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Town of Lake Cowichan Integrated Rainwater Management Plan - 2014

FINAL
Volume 1 - Report
June 2015 – Rev 0
KWL Project No. 2218.007

Prepared for:

Town of Lake Cowichan



Prepared by:

Craig Sutherland, P.Eng.

June 19, 2015

Mr. Joseph Fernandez, CAO
Town of Lake Cowichan
P.O. Box 860
39 South Shore Road
Lake Cowichan, BC V0R 2G0

Dear Mr. Fernandez:

**RE: TOWN OF LAKE COWICHAN
Integrated Rainwater Management Plan - 2014
Our File 2218.007**

We are pleased to submit to the Town of Lake Cowichan two hard copies and one electronic copy (PDF on a USB drive) of the KWL report *Integrated Rainwater Management Plan - 2014*.

Working on this project has been a rewarding experience and we appreciate you and your team's efforts and comments that have been invaluable for the completion of this report. We trust this report is sufficient for your needs, please contact the undersigned at 250-595-4223 should you have any questions or comments.

Yours truly,

KERR WOOD LEIDAL ASSOCIATES LTD.



Craig Sutherland, P.Eng.
Project Manager

CS

Encl.

cc: Nagi Rizk



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Executive Summary

The Town of Lake Cowichan (the Town), located approximately 30 km west of Duncan, is located at the headwaters of the Cowichan River at the eastern end of Cowichan Lake. The current population of Lake Cowichan is approximately 3,015 people (2008 – Statistics Canada Report).

The Town initiated this Integrated Rainwater Management Plan (IRMP) to:

- Develop a better understanding of the capacity of the existing storm drain network;
- Address known flooding and erosion concerns;
- Address water quality concerns to protect habitat quality of watercourses and receiving waters of Cowichan Lake and Cowichan River; and
- Review current Town plans, bylaws and standards to improve how rainwater is managed in the future.

IRMP Goals

The primary objective of this IRMP is to develop on-the-ground solutions to rainwater management problems guided by the principles in the community planning documents and regional guidelines. There are three primary objectives:

1. Protection of public safety and private/public property from flooding;
2. Reduction of runoff volumes and peaks to minimize erosion and protect downstream aquatic habitat; and
3. Improvement to rainwater runoff quality for both ecosystems and human health.

Key Issues in Town of Lake Cowichan

Some of the key rainwater management issues, in no particular order, include:

1. Relatively frequent flooding (ponding and overland flooding) in certain locations within the Town boundary;
2. Limited records on the location or condition of storm drain system;
3. Concerns with regard to stormwater contamination impacting fish habitat in Cowichan Lake, Cowichan River and their tributaries;
4. Potential impact of future development and densification peak runoff thus increasing erosion potential in tributary streams;
5. Traditional drainage focused subdivision and development standards without any specific criteria for rate and volume control and water quality treatment; and
6. Encroachment of existing developments into the riparian zone.

The purpose of this IRMP is to address these issues in an integrated fashion by identifying both capital improvement projects and planning initiatives which can be implemented over time to address concerns.

Rainwater Management Criteria

The first step in development of the IRMP is to establish criteria by which the both existing drainage system is to be evaluated and future rainwater management facilities are to be designed. Traditional stormwater management facilities were designed to convey only the large infrequent rainfall events such as the 10-year return period. New rainwater management approaches provide criteria to manage the full range of rainfall



events with treatment of frequently occurring rainfall events to protect water quality and instream habitat and minimize erosion to conveyance of infrequent large and extreme rainfall events to protect life and property from flooding and public safety. The following criteria are based on review of current Town standards and criteria selected from the *Stormwater Planning Guidebook*, MOE (2002 and updated in 2007), and *Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development in BC*, MOE, 2012.

Summary of Rainwater Management Criteria

Application		Criteria/Methodology	Reference
Flood Protection	Minor Drainage System	<ul style="list-style-type: none"> 10-year return period design event for storm mains less than or equal to 900 mm diameter.¹ 25-year return period design event for storm mains greater than 900-mm diameter.¹ 	Sections 4.4 and 5.3 ¹
	Major Drainage System	<ul style="list-style-type: none"> 100-year return period design event for major watercourse culverts crossing Highway 18, Lake Cowichan Way and South Shore Drive.² 	Sections 4.4 and 5.3 ²
Environmental and Erosion Protection	Volume Reduction (Source Controls)	<ul style="list-style-type: none"> On-site rainfall capture (runoff volume reduction) for 72% of 2-year 24-hour storm).³ 	Section 7.3 ³
	Water Quality Treatment	<ul style="list-style-type: none"> 90% of the average annual runoff (72% of the 2-year 24-hour storm) 	Section 7.3 ³
	Rate Control (Detention/Diversion)	<ul style="list-style-type: none"> Control post-development flows to pre-development levels for 6-month, 2-year 24-hour events.³ 	Section 7.3 ³
	Riparian	<ul style="list-style-type: none"> Establish and protect riparian setbacks.⁴ 	Section 7.5

1. The Town of Lake Cowichan Staff Discussions;
 2. BC Ministry of Transportation Supplement to Transportation Assoc. of Canada Geometric Design Guide, 2007.
 3. Stormwater Planning: A Guidebook for British Columbia, 2002; Beyond the Guidebook - June 2007
 4. British Columbia *Riparian Areas Regulation*, 2006.

Findings and Recommendations

The following summarizes the findings and recommendations for each of the three primary goals of the IRMP:

Protection of Public Safety and Property from Flooding

- Stormwater modelling indicates that approximately 10 km of existing storm drain system, or approximately 25% of the system, is undersized with respect to the drainage criteria for flood protection.
- The design precipitation intensities used in this study are between 10% to 25% greater than those provided in the original Lake Cowichan IDF curves. This is likely the primary reason why a relatively large percentage of the drainage system is undersized. The increase in design precipitation intensities is due to the fact that the original IDF curves were based only on rainfall data from March to October and did not include precipitation during higher rainfall periods from November to February.
- The total capital cost to upgrade the drainage system to meet drainage criteria is estimated to be approximately \$4.1 million (2014).
- Modelling assumes that full pipe capacity is available. However, limited CCTV inspections carried out indicate that some of the pipe network is partially blocked with debris and sediment.



