moderate amounts (above the ANZECC low guidelines). Oil and grease measurements in the Orari Street catchment stormwater were not high, however PAHs in the sediments adjacent to Portsmouth Drive have been previously attributed to runoff from the highly trafficked road (Ryder, 2006), which discharges into the same part of the harbour as the Orari Street catchment outfall.

Stormwater quality could also be contributing to poor stream health in at least one of the four Orari Street catchment streams surveyed. The management and maintenance of the stream physical environment is thought to be contributing to poor stream health at a further two sites.

9.2.1 High Variability of Stormwater Quality Results

Inconsistencies in stormwater quality results city-wide mean that a trend is unclear in stormwater quality, or confidently identify key contaminants to aid stormwater management.

Monitoring indicates, however, that there are no major contaminants of concern in the Orari Street catchment stormwater, with the only contaminant showing slightly elevated levels being zinc, which is a common contaminant to wash off residential roofs.

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

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

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

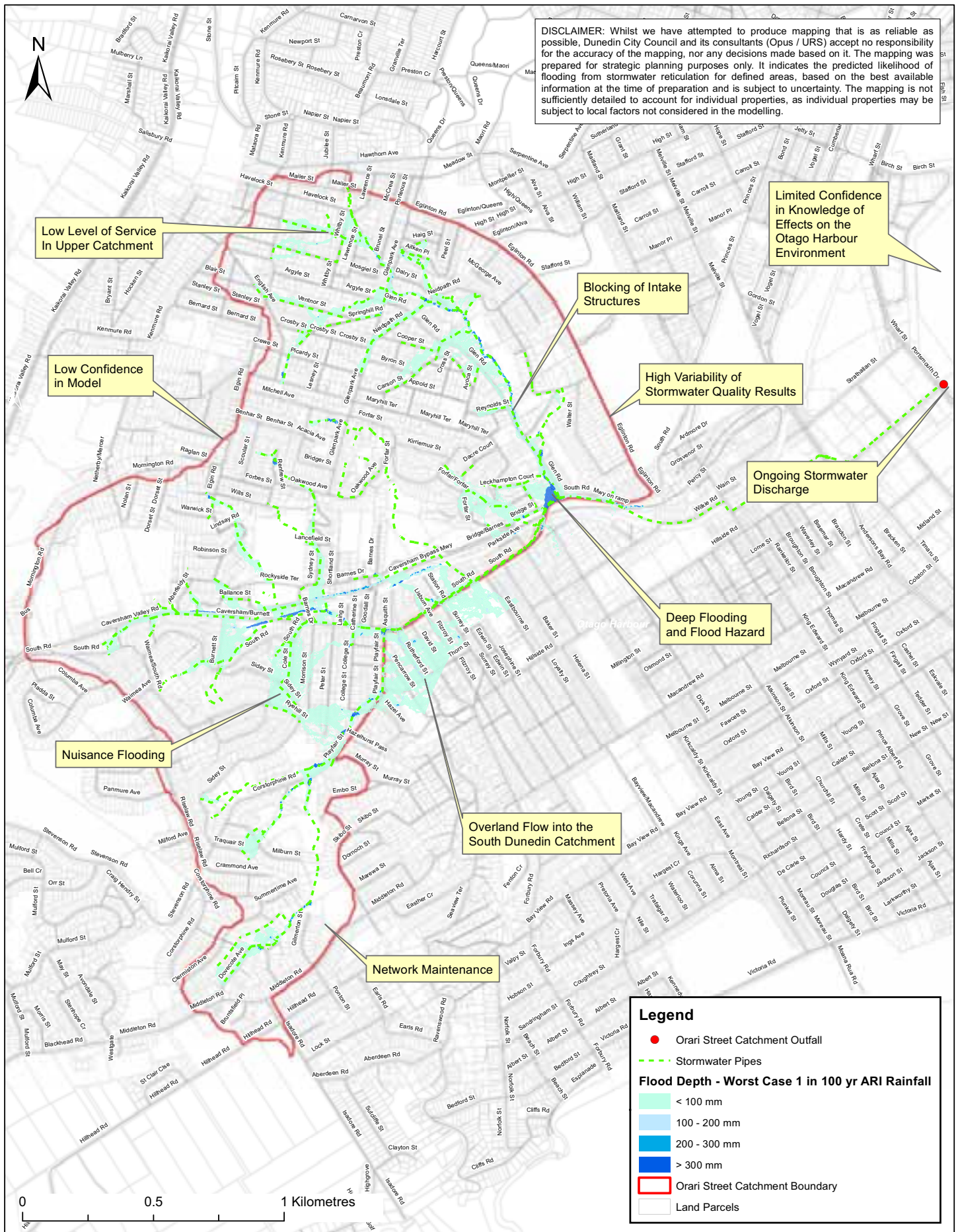


Again, there appear to be limited contaminants of concern either in the stormwater discharged, or the sediments accumulating in the harbour near the Orari Street catchment outfall. Moderate levels of PAH in the sediments at this location could be due to other discharges into the upper harbour from adjacent catchments, including the now disused gasworks in South Dunedin, or highly trafficked roads immediately adjacent to the harbour, however this link is unconfirmed.

9.2.3 Ongoing Stormwater Discharge

Stormwater quality monitoring indicates that the stormwater quality discharged from the Orari Street catchment appears to be typical or low for 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 obvious adverse effect on the receiving environment, however as discussed above, there is limited confidence in some of this information, and further data may be required.

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.