- Continue CCTV inspection and stormwater flushing program to review current condition of storm drain network to prioritize improvements and to improve capacity of the existing network.
- Where possible, integrated storm drain improvements with other infrastructure improvement projects such as watermain upgrades, road upgrades or sanitary sewer upgrades.

Protection of Stream and Riparian Habitat

- A rainwater management bylaw should be developed and adopted which require capture and infiltration of the 6-month, 24-hour return period storm event (72% of 2-year return period, 24-hour event equal to 63 mm of rainfall) and require 2-year, 24-hour return period detention as part of future subdivision or land redevelopment (building permit); and for areas draining to watercourses only.
- A preliminary review indicates that soils underlying the Town are generally well draining and suitable for infiltration of rainwater. Site specific infiltration tests should be required as part of design of rainwater management systems.
- Assuming an infiltration rate of 25 mm/hr, the estimated rain garden size per unit of impervious area is estimated to be 584 m²/ha of impervious area with a requirement for 670 m³/ha impervious area of capture volume.
- Adoption of a “Green Roads Policy” which would require development of rainwater treatment facilities as part of municipal road upgrades to protect water quality in receiving waters.
- Implement and enforce the requirements of the Riparian Areas Regulation, as part of new development or re-development of lands located adjacent to watercourses identified in the habitat inventory (see Figure 3-1) and any other open channel watercourses identified by Qualified Environmental Professional as part of site specific review.

Protection of Water Quality

- The requirements for capture and infiltration of the 6-month, 24-hour return period storm event under a new rainwater management bylaw would also address water quality protection for new developments.
- Water quality from existing development should be addressed through implementation of a Liquid Waste Management Plan (LWMP). However, some actions that could be taken prior to adopting a LWMP are:
 - Require sediment and water management BMPs to be implemented during construction and site development;
 - Street sweeping and catch basin cleaning programs;
 - Public education, outreach and contractor education programs;
 - Develop emergency spill response plans for both municipal activities as well as private construction or site redevelopment;
 - Use of structural BMPs (such as oil/grit separators) for protection of water quality where appropriate;
 - Develop and implement a cross-connection prevention program; and
 - Reduction or elimination of pesticide and herbicide use.
- Some of these actions could be formalized through adoption of a Rainwater Quality Bylaw similar to the Capital Regional District Model Stormwater Bylaw which prohibits dumping deleterious materials into the storm drain system.



1. Introduction

1.1 Background

The Town of Lake Cowichan (Town) is located in the Cowichan Valley on southern Vancouver Island, approximately a thirty minute drive west of Duncan. The current population of Lake Cowichan is approximately 3,015 people (2008 – Statistics Canada Report).

The Integrated Rainwater Management Plan (IRMP) study area, as shown in Figure 1-1, is located to the north and south of the town and is bounded by the hills to the north of Youbou Road, Cowichan Lake to the west, Kwassin Lake to the East and the hills to the east of South Shore Road.

The creeks and streams within the study area drain into Cowichan River which runs southeasterly from Cowichan Lake, through the town, and discharges to Cowichan Bay.

The study area watersheds are approximately 1,932 ha, of which 405 ha is within the Lake Cowichan town boundary. The remaining 1,527 ha is outside the town boundary. The watersheds within the town boundary are presently subject to a range of urban development, while the watersheds outside of the town boundary are relatively undeveloped and naturally forested. The study area and watershed boundaries are shown in Figure 1-1.

Integrated Rainwater Management Planning Objectives

As an acknowledged partner in the development of *Beyond the Guidebook 2010* prepared by Convening for Action on Vancouver Island partnership, the Town is committed to sustainable rainwater management practices. This commitment is also outlined in other local planning documents such as the recently updated *2011 Official Community Plan (OCP)* and the *2007 Cowichan Basin Water Management Plan (CBWMP)*.

Chapter 4 of the OCP outlines the importance of the natural environment and its stated goal is:

To preserve, maintain and enhance areas which are of natural, scenic, cultural, heritage and recreational value.”

The objectives of *Chapter 4, The Natural Environment* related to rainwater management of the OCP include:

- 4.3 a) *“To identify, protect and enhance natural areas, including stream corridors, for the long term benefit of natural ecosystems, including fish, wildlife and plant habitat.”*
- 4.3 c) *“To reduce and prevent air, land and water Pollution.”*
- 4.3 d) *“To maintain the water quality of Cowichan Lake and the Cowichan River.”*
- 4.3 f) *“To ensure a healthy water balance approach to rainwater management for all development.”*

Several of the objectives outlined in the CBWMP are also related integrated rainwater management, the most specific being:

Objective 2d. Protect surface and ground water resources from contamination that could reduce supply.

Action 2d-1: “Implement Best Management Practices (BMPs) for stormwater management and protection of ground water resources in the Cowichan Basin.”

Objective 4e. Promote stormwater management that emphasizes infiltration and detention and minimizes impervious surfaces to avoid increases in peak flows.

4e-1. Install appropriate stormwater management infrastructure based on Low Impact Development 4e-1. Install appropriate stormwater management infrastructure based on Low Impact Development (reduced runoff, on-site infiltration) in new developments, and retrofit existing developments to reduce peak runoff consistent with the FDMP.

4e-2. Adopt subdivision or development services bylaws and Official Community Plan policies based on Low Impact Development principles.

Although these planning documents provide policy level guidance on rainwater management, a more detailed plan is required for implementing rainwater management at the community level.

The primary objective of this IRMP is to develop on-the-ground solutions to rainwater management problems guided by the principles in the community planning documents and regional guidelines. Typically a rainwater management plan has three primary objectives:

1. Protection of public safety and private/public property from flooding;
2. Reduction of runoff volumes and peaks to minimize erosion and protect downstream aquatic habitat; and
3. Improvement to rainwater runoff quality for both ecosystems and human health.

1.2 Key Issues

Some of the key rainwater management issues in the Town include:

1. Relatively frequent flooding (ponding and overland flooding) in certain locations within the Town boundary;
2. Limited records on the location or condition of storm drain system;
3. Concerns with regard to storm water contamination impacting fish habitat in Cowichan Lake, Cowichan River and their tributaries;
4. Potential impact of future development and densification peak runoff thus increasing erosion potential in tributary streams;
5. Traditional drainage focused subdivision and development standards without any specific criteria for rate and volume control and water quality treatment;
6. Encroachment of existing developments into the riparian zone.