**Dunedin 3
Waters
Strategy**

ORARI STREET INTEGRATED CATCHMENT MANAGEMENT PLAN

Figure 9-1

Orari Street Catchment Issues

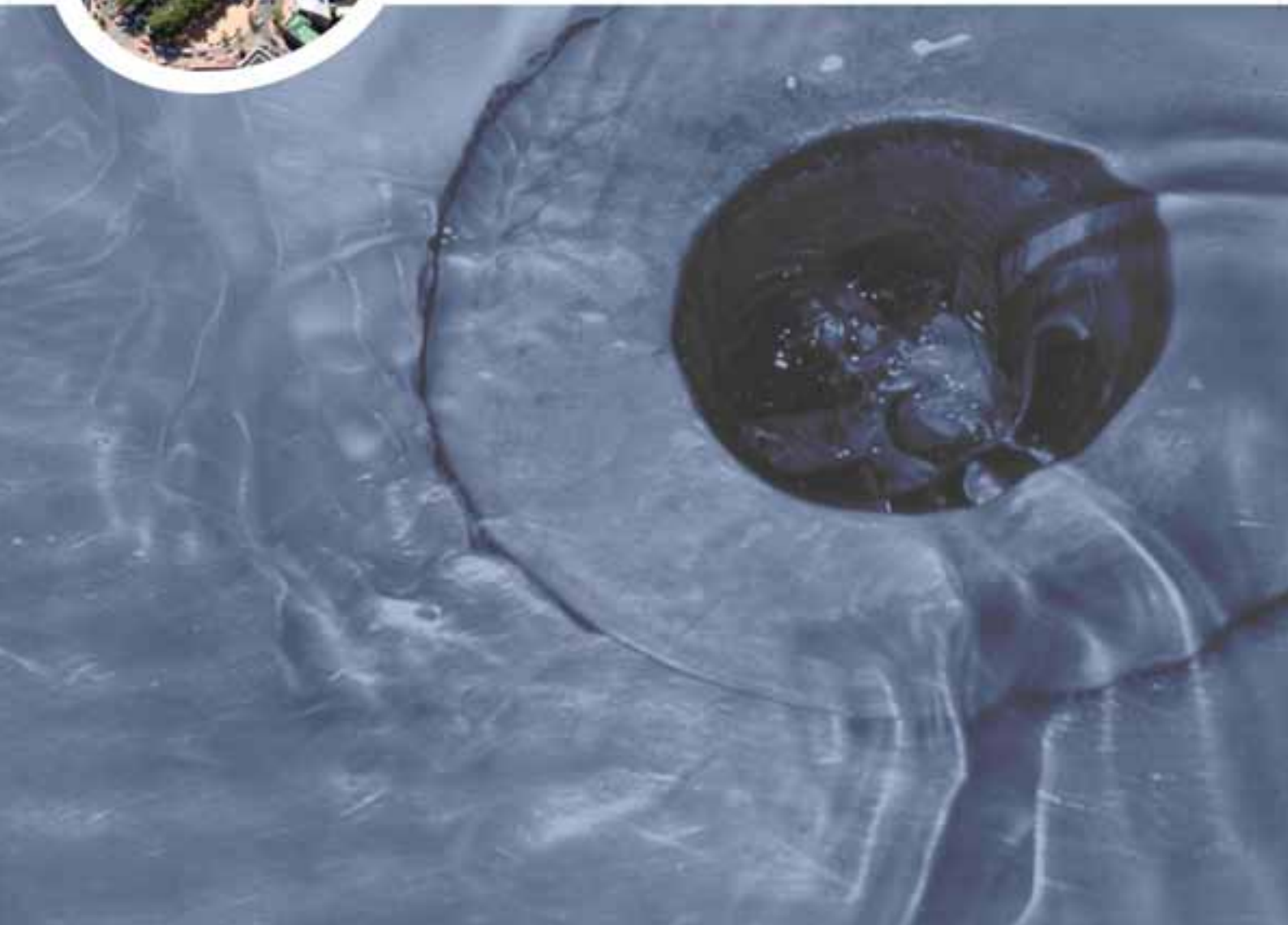
DISCIPLINE
Stormwater

Status: Final		
Scale: 1:13,500	Plot Date: Sep 2011	
Drawn By: CO	Approved: HS	
Checked: JH	Date: Sep 2011	
Job No: 42173227	Map No: Figure 9-1	Revision: -



Part 4

Targets





10 Issues Prioritisation

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

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

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

Note

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

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



Table 10-1: Issues Prioritisation

Issue (Problem Description)	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Problem Management
Deep flooding	70	3	Deep flooding predicted on a number of residential properties during events as small as a 1 in 2 yr ARI rainfall event, however suspected to be mostly exterior to buildings. Limited knowledge of threat (no surveyed floor levels). Risk to building interiors and major road corridors predicted to increase with lower frequency events (1 in 10 yr ARI and 1 in 50 yr ARI). Formal complaints would occur.	210	Manage Actively
Limited Confidence in Knowledge of Effects on the Otago Harbour Environment.	40	4	Past sampling programmes provide inconclusive data which means that the ongoing effects of stormwater discharges are unclear. Without better knowledge, DCC will be unable to meet its strategic objectives and ensure ongoing sustainable stormwater management. Failure to establish clear links between stormwater quality and receiving environment quality may weaken DCC's position both legally and in terms of public perception. It is unlikely however, from the monitoring undertaken to date, that the stormwater quality from the Orari Street catchment, is having a significant adverse effect on the receiving environment.	160	Manage Actively
Blocking / Maintenance of Intake Structures	40	4	Intake structures in a number of locations sensitive to blockage, resulting in significant overland flow. Fish passage prohibited by blockage and potentially intake structure design. Collectively, could result in disruption to a number of properties, and may be exacerbating effects of larger events.	160	Manage Actively
High Variability of Stormwater Quality Results	40	3	Stormwater quality monitoring could be made more robust. Relatively low / moderate confidence in data. Without better knowledge, underpinned by good quality data, DCC cannot reliably meet its strategic objectives. Discharges from the Orari Street stormwater catchment, however, have contained moderately low levels of contaminants over the four year sampling period.	120	Manage Actively



Issue (Problem Description)	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Problem Management
Low Confidence in Model	40	3	Model predictions indicate flooding (of varying depths) at a number of locations not supported by community complaints or DCC staff records, however main areas of flooding predicted are corroborated (a moderate state of knowledge of the threat has been achieved). Further information is required to validate some results. DCC would be unable to undertake major capital works without better asset data information or a calibrated model. Flood estimates impact on a large number of properties.	120	Manage Actively
Flood Hazard – Current and Future 1 in 100 yr ARI	40	2	Areas of 'significant / extreme' flood hazard, predominantly due to deep flooding in known locations (predominantly in roads or watercourse gullies) or fast flows down road. Extent of flood hazard slightly exacerbated by climate change effects.	80	Manage Actively
Network Maintenance	10	5	Inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures. Potential to exacerbate or transfer flooding effects.	50	Manage Passively
Ongoing Stormwater Discharge	10	4	Ongoing discharge of stormwater (and associated contaminants) to the harbour. The extent of contamination is unconfirmed, but available data indicates that contaminants discharged are typical of land use, and the consequences are minor.	40	Manage Passively
Nuisance Flooding	10	4	Flooding predicted in a small number of locations. On major transport and bus routes, however not predicted to prevent access during small rainfall events. Effects likely to increase with climate change.	40	Manage Passively
Low Level of Service in Upper Catchment	10	4	Low level of service provided by some upper catchment networks. Results in overland flow towards stream gullies during small events, estimated to affect a small number of properties, but model results unconfirmed. Small local upgrades may resolve issues.	40	Manage Passively



Issue (Problem Description)	Consequence Rating	Likelihood Rating	Discussion	Risk Matrix Score	Problem Management
Overland Flow into the South Dunedin Catchment	10	3	Overland flow into the South Dunedin catchment is predicted to occur during large storm events. The confidence in the model is 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



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 has been used to identify the key stormwater management issues for the Orari Street catchment. These issues have been prioritised and ranked, according to DCC's risk matrix, which looks at the consequence and likelihood of each issue.

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

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

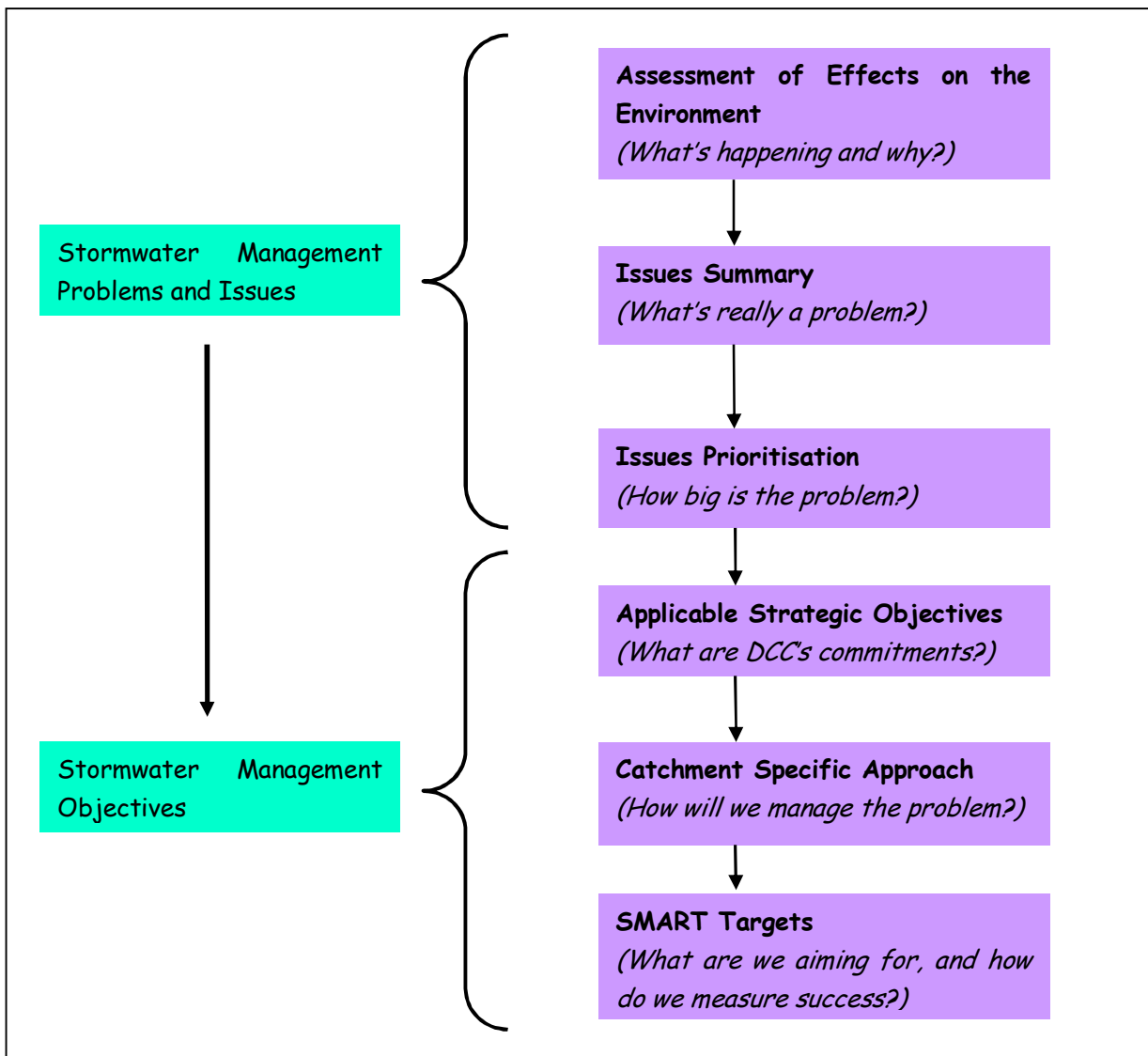


Figure 11-1: Target Development Process



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

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

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

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

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

Tables 11-1 and 11-2 outline catchment specific approaches and SMART targets for each of the key stormwater issues identified in the Orari Street catchment.

11.1 Stormwater Quantity Targets and Approaches

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

While a large proportion of the Orari Street stormwater catchment can accept stormwater from events up to a 1 in 10 yr ARI rainfall event, there are a number of different issues which are contributing to poor performance and flood hazard in some areas of the catchment. As such the approaches and targets for catchment management in the Orari Street catchment will be issue, and sometimes site, specific.

11.1.1 Deep Flooding

The Building Act requires that habitable floors (or 'useful floor space' in relation to non-residential properties) should not be at risk of flooding during a 1 in 50 year rainfall event. The modelling predicts that currently, up to 85 land parcels may experience flood depths greater than 300 mm



during a 1 in 50 yr ARI event. Ten properties are estimated to be at risk during a 1 in 2 yr ARI rainfall event.

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

Because the modelled flood extents indicate that in many cases, flooding may not actually enter buildings, parcels identified as potentially being subject to deep flooding during 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, prior to detailed design of options. 'Land parcels' and 'properties' are both used to provide information in this context, however model results only provide information in terms of 'land parcels'. DCC's targets are focussed on avoiding habitable floor, or significant private property flooding, therefore actual numbers of properties / premises at risk is likely to be less than the number of land parcels reported.

11.1.2 Blocking / Maintenance of Intake Structures

The blocking of the intake structure at 101 Glen Road is known to exacerbate overland flow down Glen Road, and increase flood hazard in the area. Other screens and intake structures throughout the catchment are also reported to have blockage issues. Blocked screens and structures not only divert stormwater overland, or detain water in a ponding area, but also potentially block fish passage up watercourses, reducing the ecological values of the watercourse.

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

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

11.1.3 Low Confidence in Hydraulic Model

The low level of confidence in the Orari Street catchment stormwater model means that flood alleviation works are limited to areas where flooding has been confirmed; a number of other areas, which are predicted to flood by the model (and may flood but have not been reported to) may not have issues addressed due to the low confidence in the model.

Additionally, DCC will have difficulty measuring network performance with confidence if the model is not calibrated.

Increased confidence in model results can be achieved by either flow calibration, or collection of further anecdotal evidence of flooding.

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

As a consequence of the deep flooding and fast overland flows predicted in a number of locations in this catchment, flood hazard is present. In large events (e.g. 1 in 100 yr ARI rainfall events), flood hazard predominantly affects transport corridors, rather than large areas of residential land.



Approaches and targets set for managing deep flooding in the Orari Street catchment will go some way towards reducing flood risk during these large events.

In terms of managing the flood hazard in these areas, the predominant issue will be maintaining transport routes in the event of a flood. South Road, in particular, contains a bus route into the city.

11.1.5 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.

11.1.6 Nuisance Flooding

Nuisance flooding is predicted and confirmed in the three main areas also predicted to experience deep flooding during large rain storms. The flooding predicted is minimal, mainly confined to roads and stream gullies, and hence is unlikely to have a severe impact on the activities in the catchment. Options pursued to resolve deep flooding in these areas, along with network renewals over time, are expected to resolve the majority of the nuisance flooding issues in the catchment.

11.1.7 Low Level of Service in Upper Catchment

A number of smaller pipes in the upper catchment have minimal capacity, and overflows result in overland flow down the 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.

In general, the council will adopt a long term approach to improving network performance and adapting to climate change by ensuring that all new network components (for example, planned pipe renewals, or upgrades in specific locations) are designed to a 1 in 10 yr ARI level of service, using conservative design storms that incorporate projected changes in rainfall intensity, coupled with conservative tidal boundary conditions. This is consistent with DCC's Code of Subdivision and Development, and also with the Building Act. Based on the age of the network, the pipes in the Orari Street catchment will be prioritised for assessment under the DCC pipe renewals programme. By 2060, 83 % of the pipes in the network (including those already at the desired level of service) will have been inspected and dependent on condition and performance, potentially replaced (with new pipes designed to convey the 1 in 10 yr ARI rainfall event).

The historical data collection methods used for customer complaints logging has resulted in variable information on complaints. Improvements in complaints recording will result in a clearer picture of customer satisfaction in the future. The residents' opinion survey (ROS) has been running in its



current format since 2003, and gauges Dunedin city residents' overall satisfaction with the stormwater collection service, amongst other council services. The Orari Street catchment is difficult to gauge from this survey, as it lies partly within the South Dunedin, Dunedin City and Green Island groups of this survey.

11.1.8 Overland Flow into the South Dunedin Catchment

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

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



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

Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Deep Flooding	Model results indicate 10 parcels affected by deep flooding during 1 in 2 yr ARI rainfall event; rises to 85 land parcels during 1 in 50 yr ARI rainfall event in current and 99 land parcels in future planning scenarios. Large number of properties affected during extreme climate change scenario. A large amount of deep flooding is predicted to be exterior to buildings (although surveys not yet undertaken).	Ensure new development provides a 1 in 10 year level of service for stormwater, and avoids habitable floor flooding during a 1 in 50 yr ARI rainfall event. Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase potential habitable floor flooding due to the stormwater system in events up to a 1 in 50 yr ARI rainfall event. 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).	< 85 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. > 70 % 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
Blocking / Maintenance of Intake Structures	Intake structures on a number of open channels (the majority of which are privately owned) are undersized and / or sensitive to blockage, and overland flow from blocked or overflowing screens is exacerbating flooding in critical areas.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network. Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Actively Undertake an inspection of all open channel sections, to record status of intake structures. Ensure damaged screens are replaced / fixed. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk. Work with property owners to ensure screens and intakes are properly maintained.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets in the catchment (in conjunction with city-wide criteria) by 2012. Develop list of key intake structures in Orari Street catchment requiring additional cleaning and maintenance checks by 2013. Document cleaning and maintenance responsibilities for all stormwater inlet assets in the catchment by 2013. Ensure all damaged, poor performing, or missing screens are replaced (if appropriate) by 2013.
Low Confidence in Hydraulic Model	There is low confidence in hydraulic model results in areas where flooding is not validated by photographic or anecdotal evidence. The current hydraulic model is suitable for planning purposes, but not for preliminary design.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives.	Manage Actively Improve model confidence by seeking flood related information in areas predicted to flood by the model (but unconfirmed). Improve model confidence by undertaking local survey and flow calibration wherever capital works are proposed and preliminary design is necessary.	Improve level of confidence in the Orari Stormwater Hydraulic model to 'moderate' by 2014.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Flood Hazard – Current and Future 1 in 100 yr ARI	‘Significant / extreme’ flood hazard during large rainfall events. Predicted in a number of areas, particularly on South Road at the base of the Glen Valley, and on Glen Road.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Actively Ensure new development does not increase the number of properties predicted to flood due to the stormwater system in a 1 in 100 yr ARI rainfall event. Protect key and vulnerable infrastructure (e.g. pump stations, works depots, schools, hospitals, electricity supply etc) from flood hazard. Avoid development of vulnerable sites / critical infrastructure in flood prone areas. Ensure transport routes around flooding areas will be available. Develop a better understanding of the likely effects and magnitude of climate change.	Provide modelled flood predictions to agencies responsible for transport routes. Provide modelled flood predictions to DCC Climate Change Adaptation Group to ensure information is taken into account during the development of a city-wide climate change adaptation plan.



Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Network Maintenance	Flooding extents and durations in the Orari Street catchment are potentially exacerbated by variations in the frequency and standards of catchpit and inlet screen cleaning and maintenance. City-wide inconsistencies in frequency and standards of cleaning and maintenance of stormwater structures (inlets and catchpits) can lead to discrepancies in level of service.	Maintain key levels of service into the future by adapting to climate change and fluctuations in population, while meeting all other objectives. > 60 % residents' satisfaction with the stormwater collection service.	Manage Passively Ensure consistency city-wide of stormwater structure cleaning and maintenance. Ensure cleaning and maintenance schedules and contracts are sufficiently robust. Identify areas in catchment where more regular stormwater structure cleaning and maintenance could reduce flooding risk.	Develop consistent cleaning and maintenance criteria for all stormwater inlet assets (city-wide) by 2012. Document cleaning and maintenance responsibilities for all stormwater inlet assets (city-wide) by 2013. Develop list of key stormwater assets in the Orari Street catchment requiring additional cleaning and maintenance checks by 2013.
Nuisance Flooding	Nuisance flooding is predicted and confirmed in three main areas; South Road beneath the Motorway over-bridge, in the South Road commercial area, and on the northern part of the Caversham Bypass Motorway. Flooding not significant during small events, but becomes progressively worse with larger events.	Ensure there will be no increase in the number of properties at risk of flooding from the stormwater network.	Manage Passively Design new pipes with capacity to convey a 1 in 10 yr ARI rainfall event (including climate change allowances). Undertake pipe renewals programme as scheduled (with older pipes prioritised).	< 0.1 % of catchment surface area predicted to flood during a 1 in 2 yr ARI rainfall event by 2060. > 70 % 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
Low Level of Service in Upper Catchment	Small diameter pipes in the upper reaches of the network only have capacity to convey 1 in 2 yr ARI rainfall events. Overflow causes overland flow and exacerbates flooding in other locations.	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.	> 70 % of pipes to convey a 1 in 10 yr ARI rainfall event by 2060. > 60 % residents' satisfaction with the stormwater collection service (ongoing).
Overland Flow into the South Dunedin Catchment	Overland flow is predicted to enter the South Dunedin catchment from the South Road commercial area, and Corstorphine area, during large 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 Orari Street catchment on South Dunedin catchment. > 70 % 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 Orari Street catchment are presented in Table 11-2. The catchment specific approaches and targets are discussed in further detail below.

Whilst the monitoring information to date does not suggest that the stormwater quality from the Orari Street catchment is adversely affecting the marine environment, targets and approaches set out below describe a city-wide approach to stormwater quality as the Otago Harbour is a common receiving environment for all DCC coastal stormwater discharges. Through the development and implementation of this programme, it is expected to transpire that the Orari Street catchment is not a high priority catchment in terms of discharge of stormwater contaminants.

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

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

There is high variability in stormwater quality monitoring results from each catchment. Whilst stormwater quality is influenced by many variables and it is not unusual to see a wide range of contaminant levels in monitoring results, it is considered that this issue is compounded by the current monitoring technique of obtaining single annual grab samples of stormwater for analysis. Samples taken from the Orari Street catchment have, however, only contained moderate or low levels of residential land use associated contaminants, despite the variability in results (contaminants have often been below the detectable limits of the analysis methods used).

Sediment monitoring has been carried out to date (2007 to 2010) to determine the quality of the marine sediments. Sampling across the catchments has indicated that there are some contaminants of concern within the harbour, measured at relatively high levels. However, it remains unclear whether the contaminant levels observed are as a result of historic contamination or current discharges (from either stormwater or other sources). For this reason, the sources of contamination are difficult to identify, as are any links with the quality of DCC stormwater discharges. High contamination in sediments sampled adjacent to the Orari Street catchment have only been detected sporadically, with the exception of PAHs which have been measured in consistently moderately high concentrations. PAHs however, could be attributed to sources outside of the Orari Street catchment.

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

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



stormwater quality, a suitable monitoring framework, and improved confidence in monitoring data is required.

As indicated above and in the AEE, the monitoring information to date does not suggest that the stormwater quality from the Orari Street catchment is adversely affecting the marine environment, therefore targets and approaches outlined in this section relate to city-wide concerns, rather than catchment specific ones.

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

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

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

Due to the low concentrations of contaminants measured in the stormwater discharged from the Orari Street catchment, it is likely that this catchment will not be highly prioritised for immediate extensive monitoring, and a passive management approach is recommended, whereby monitoring is undertaken to ensure stormwater quality does not deteriorate over time.

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

- Considering the cost and benefit of incorporating stormwater treatment into flood mitigation works where practicable.
- Requiring source control or management of stormwater contaminants in high contaminant generating land uses by enforcing the Trade Waste Bylaw, and working to educate occupiers of high-risk sites with respect to stormwater discharge quality.



- The Dunedin Code of Subdivision and Development indicates that at-source management of stormwater quantity is desirable and Low Impact Design methods are preferred.

11.2.2 Ongoing Stormwater Discharge

The monitoring data at present does not indicate that the levels of contaminants in stormwater from the Orari Street catchment stormwater are significantly high. Therefore, based on the best available information at this time, the prioritisation of this issue has resulted in a 'passive management' approach.

However, it is acknowledged that there is low confidence in the current annual monitoring data and a single time-proportional sample is insufficient to give a clear indication of stormwater quality or trends over time.

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

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



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

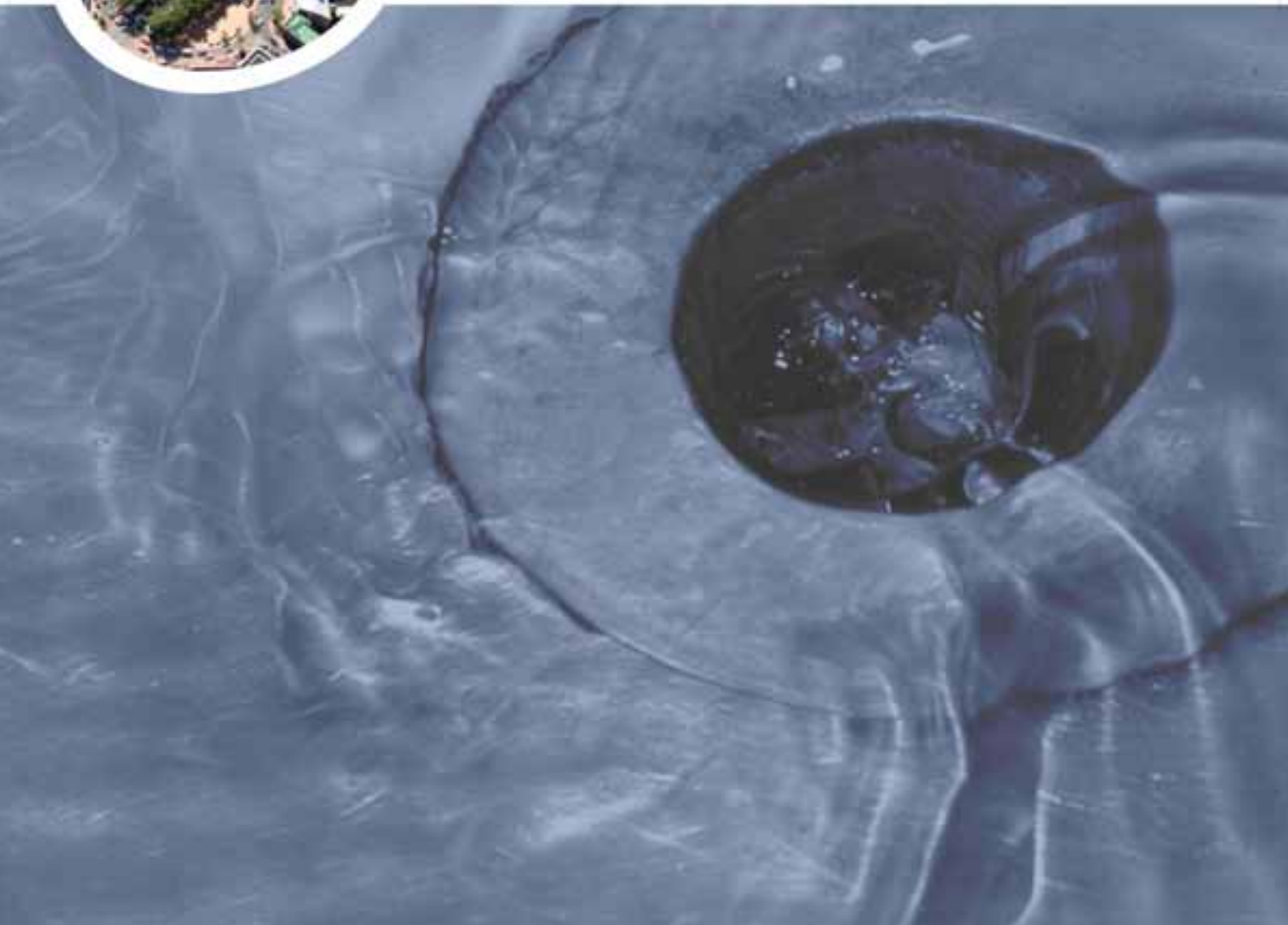
Issue (Problem Description)	Effects Summary	Strategic Objectives and Targets	Catchment Specific Approach	SMART Targets
Limited Confidence in the Knowledge of Effects on Harbour Environment and Variability of Stormwater Quality Results	High variability of stormwater quality results, any trends in stormwater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