Frequent flooding at corner of Cowichan and Pine Street due to inadequate drainage

1.3 Scope of Assignment and Major Tasks

In May 2013, Kerr Wood Leidal Associates (KWL) was retained by the Town to prepare an IRMP. The scope of the project included:

1. Completing the inventory of stormwater sewer and drainage network within the Town and preparing network map, GIS database and CCTV camera inspections of major trunk stormwater systems;



2. Carrying out a habitat inventory to identify and map condition of aquatic and riparian habitat features;
3. Developing a hydrologic/hydraulic model to test existing and future land use scenarios for full spectrum of rainfall events. Quantifying the impacts of proposed development and assessing the adequacy of the existing drainage system to minimize flooding and erosion;
4. Recommending mitigation measures/rainwater management facilities for flow reduction and control and water quality improvement using local precipitation and soil conditions;
5. Reviewing community bylaws and land-use planning documents to recommend changes and updates such that impacts of development and/or redevelopment are minimized with the focus on rainwater management practices;
6. Reviewing Municipal Engineering Standards to make recommendations on incorporating rainwater management measures both during construction and permanent facilities;
7. Assessing existing stormwater drainage facilities for flood conveyance and recommended capital improvements; and
8. Developing an IRMP that outlined the overall strategy for the Town and an implementation strategy that outlines priorities, costs and responsibilities. Recommendations should also be integrated with other community plans such as park improvements or transportation upgrades.

Table 1-1 summarizes the major tasks involved in undertaking this study.

Table 1-1: Project Work Program

Task No.	Major Tasks
1	Drainage Inventory and GIS Database Set-Up
1.1	Site Visit and Survey
1.2	CCTV Camera Inspections
1.3	CCTV Inspection Quality Review
1.4	Drainage Inventory Mapping
2	Habitat Inventory
2.1	Site Visit/Field Review
3.2	Habitat Inventory Mapping
3	Hydrologic Model Set-up
3.1	Catchment Delineation and Development of Existing and Future Land-Use Maps
3.2	Set-Up PC-SWMM Model Network
3.3	Develop Design Storm Events
3.4	Existing Land-use Models – 10-year, and 100-year Return Period
3.5	Future Land-use Models – 10-year, and 100-year Return Period



Task No.	Major Tasks
4	Small Rainfall Event Management – Lot/Neighbourhood-Scale Rainwater Management Facility Sizing
4.1	Establish maximum lot coverage, regional rainfall and soils information
4.2	Size typical rainwater management facilities
4.3	Typical Rainwater Management Details
5	Large Rainfall Event Management – Stormwater Drainage Master Planning
5.1	Drainage Network Capacity Review
5.2	Conceptual (Class D) Cost Estimates for Drainage Improvements
5.3	Climate Change Impacts
6	Land-use Planning, Bylaws and Standards Review
6.1	Bylaws and Planning Documents
6.2	Engineering Standards
7	Integrated Master Drainage Plan Reporting
7.1	Identification of Specific Drainage Improvement Projects
7.2	Implementation Plan
7.3	Draft Plan Report
7.4	Final Plan Report
8	Meetings and Project Management
8.1	Meetings
8.2	Project Management

1.4 Rainwater Management Criteria

The criteria applicable to this study were derived from:

- The Town Staff Discussions;
- BC Ministry of Transportation Supplement to Transportation Assoc. of Canada Geometric Design Guide, 2007;
- Stormwater Planning: A Guidebook for British Columbia, 2002;
- Beyond the Guidebook – Context for Rainwater Management and Green Infrastructure in British Columbia, 2007; and
- Develop with Care 2012: Environmental Guidelines for Urban and Rural Land Development in BC, MOE, 2012; and
- British Columbia Riparian Areas Regulation, 2006.



The rainwater criteria required to meet the goals of the Town and the IRMP are set out in Table 1-2.

Table 1-2: Summary of Rainwater Criteria

Application		Criteria/Methodology
Flood Protection	Minor Drainage System	<ul style="list-style-type: none"> 10-year return period design event for storm mains less than or equal to 900 mm Diameter.¹ 25-year return period design event for storm mains greater than 900-mm Diameter.¹
	Major Drainage System	<ul style="list-style-type: none"> 100-year return period design event for major watercourse culverts crossing Highway 18, Lake Cowichan Way and South Shore Drive.²
Environmental and Erosion Protection	Volume Reduction (Source Controls)	<ul style="list-style-type: none"> On-site rainfall capture (runoff volume reduction) for 72% of 2-year 24-hour storm).³
	Water Quality Treatment	<ul style="list-style-type: none"> 6-month 24-hour storm (72% of the 2-year 24-hour storm)
	Rate Control (Detention / Diversion)	<ul style="list-style-type: none"> Control post-development flows to pre-development levels for 6-month, 2-year 24-hour events.²
	Riparian	<ul style="list-style-type: none"> Establish and protect riparian setbacks.⁴

1. The Town of Lake Cowichan Staff Discussions;
 2. BC Ministry of Transportation Supplement to Transportation Assoc. of Canada Geometric Design Guide, 2007.
 3. Stormwater Planning: A Guidebook for British Columbia, 2002; Beyond the Guidebook - June 2010
 4. British Columbia *Riparian Areas Regulation*, 2006.

1.5 Previous Studies and Background Information

Several previous studies and plans provided guidance and background to the development of the IRMP, they are as follows:

Table 1-3: Summary of Background Material

Year	Title
2011	Town of Lake Cowichan Official Community Plan
2010	Beyond the Guidebook 2010: Implementing a New Culture for Urban Watershed Protection and Restoration In British Columbia
2007	Cowichan Basin Water Management Plan
1976	The Town of Lake Cowichan Subdivision Bylaw No. 276

1.6 Project Team

The study was led and directed by the following Town of Lake Cowichan staff:

- Joseph Fernandez, Chief Administrative Officer; and
- Nagi Rizk, Superintendent, Public Works and Engineering Services.



The consulting project team is outlined below:





Table 1-4: Project Team

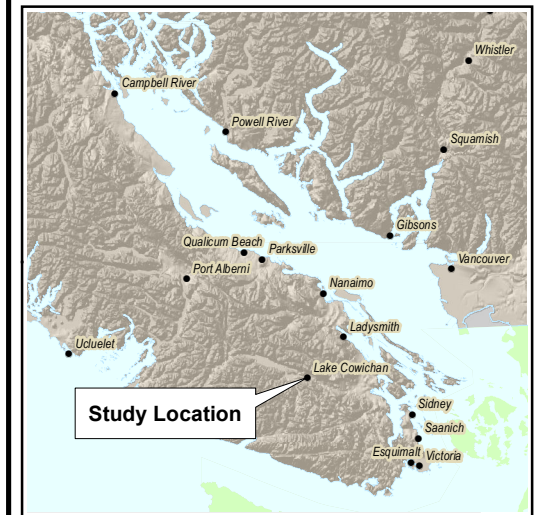
Company	Team Members
Kerr Wood Leidal Associates Ltd. (KWL)	Crystal Campbell, P.Eng. – Technical Review Craig Sutherland, P.Eng. – Project Manager David Lee, P.Eng. – Project Engineer Aidan Hough, E.I.T. – Modeller Max Scruton, E.I.T. – Modeller Peter Collins, Technologist – Drainage Inventory Jack Lau, AScT – GIS/Mapping
Swell Environmental Consulting Ltd. (Swell)	Lehna Malmkvist, R.P.Bio – Project Biologist/Ecologist Sara Stallard, AScT – Environmental Technologist

No external stakeholder or public consultation was conducted during this study, however, the main guiding principles were based on those established during the OCP processes that had stakeholder and public input.

**Town of Lake Cowichan
Integrated Master Drainage Plan**

Legend

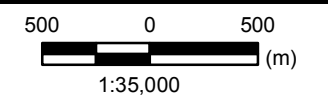
-  Municipal Boundary
-  Area of Study Focus
-  Study Watershed Boundary
-  Watercourse



Reference:
Service Layer Credits:
GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.



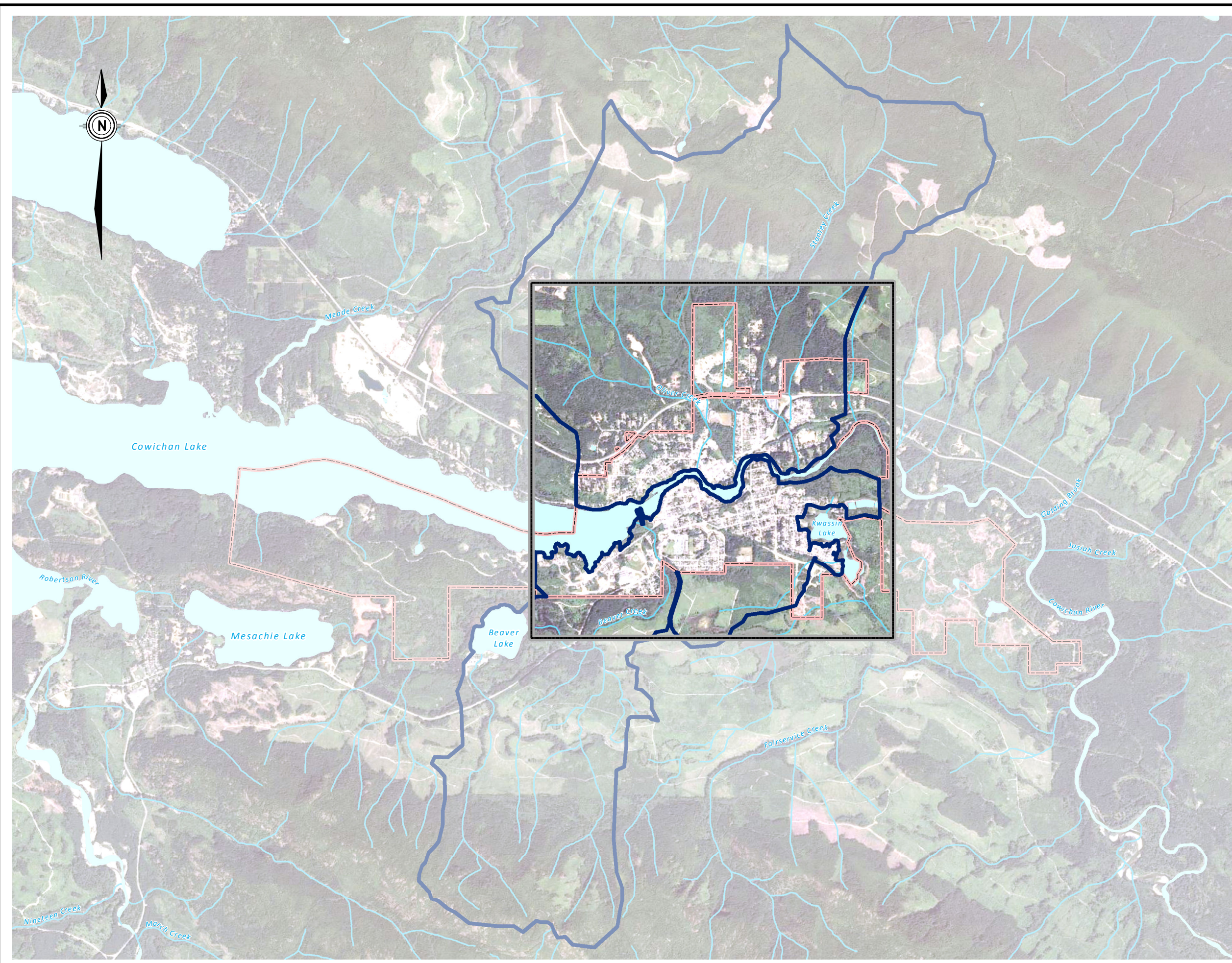
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Project No. 2218-007	Date December 2014
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Study Area

Figure 1-1



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 Author: JIau



2. Overview of the IRMP Study Area

2.1 Introduction

This section describes the Town study area, including:

- Description of the drainage patterns;
- Existing and future land uses; and
- Drainage and hydrogeology inventory.