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



Part 5 Solutions





12 Stormwater Management Options

12.1 Introduction

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

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

- Option must be technically feasible.
- Option must meet relevant legislative requirements.
- Option must be consistent with the principles of the Treaty of Waitangi.
- Option must be aligned with the catchment specific objectives developed in Section 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.
- Option should not increase health and safety risks compared with the 'do nothing' option.

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

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

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

12.2 Potential Options

Outlined below are preliminary options identified for the key stormwater management issues present in the Orari Street catchment. Option 'deal breakers' are eliminated and feasible options are described in further detail.



Where an issue has been prioritised as 'manage passively', management options are discussed in more general terms, although planning based options may be presented where applicable.

Where an issue is prioritised as 'manage actively', where available, a number of alternative options may be considered for further evaluation in Section 14, if more than one potential solution is available.

12.2.1 Deep Flooding – Manage Actively

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. A damage assessment of affected properties which are commercial or industrial premises is often also useful in terms of identifying particularly vulnerable businesses. This assessment would consider the use of the premises, and estimate the likely loss of equipment or stock during a flood event, based on surveyed levels and information from the property owner.

Based on the results from modelling of the Orari Street catchment, a number of properties are predicted to flood during the 1 in 50 year event, 85 and 99 of which are at risk of habitable / commercial floor flooding under the current (2010) and future (2060) scenarios respectively. However, the main areas subject to flooding appear to be in the road corridor; deep flooding is predicted to an extent that would severely disrupt traffic.

A number of options have been developed to resolve issues in the three main flooding areas. These are described below.

12.2.1.1 Glen Valley / South Road

A number of options are presented below with respect to flooding in this area. Capital works options were modelled to determine the effect on the deep flooding predicted at South Road beneath the Caversham Valley Motorway and throughout the Glen Valley sub-catchment. This flooding is caused predominantly by overland flow from the upper Glen Valley sub-catchment, and the Leckhampton Court / Forfar Street / Bridge Street area.

O1: Glen Valley Upgrades

This option involves culvert and pipe upgrade from 80 Neidpath Road to the open channel along Glen Road, plus channel widening of upstream and downstream open channels. Pipes in this area were predominantly installed between 1901 and 1940, thus would be due for inspection under the renewals programme within the next 30 years.

Existing open channels in the gully behind Glen Road could be utilised to provide extra detention for peak flows by upsizing the channel. There appears to be sufficient room in the existing gullies to accommodate additional stormwater, however some land purchase may be required. The upgrade of the associated culvert and pipes is required to prevent hydraulic bottlenecks in the upper catchment.



O2: Sealed Manholes on Leckhampton Court

Sealing problem manholes is sometimes a fast and economic way of reducing localised flooding issues, however this can redirect the flooding further upstream, and is less effective where adjacent low-lying catchpits provide an alternative outlet for overflows.

Three manholes at the intersection of Leckhampton Court, Bridge Street and South Road were modelled as sealed, as shown in Figure 12-1 below, in an effort to reduce manhole surcharge and overflow at the point where steeply laid lateral stormwater pipes connect with a flatter stormwater main. In this instance, predicted flooding is not transferred upstream.



Figure 12-1: Sealed manholes, Option O2



O3: Local Pipe Upgrades – South Road / Leckhampton Court

A hydraulic bottleneck at the intersection of Leckhampton Court and South Road was identified, and increased in size to reduce manhole surcharge immediately upstream. Additionally, capacity available in the main stormwater line along South Road indicates that additional catchpits in the area would allow overland flow to enter the system, and ponded water to recede faster. Figure 12-2 below indicates pipes upgraded and areas of additional catchpits recommended as part of this option. Specific details will need to be confirmed following pipe survey to confirm sizes and configuration.



Figure 12-2: Option O3: Local Upgrades – South Road / Leckhampton Court

O4: Installation of Pump(s) at the Outfall

The installation of a pump station at the outfall could provide additional capacity in the trunk stormwater pipe and reduce the tidal influence on the network. Furthermore, there already exists an unused wet well with screen and pump chamber in the Orari Street network, approximately 20 m upstream of the outfall.

O5: Increase Outfall Pipe Capacity

To drain the water from the catchment faster, a significantly larger pipe from the Glen Intake to the outfall was modelled, using the same grade and location as the existing pipeline. The modelled pipe contained at least double the existing capacity, and was modelled as a conceptual option for relieving flooding in the catchment. The existing pipeline was installed in the early to mid 1930s, and is due to be assessed under the pipe renewals programme within the next 20 years.



12.2.1.2 South Road Commercial Area

Predicted manhole overflows at the South Road / Laing Street intersection results in deep flooding in the South Road commercial area. Options explored to reduce manhole overflow include increasing pipe sizes, and detention in the open channel and vacant lot area adjacent to the railway corridor in this area. Figure 12-4 provides a sketch of the area and potential upgrades (in red).

O8: Local Pipe Upgrade(s)

Increasing the pipe size of small sections of the piped network to provide additional capacity and reduce hydraulic bottlenecks was explored as a solution to the predicted flooding in this area. This option could be implemented as twin pipes, or a single larger pipe.

O9: Detention at 380 South Road and 12-14 College Street

Existing open channels could be utilised to provide extra detention for peak flows by upsizing the channel and / or creating in-line ponds or structures; vacant lots or purchased land could also be utilised to accommodate detention devices.



Figure 12-4: Options: South Road Commercial Area



12.2.1.3 Caversham Bypass Motorway

The predicted flooding along the Caversham Bypass Motorway is predominantly a result of significant overflows at two manholes on Barnes Drive, from which stormwater then flows down the embankment south of Barnes Drive and accumulates on the northern lanes / verge of the motorway. Several potential options exist to reduce the flooding along the Caversham Bypass Motorway, including pipe upgrades and storage / detention devices.

Given the current predicted flooding in the South Road commercial area (which is downstream of one of the Barnes Drive tributaries) modifications to the Barnes Drive / Sydney Street sub-network will likely have an adverse affect on the flooding downstream. It is recommended that this option be explored if the South Road commercial area detention option is investigated further, which includes an additional provision for increased flows from an upgraded Barnes Drive pipe. The upgrade could include an increase in pipe diameter and straightening of the pipe (reduction of sharp bends) downstream of 14B Barnes Drive.

A detention and attenuation option incorporating stormwater swales running east along the bottom of the embankment adjacent to the motorway (discharging to the open watercourse south of Forfar Street / Oakwood Avenue) could also be considered, though this is subject to confirmation of the existing motorway drainage and proposed future upgrades of this road.

Sealing the manholes on Barnes Drive may provide minor relief of overflows, however given the proximity and estimated invert elevations of the nearby catchpits, overflows from these outlets are still expected to occur in a 1 in 10 yr ARI rainfall event.