2.2 Study Area Characteristics

Land Use

Although the Town municipal boundary extends from Lakeview Park in the west to east of Kwassin Lake. The primary focus of the IRMP is the built up area within the Town boundary from Point Ideal in the east to Kwassin Lake in the west. The limits of the focus area are shown in Figure 1-1.

The study area watersheds are approximately 1,932 ha, of which 405 ha is within the Town boundary. The remaining 1,527 ha is outside the Town boundary. The watersheds within the Town boundary are reasonably developed with a total impervious area coverage of approximately 39%. Impervious area is defined as the surface area that rainwater cannot permeate into the ground such as paved areas, roads and building roof areas. This area was calculated based on available digital air photos from 2010 and based on typical impervious area percentages for various land use types and the current (2006) zoning mapping.

The areas within the watersheds outside the Town boundary lie within lands within the jurisdiction of the Cowichan Valley Regional District and are for the most part private forest lands with some larger rural residential lots.

Watershed and Creek Characteristics

A number of background reports and GIS layers were available for the study. This data was supplemented by drainage system and environmental field inventories. Table 2-1 summarizes the key study area characteristics.

Table 2-1: Drainage Overview

Description	Lake Cowichan Study Area
Drainage Area	<ul style="list-style-type: none">• 1,932 ha total, including:<ul style="list-style-type: none">◦ 405 ha in the within the town boundary (21% of the watershed)
Stream Structure	<ul style="list-style-type: none">• 8 km watercourses. Figure 1-1 shows the Cowichan River and the main watercourses within the study area.
Topography	<ul style="list-style-type: none">• Topography ranges from El. 1040 m (in the hills to the north of the study area) to El. 160 m (along the banks of Cowichan River)



Description	Lake Cowichan Study Area
Land Use	<p>Existing – based on 2006 Zoning Bylaw and 2010 Air Photo (within the town boundary):</p> <ul style="list-style-type: none"> • 2.1% General Commercial, 0.3% Mixed Use Commercial, 0.02% Local Commercial, 1.1% Lakefront and Riverfront Commercial, 0.02% Business Commercial, 2.2% Comprehensive Development, 9.91% Public Use (Parks and Institution), 38.6% Urban Residential, 13.1% Single Family Residential, 10.22% Suburban Residential, 3.8% Multi-Family Residential, 1.1% Modular Home Residential and 17.5% Road Right Of Way • Study Area within Town Boundary Total Impervious Area (TIA) is 39%. • Overall Study Area TIA is 14%. <p>Future – based on current (2011) OCP (within the town boundary):</p> <ul style="list-style-type: none"> • 54.1% Urban Neighbourhood, 17.5% ROW, 7.9% Urban Neighbourhood Compact, 7.3% Parks and Open Space, 7.3% Institutional, 3.0% Downtown, 2.6% Urban Reserve/Comprehensive Development Area and 0.3% Highway Commercial • Study Area within Town Boundary TIA is 62% <p>Figure 2-1 shows existing zoning, Figure 2-2 shows the existing 2010 land use percentage impervious, Figure 2-3 shows future OCP land use zoning and Figure 2-4 shows the future OCP land use zoning percentage impervious.</p>
Drainage	<ul style="list-style-type: none"> • The creeks and streams within the study area drain into the Cowichan River which runs southeasterly from Cowichan Lake, through the town, and discharges to Cowichan Bay. • There are 58 known storm drain and watercourse outfalls flowing into Cowichan Lake and the Cowichan River. Existing storm sewers range in size from 150 mm to 900 mm.
Soils	<ul style="list-style-type: none"> • Well-Draining Soils. Figure 2-5 shows the soil classification based on available mapping.
Hydraulic Structures	<ul style="list-style-type: none"> • System includes 17 km of conduits • 483 conduits and 360 manholes were modelled • 87 Culverts <p>Figure 2-6 shows an overview of the drainage system.</p>

2.3 Existing and Proposed Future Land Use

Existing Land Use

The current land use within the Town boundary is mostly urban residential, single-family residential, commercial and public use parks. Undeveloped parcels make up the majority of the land outside the town boundary within study area. The existing land use is based on zoning outlined in Town Zoning Figure (2006) shown in Figure 2-1 and checked with air photography (2010).



The majority of the watershed within the town boundary is at least partially developed, primarily consisting of residential properties. Treed areas of the watershed include land surrounding Fern Road, Alder Street, Hobson Avenue and Grosskleg Way. The watersheds also include land uses consisting of general, mixed use and local commercial properties.

The majority of residential and commercial developments along Cowichan River are located within the foreshore watershed and drain directly to the river.

The existing land use percentage impervious coverage is shown in Figure 2-2.

Table 2-2: Existing Land Use within Municipal Boundary

Land Use Type	Area (ha)	Percentage Area Within Town Boundary ₁	Average Impervious Percentage (TIA) ₂
Urban Residential	156.5	38.6%	41%
Single Family Residential	53.2	13.1%	33%
Suburban Residential	41.4	10.2%	5%
Multi-Family Residential	15.5	3.8%	19%
Modular Home Residential	4.4	1.1%	49%
General Commercial	8.5	2.1%	74%
Mixed Use Commercial	1.0	0.3%	40%
Local Commercial	0.1	0.0%	90%
Lakefront and Riverfront Commercial	4.6	1.1%	50%
Business Commercial	0.1	0.0%	60%
Comprehensive Development	8.7	2.2%	17%
Public Use (Parks and Institution)	40.2	9.9%	34%
Road Right Of Way	71.1	17.5%	70%
TOTAL	405.2	100%	40%

Note:

1. Values based on Town Of Lake Cowichan Zoning layer (2006) and digital air photos provided from Cowichan Valley Regional District 2010.
2. TIA based on typical percent impervious area values for land-use types.

Future Land Use

Proposed land use in the watershed is defined by the recently adopted OCP (2011). The only major exceptions are development and in-fill of parcels that are already zoned for development.

Existing approved development will provide for approximately 380 additional dwelling units: a 7-to-11 year supply. Additionally, there is sufficient zoned land to accommodate an additional 4,700 units at maximum permitted densities.

Impervious areas are expected to increase on average based on development for currently vacant land and re-development of existing single family residential to higher density (and higher impervious land-cover) usage.



Table 2-3 and Figure 2-4 show the proposed future OCP land use and the percentage impervious values for each land use.