12.2.2 Blocking / Maintenance of Intake Structures – Manage Actively

Blocking of intakes structures has been identified as a key issue in the Orari Street stormwater catchment. Sensitivity analysis of the intake screen at 91 Glen road showed that overflow volumes doubled when the screen was partially blocked, resulting in overland flow to the base of Glen Road. When clear, this intake structure can convey flows from a 1 in 10 yr ARI rainfall event.

Screens on private property are not all routinely inspected by DCC staff, unless a known flooding issue results from screen blockage, however modelling indicates that there may be other screens / intake structures in the catchment that would benefit from review.

At a minimum, it would be advisable to have an inventory of intake structures and their condition.

The following approach has been recommended for this issue:

- Undertake an inspection of all open channel sections, to record status of intake structures.
- Ensure damaged screens are replaced or repaired (in conjunction with watercourse approaches outlined in Section 11.2).
- Identify areas in catchment where more regular cleaning and maintenance could reduce flooding risk.
- Work with property owners to ensure screens and intakes are properly maintained.

The options to be considered at each site in order to reduce the risk of flooding (locally and at key flood locations) will be site dependent. 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.

With respect to the Intake screen at 91 Glen Road, an alternative design that is less prone to blockage would be appropriate, given the effects of screen blockage on catchment flooding. Regular maintenance would still be required, however relying on maintenance staff to keep the current screen clean during rainfall events, rather than replacing the screen, would not reduce the risk of flooding at this location.

12.2.3 Low Confidence in Hydraulic Model – Manage Actively

The low confidence in the Orari Street hydraulic stormwater model has resulted in a number of ‘non validated’ flood predictions. Validation of these predictions could lead to the identification of further flooding issues in the catchment. Additionally, higher confidence in the model would greatly enhance its usefulness as a preliminary design tool.

Model confidence can be increased by collection of anecdotal, photographic and even depth information during flood events. Additionally, flow monitoring can be undertaken, however this can be costly.

With respect to options considered for deep flooding solutions in the Orari Street catchment, the current model has proved adequate for conceptual analysis, however detailed design would require further information.

It is recommended, therefore, that confidence in the model is increased in locations where capital works are progressed – this would involve both survey data (which would also be required for detailed design), and potentially flow calibration. The benefits of undertaking this in isolated areas are that the information is directly useful, and costs of model upgrade can be minimised.

12.2.4 Flood Hazard (Current and Future) – Manage Actively

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

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

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

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

**O10: Develop Emergency Response Plan**

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

The areas predicted to have the most significant flood hazard contain several transport routes into the city from outlying suburbs. The South Road area will be significantly affected during an extreme flooding situation, making bus transport impossible. An emergency response plan could be prepared to ensure that alternative routes are used during a large storm event. This plan could also include the identification of vulnerable premises, and provide a specific evacuation plan for these.

O11: Develop Climate Change Adaptation Plan

Flood hazard in the catchment is predicted to intensify in the future due to climate change impacts (only slight intensification is expected in the catchment), therefore a single option is presented reflecting this driver.

In order to develop a better understanding of the likely effects and magnitude of climate change, there needs to be an ongoing re-visitation of new information regarding climate change predictions, and the implications of these for the Orari Street catchment. The hydraulic model developed for this study would be a key tool in assessing the impacts of a range of further climate change scenarios. A climate change adaptation plan for the whole of Dunedin city would incorporate findings in terms of a plan for flood affected areas. Damage assessment of critical and vulnerable sites would form part of this work, as discussed in Section 12.2.1.

12.2.5 Network Maintenance – Manage Passively

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

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

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

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

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

- Intake screen at 91 Glen Road.
- 80 Neidpath Road.



- Glen Intake structure.

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

12.2.7 Low Level of Service in Upper Catchment – Manage Passively

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

Low level of service in the upper catchment will be addressed over time via pipe renewals; 83 % of the stormwater pipes in the Orari Street catchment are due for renewal within the timeframe of this document. The renewals process includes inspection and condition assessment, and potentially extends the useful life of a stormwater asset beyond 100 years, if it is in good condition. However where capacity is an issue and the level of service is compromised, as it is in the upper Orari Street catchment, renewals will be necessary.

A number of 'quick wins' were explored to address this issue. Open channel intake culverts were increased in size in an attempt to reduce upstream flooding. This resulted in a reduction of catchment flooded area by 11 % during a 1 in 10 yr ARI rainfall event. The size and configuration of a number of these intakes / culverts is, however, unconfirmed.

In the interim, the ROS can be used to gauge satisfaction with the stormwater system performance. The Orari Street catchment is most closely aligned with the South Dunedin catchment group surveyed. In 2010, 63 % of the residents surveyed in the South Dunedin area were either very satisfied or 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

12.2.8 Overland Flow into the South Dunedin Catchment – Manage Passively

Modelling in the Orari Street catchment indicates that flooding from the South Road commercial area and the Corstorphine area may flow overland into the South Dunedin catchment.

Upgrades in the Orari Street catchment, either as a direct result of options investigated to resolve flooding, or as part of the pipe renewal process, should reduce the extent of overland flow, however it will most likely still occur in large events, to a smaller extent (e.g. larger than a 1 in 10 yr ARI event).

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, 2010) indicated surcharging manholes in the Rutherford Street area, where flood flows are predicted to travel from South Road. Major surface flooding is not, however predicted during events up to or including the 1 in 100 yr ARI event. 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 Orari Street catchment model with the South Dunedin catchment model, may be necessary to quantify the risk.

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

Although the stormwater and sediment quality results from the Orari Street catchment do not indicate a significant adverse effect is occurring in the environment due to stormwater discharges currently, the stormwater and harbour environment monitoring regime to date has been insufficiently robust to enable the identification of any relationship between stormwater quality and harbour environment health.

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

- Redesign the monitoring programme to develop a robust framework that will yield good quality, useful data at appropriate sites to enable a sound understanding of both catchment stormwater quality and health of the harbour environment and allow any linkages between the two to be identified.



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

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

- Develop and implement a robust monitoring framework by 2012.

The approach and targets recommended include a staged approach that seeks to redesign the current monitoring framework to ensure that it will provide more comprehensive and defensible information on current stormwater discharge quality and the effects thereof. Following this, stormwater management approaches will be reviewed and adjusted where necessary to reflect DCC's strategic objectives. Depending on the extent of the monitoring programme developed, monitoring may be prioritised. However, based on the time-proportional results obtained for this catchment, it is not recommended that this catchment be prioritised for immediate further monitoring.

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

O12: Design a Framework for Stormwater Quality and Harbour Environment Monitoring

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

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

- Improved confidence in stormwater quality data;
- Sound understanding of marine sediment quality, including the extent of historic contamination and rate of any ongoing contamination and potential sources;
- Identification of harbour biological health, using suitable indicators to attempt to 'single out' effects of stormwater discharges on the harbour environment;



- Identification of any links between pipe discharge and sediment quality, marine water quality, marine biology; and
- Identification of catchments / discharges of concern and associated stormwater contaminants of concern.

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

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

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

Based on the stormwater quality results collated in this catchment, as part of the city-wide programme, comprehensive stormwater monitoring in the Orari Street catchment will not be a high priority when discharges from other catchments are also considered. It is therefore likely, that a 'baseline' monitoring programme can be introduced to ensure that stormwater quality over time does not deteriorate. The design of this monitoring programme would form part of the city-wide programme, in order to ensure that results were complementary.

12.2.10 Ongoing Stormwater Discharge – Manage Passively

The monitoring data at present indicates that the levels of contaminants in stormwater from the Orari Street catchment stormwater 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. It is recommended that all options are applied.

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

The management of stormwater discharges as new or re-development occurs could be undertaken using several mechanisms, however because the area of industrial land use in the catchment is small, the Trade Waste Bylaw enforcement would not be expected to provide significant gains in stormwater quality:

- Development Controls: DCC have a preference for at-source management and low impact stormwater design as outlined in the draft Code of Subdivision and Development. This document also requires a minimisation of damage to the environment from adverse effects of stormwater runoff; that habitat requirements are taken into account; that stormwater treatment is put into place where practical and that road drainage applies appropriate stormwater treatment.
- An amendment to the business processes used to manage subdivision and development. This would be aimed at ensuring that the developer / DCC representative review the appropriate ICMP for the area of development, in order to direct stormwater treatment based on catchment specific requirements.