Table 2-3: Future Land Use within Municipal Boundary

Land Use Type	Area (ha)	Percentage of Area Within Town Boundary	Average Impervious Percentage (TIA)
Downtown	12.2	3.0%	90%
Highway Commercial	1.4	0.3%	90%
Institutional	29.4	7.3%	70%
Parks and Open Space	29.7	7.3%	20%
Urban Neighbourhood	219.1	54.1%	60%
Urban Neighbourhood Compact	32.0	7.9%	70%
Urban Reserve/Comprehensive Development Area	10.6	2.6%	70%
Road Right Of Way	70.8	17.5%	70%
TOTAL	405.2	100.0%	62%
Note: 1. Values based on Town Of Lake Cowichan Zoning layer (2006) and digital air photos provided from Cowichan Valley Regional District 2010. 2. TIA based on typical percent impervious area values for land-use types.			

The projected increase in total impervious area (TIA) from existing to future land use is:

40% (Existing - 2010) ⇒ 62% (Future - OCP)

These impervious area values are based on an amalgamation typical land use values and of GIS analysis of air photos to assess typical impervious coverage for older existing versus new and changing land use in the Town.

2.4 Surficial Geology

The surficial geology characteristics for the study area were obtained from the *Soils of South Vancouver Island, Soils Survey Report No. 44*. This map suggests that the Lake Cowichan study area is underlain principally by well-draining Moraine and Colluvium soils. Refer to Figure 2-5 for soils mapping.

While the soils information available must be considered approximate only, it indicates that the watersheds are underlain by rapid to well drained soils, which are beneficial for infiltration of rainwater.

2.5 Drainage Inventory

Storm Drain System Mapping

Mapping of the Town’s storm drain system is based on data collected by KWL staff since 2008. The locations of manholes, catch basins and outlets were collected using handheld Trimble GPS with horizontal accuracy of +/- 1 m. The diameter, depth to invert from the cover rim and azimuth (compass bearing) of outlet and inlet pipes were recorded for each point. Where possible, pipe materials were also recorded. The field log of the collected storm drain system is included in Appendix A under separate cover.

LiDAR topographic mapping of the Town has been used to establish manhole or catch basin cover elevations. The depth to invert distances recorded in the field was then used to derive invert elevations of the drainage system, such that:

1. Elevation of Manhole Cover (from LiDAR mapping) – Depth to Invert (from field measurement) = Elevation of pipe invert
2. The accuracy of the LiDAR mapping is about +/- 0.1 m vertical

A map of the known storm drain system is shown in Figure 2-6. It should be noted that there remains some small portions of the storm drain system that could not be confirmed as part of this study. Assumptions have been made for these areas as outlined in the drainage assessment in Section 4.

The mapping confirmed that the Town has 58 known storm drain outfalls. The majority of the outfalls flow directly into Cowichan Lake, Cowichan River or Kwassin Lake with a small number of outfalls flowing into tributary streams. The sub-catchment areas for the storm drain system are shown in Figure 2-7.

CCTV Review

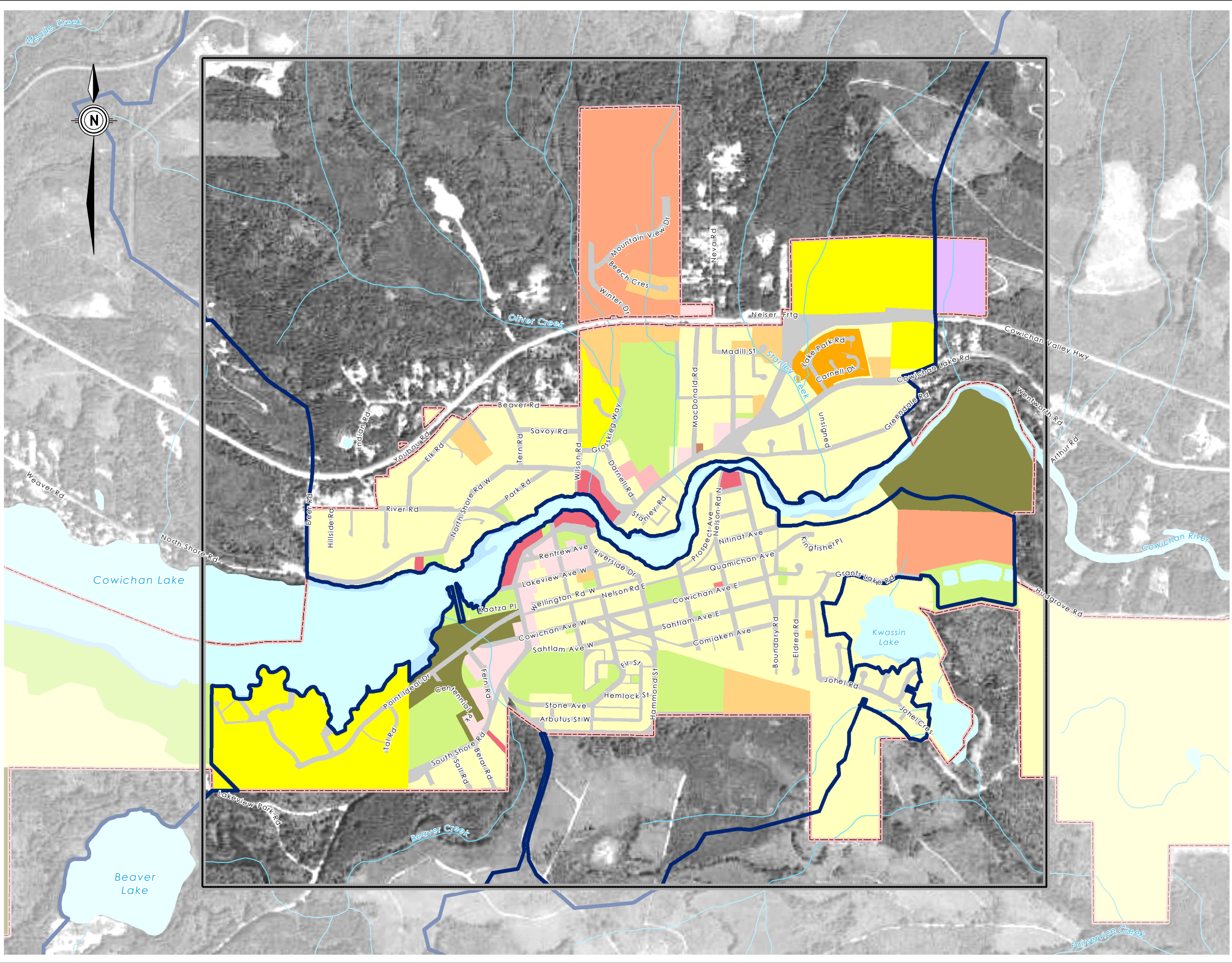
A CCTV inspection of a portion of the Town's stormwater drainage system was completed. Approximately 1,370 m (about 7%) of the drainage system was captured by remotely controlled CCTV cameras. The work was completed by Pipe-Eye Video inspection in October 2013 with a follow up inspection in July 2014. A map showing the segments of the storm drain system inspected by CCTV is shown in Figure 2-8.