- **Trade Waste Bylaw:** The Trade Waste Bylaw currently includes standards for stormwater discharge quality. Enforcement of this Bylaw would result in an improved quality of stormwater discharge leaving industrial or commercial sites. The Bylaw currently includes standards for stormwater discharge relating to the ANZECC (2001) guidelines for Fresh and Marine quality. Following improved understanding of stormwater discharge quality and its effects, this Bylaw may require review.
- **Education and Assistance:** Also under the Trade Waste Bylaw, inspections of industrial premises could be undertaken to ensure that adequate on site management practices are being applied. Assistance could be provided by DCC to help achieve higher stormwater quality. It is anticipated that ORC would be involved in this type of scheme for consented discharges, and potentially have resources available to assist in city-wide education.



13 Three Waters Integration

13.1 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 are 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.

Renewals have been recommended in the Orari Street catchment water supply network, in order to resolve low pressure and fire flow issues; this provides an opportunity to combine capital works, particularly where stormwater pipe renewals or other capital works may also be scheduled.



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.

I&I issues in the South Road area are currently being resolved through capital works. It is not expected that this work would have a large influence on stormwater network performance in the Orari Street catchment; however, as the I&I issues arise from other catchments.

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), 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. Weighting for each of the criteria has been assigned by DCC.



Table 14-1: Option Assessment Criteria and Scoring System

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



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



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



14.2 Options Comparison

Options comparison was not undertaken for all issues identified as requiring active management, the assessment of a number of the issues resulted in only a single option being identified, or the need for further study.

However, several options were tested to alleviate deep flooding predicted in key areas as described in Section 12.2.1. The options were modelled using the current land use scenario and a 1 in 10 yr ARI rainfall event, and a preliminary options evaluation undertaken to identify deal breakers. The options shortlist was then used to undertake full QBL evaluation.

14.2.1 Preliminary Options Evaluation

14.2.1.1 Glen Valley / South Road

Preliminary evaluation of the options identified to resolve the deep flooding in the South Road / Glen Valley area combined engineering judgement with hydraulic modelling of a number of options to assess the likely effectiveness of those options for reducing flooding. The options developed and outcomes of the preliminary evaluation are described below. Further information is provided in Appendix F.

O1: Glen Valley Upgrades – Deal Breaker

Increasing the capacity of the network through the Glen Valley, without providing attenuation results in stormwater reaching the bottom of the network faster, and an increase in the number of properties predicted to flood during both a 1 in 10 yr ARI and a 1 in 50 yr ARI rainfall event.

O2: Sealed Manholes on Leckhampton Court - Deal Breaker

Sealing manholes on Leckhampton Court Drive is predicted to have a better effect during small events – resulting in one less property flooding during the 1 in 10 yr ARI rainfall event, and a significant reduction in flooding on South Road, but no noticeable effect during the 1 in 50 yr ARI event.

O3: Local Pipe Upgrades – South Road / Leckhampton Court - Shortlist

Local upgrades on South Road / Leckhampton Court reduce potential deep flooding to below 300 mm deep on 11 properties during the 1 in 10 yr ARI event, however the modelled design has only a minor effect during the 1 in 50 yr ARI rainfall event.

O4 and O5: Installation of Pump(s) at the Outfall, and Increased Outfall Pipe Capacity – Deal Breaker

The main Orari Street catchment stormwater pipeline from the Glen to the outfall at Orari Street has capacity during a 1 in 10 yr ARI rainfall event, however not during a 1 in 50 yr ARI rainfall event. The only way this option could improve flood conditions during a 1 in 50 yr ARI rainfall event would be for this pipeline to provide a level of service of greater than 1 in 10 yr ARI.

O6: Upper Catchment Storage - Shortlist

Of the two locations modelled for upper catchment storage, the location at the top of the catchment (above Neidpath Road) has the best outcome in terms of flood reduction; during a 1 in 10 yr ARI rainfall event, two properties benefit from reduced deep flooding; this increases to six properties during a 1 in 50 yr ARI rainfall event. Figure 14-1 below depicts deep flooding (> 300 mm deep) in the Glen Road / South Road area during the 1 in 50 yr ARI rainfall event currently (blue) and with this option in place (yellow).



Figure 14-1: Upper Catchment Detention Effects – Current 1 in 50 yr ARI Rainfall Event

O7: Flood Management Strategy - Shortlist

Preliminary analysis of this option was not undertaken, as there would be no change to the predicted flooding in the area, however a reduction of risk would take place due to the existence of a strategy for flood management.



14.2.1.2 South Road Commercial Area

Predicted manhole overflows at the South Road / Laing Street intersection results in deep flooding in the South Road commercial area. Use of local pipe upgrades (option O8) resulted in transferred flooding downstream, however option O9 (detention) provided some flood relief, particularly when combined with some minor pipe upgrades. Therefore, further evaluation of these options is not required, and option O9 is the preferred solution in this instance.

Flooding from the surcharging manhole is eliminated with this option, also preventing flows entering the South Dunedin catchment, however the option requires provision of approximately 900 m³, and would be expensive. Predicted deep flooding in the area would be reduced by approximately four land parcels, therefore unless the effects on the South Dunedin catchment are found to be significant, this option would not be recommended.

14.2.1.3 Caversham Bypass Motorway

The predicted flooding along the Caversham Bypass Motorway is predominantly a result of significant overflows at two manholes on Barnes Drive, from which stormwater then flows down the embankment south of Barnes Drive and accumulates on the northern lanes / verge of the motorway. Several potential options exist to reduce the flooding along the Caversham Bypass Motorway, including pipe upgrades and storage / detention devices. Pipe upgrades in the vicinity transfer flows downstream, to the South Road commercial area, which is already the subject of flooding. If this option were pursued, it would need to be in combination with upgrades / detention in the South Road commercial area.

However, due to a lack of information relating to motorway drainage, and current modifications to the motorway, it is recommended that these options only be pursued once information regarding the motorway drainage is confirmed.

14.2.2 Shortlist Options Evaluation

14.2.2.1 Glen Valley / South Road

A number of options were modelled to determine the effect on the deep flooding predicted at South Road beneath the Caversham Valley Motorway and throughout the Glen Valley sub-catchment. Of the four options modelled, only one (option O4 – installation of pump(s) at the outfall) failed to significantly reduce flooding. The remaining three options are technically feasible and suitable for full comparison. Refer Table 14-2.



Table 14-2: Shortlist Option Comparison

QBL Assessment Criteria	Category Weighting	Sub- weighting	Option		
			O3 Local Pipe Upgrades	O6 Upper Catchment Storage	O7 Flood Management Strategy
Removal of known wastewater cross connections	10	N/A	N/A	N/A	N/A
Contaminant Reduction		1.67	-10	-5	-10
Use of Source Control / LID		1.67	-10	-5	-10
I&I reduction		1.67	0	0	0
Construction effects		1.67	5	-5	10
Replication of current flow patterns		1.67	-10	0	-10
Option flexibility		1.67	0	0	-10
Interest / support of community / social interest groups	10	10	0	5	0
Fit with Māori cultural values	10	10	-5	-5	0
Risk of operational failure	20	20	10	5	10
Estimated Capital Cost - order of magnitude (note does not allow for internal costs)	10	2.5	5	0	10
Risk of cost escalation due to construction unknowns		2.5	10	-5	10
Risk of land availability		2.5	10	0	10
Risk of protracted consent process with authorities		2.5	10	0	10
Risk Reduction	30	7.5	-5	0	-5
Deep flooding 1 in 50 yr future-current		7.5	5	10	0
Manholes overflowing 1 in 10 yr - future-current		7.5	5	5	-5
Improvement in level of service		7.5	5	10	0
Weighted Total Score:			271	250	175



15 Option Selection

15.1 Approaches for Active Management

The issues that have been prioritised in the Orari Street catchment as requiring 'active management' are identified below. A number of different options were considered relating to the deep flooding issue, however the majority of the other options did not have feasible alternatives, and all options presented have been recommended.

- Deep Flooding;
- Limited Confidence in Knowledge of Effects on the Otago Harbour Environment;
- Blocking / Maintenance of Intake Structures;
- High Variability of Stormwater Quality Results;
- Low Confidence in Model;
- Flood Hazard – Current and Future (1 in 100 yr ARI);

The following options have been recommended:

- Deep Flooding - in terms of resolving deep flooding issues in the catchment, the local upgrades on the corner of Leckhampton Court and South Road have the greatest improvement on current, high frequency flooding. It is possible that slight modifications to this design could result in improved performance for future and larger events also. To resolve both low and high frequency flooding, upper catchment detention along with these local upgrades could be considered. Detention, however, would be significantly more expensive than local upgrades.
- Undertake watercourse inspections, to record status of watercourse environment and current maintenance levels, and create an inventory of stormwater structures. Assess watercourses for opportunities to provide both stormwater quantity and quality benefits, and to provide enhanced amenity values.
- Liaise with stakeholders regarding amenity values of watercourses.
- 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.
- Replace the screen at 91 Glen Road with a design less prone to blockage.
- Redesign and implement the city-wide framework for stormwater quality and harbour environment monitoring, including provision for 'baseline' monitoring in the Orari Street catchment.
- Increase hydraulic model confidence in The Glen Valley, South Road commercial area and around the Caversham Bypass Motorway, via survey, data collection and / or flow monitoring and calibration.



- Develop an emergency response plan to re-route traffic during extreme rainfall events, and identify vulnerable properties.
- Provide information regarding predicted future flooding to the climate change adaptation team.

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

15.2 Approaches for Passive Management

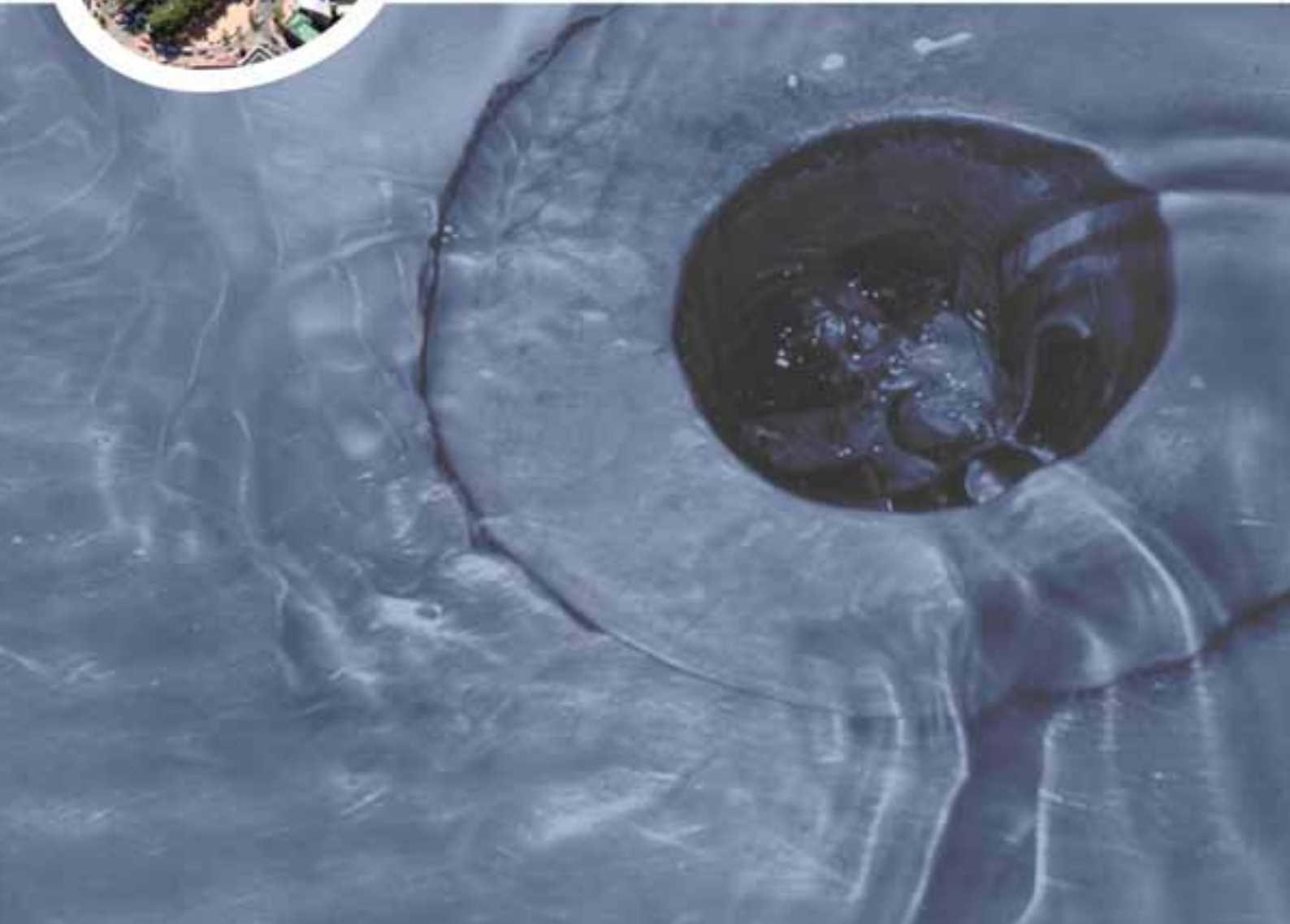
A number of other issues that have been prioritised as requiring 'passive' management will have targets achieved through measures already in place, or via the options identified for other issues in the catchment. The following options have also been identified to aid management of some of these issues:

- Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.
- Develop list of key stormwater structures for more regular cleaning as part of existing and / or future maintenance contracts, incorporating The Glen Intake, 80 Neidpath Road, and the Intake Structure at 91 Glen Road.
- Consider prioritisation of watercourse intakes and culverts for replacement / upgrade under the pipe renewals programme.
- Utilise ROS information to continuously gauge customer satisfaction with the stormwater service.
- Identify and undertake floor level survey and damage assessment of properties 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.
- Review flood hazard in South Dunedin catchment, incorporating effects from the Orari Street catchment.



Part 6

Way Forward





16 Recommendations

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

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

Table 16-1: Further Study Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
210	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
160	Redesign the city-wide framework for stormwater quality and harbour environment monitoring.	\$ 20 k	3 - 6 months
120	Increase hydraulic model confidence in The Glen Valley, South Road commercial area and around the Caversham Bypass Motorway, via survey, data collection and / or flow monitoring and calibration.	\$ 50 - \$ 100 k	12 months
40	Utilise stormwater complaints and ROS information to continuously gauge customer satisfaction with the stormwater service.	\$ 0	Ongoing



Table 16-2: Planning and Education Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Review the education / advice provided to property owners responsible for watercourses to ensure adequate information and assistance is provided.	\$ 0	3 - 6 months
80	Contribute information to a city-wide climate change adaptation plan.	\$ 0	6 - 12 months
80	Develop an emergency response plan to re-route traffic during extreme rainfall events, and identify vulnerable properties.	\$ 0	3 - 6 months
40	Review business processes to ensure subdivision and development incorporates catchment specific requirements per the relevant ICMP.	\$ 0	2 months
30	Review flood hazard in South Dunedin catchment, incorporating effects from the Orari Street catchment.	\$ 10 - \$ 20 k	2 months

Table 16-3: Operation and Maintenance Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
160	Ensure damaged screens and / or intake structures on open channels and watercourses are replaced or repaired.	tba	Ongoing
160	Implement the revised city-wide monitoring framework.	\$ 25 k	Annual
50	Compile an inventory of all stormwater structures including asset condition, ownership and identify key locations for more frequent cleaning and maintenance.	\$ 5 k	2 months
50	Undertake a city-wide review of all current contracts for maintenance of stormwater structures; documenting scope and standards.	\$ 20 k	2 months

Table 16-4: Capital Works Recommendations

Risk Matrix Score	Task	Budget Cost	Work Period
210	Undertake local pipe and catchpit upgrades in South Road / Leckhampton Court area.	\$ 200 k	6 months
160	Replace the screen at 91 Glen Road with a design less prone to blockage.	\$ 10 k	1 month
40	Progressively upgrade intakes / culverts in upper network.	\$ 200 k	Ongoing



17 Implementation, Monitoring and Continuous Improvement of the ICMP

17.1 Implementation

As detailed in Section 1 of this report, there are a number of DCC documents that 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, and may either be minor updates or major changes as follows:

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



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