The inspection indicates that in those areas inspected, the drainage system is not standard and is in relatively poor condition. There are many instances of pipe material or pipe diameter changes partially through a run between manholes. There were also several instances where CCTV inspection found considerable debris or collection of sediment within the storm drain system. Copies of the CCTV inspection reports are included in Appendix B under separate cover.



CCTV inspection of storm drain system found considerable sediment build up in some pipes

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 Author: J.Lau



**Town of Lake Cowichan
 Integrated Master Drainage Plan**

Legend

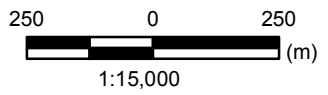
- Municipal Boundary
- Area of Study Focus
- Study Boundary
- Watercourse

- Existing Zoning**
- | | |
|---|--|
| ROAD | P-1 (Public Use - Parks and Institution) |
| C-1 (General Commercial) | R-1 (Urban Residential) |
| C-1-A (Mixed Use Commercial) | R-1-A (Single Family Residential) |
| C-2 (Local Commercial) | R-2 (Suburban Residential) |
| C-3 (Lakefront and Riverfront Commercial) | R-3 (Multi-Family Residential) |
| C-4 (Business Commercial) | R-4-A (Modular Home Residential) |
| CD-1 (Comprehensive Development) | W-1 (Water Recreation) |
| I-1 (Light Industrial) | |

Reference:
 Service Layer Credits:
 GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.
 Existing Zoning based on Bylaw 819-2006 adopted on February 14, 2006



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Project No. 2218-007	Date December 2014
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Existing Land Use












Figure 2-1

**Town of Lake Cowichan
Integrated Master Drainage Plan**

Legend

-  Municipal Boundary
-  Area of Study Focus
-  Study Watershed Boundary

Modelled Catchments

-  5% Impervious *
-  20% Impervious
-  30% Impervious
-  34.5% Impervious
-  40% Impervious
-  50% Impervious
-  60% Impervious
-  70% Impervious
-  80% Impervious
-  90% Impervious
-  100% Impervious

NOTE: All upstream watersheds assumed to have 5% impervious areas.

Reference:
Service Layer Credits:
GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.

 **KERR WOOD LEIDAL**
consulting engineers
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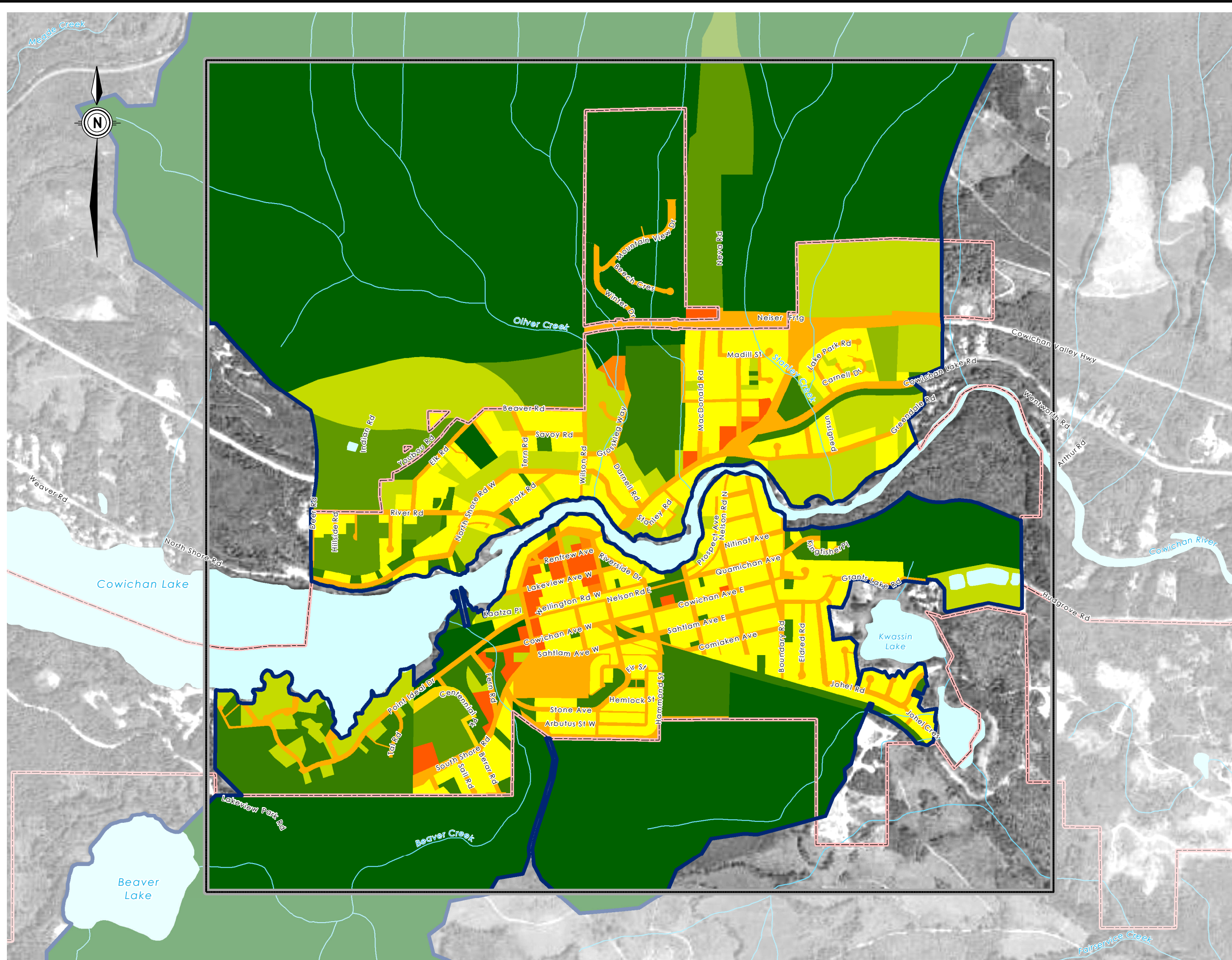
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Project No. 2218-007	Date December 2014
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






**Existing Land Use
Percentage Impervious**

Figure 2-2



**Town of Lake Cowichan
Integrated Master Drainage Plan**

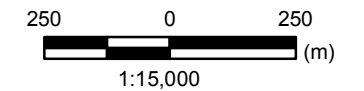
Legend

-  Municipal Boundary
 -  Area of Study Focus
 -  Study Watershed Boundary
 -  Watercourse
- OCP Landuse**
-  D (Downtown) - 90% Imp
 -  HC (Highway Commercial) - 90% Imp
 -  I (Industrial or Comprehensive Development) - 70% Imp
 -  INS (Institutional) - 70% Imp
 -  P (Parks and Open Space) - 20% Imp
 -  UN (Urban Neighbourhood) - 60% Imp
 -  UNC (Urban Neighbourhood Compact) - 70% Imp
 -  URS (Urban Reserve/Comprehensive Development Area) - 70% Imp
 -  Friendship Park Special Designation Area - 20% Imp

Reference:
Service Layer Credits:
GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.
OCP from the Town of Lake Cowichan.



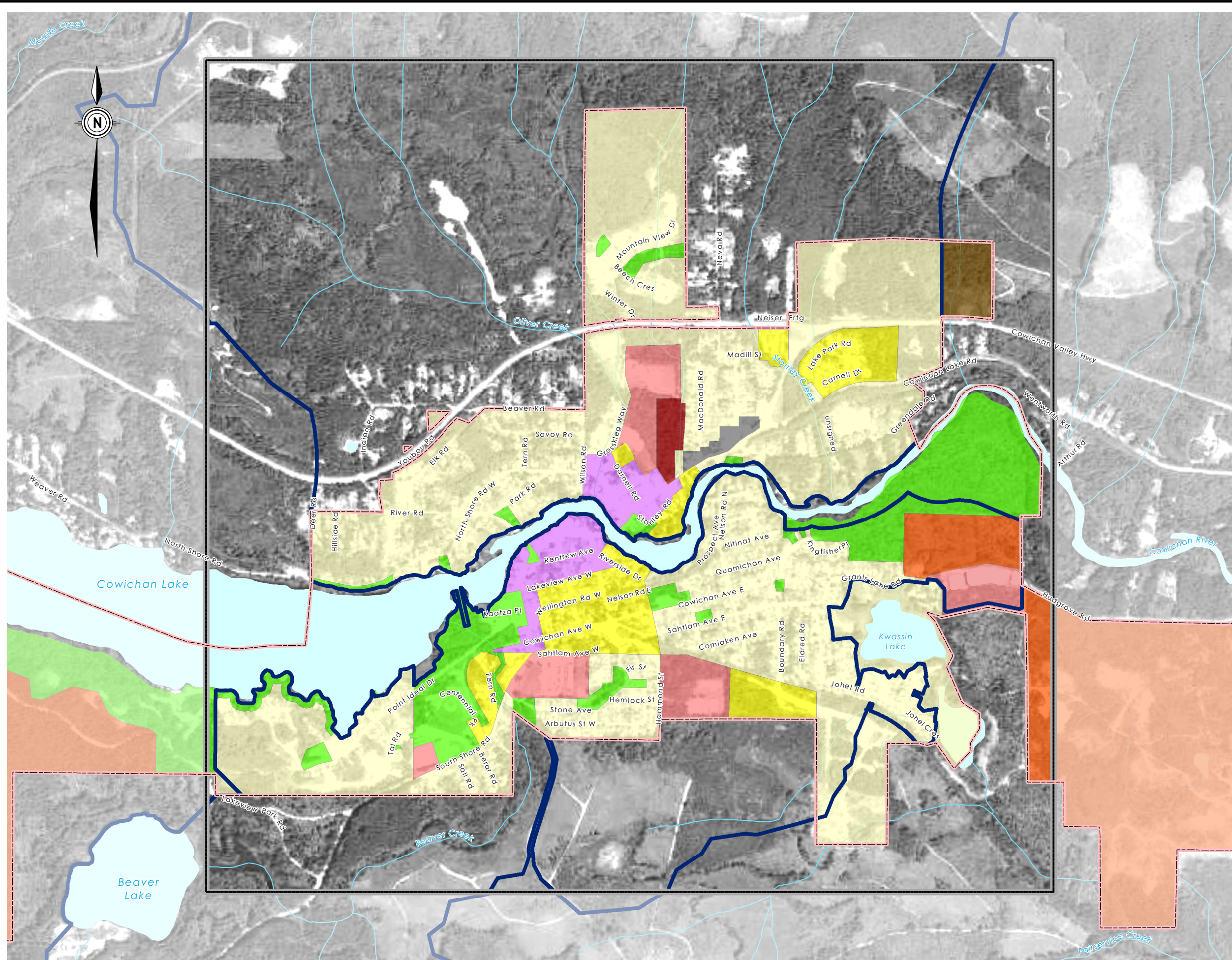
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Project No. 2218-007	Date December 2014
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OCP Land Use

Figure 2-3











**Town of Lake Cowichan
Integrated Master Drainage Plan**

Legend

-  Municipal Boundary
-  Area of Study Focus
-  Study Watershed Boundary
-  Watercourse

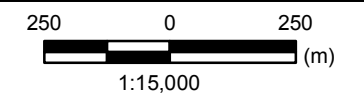
OCP Impervious (%)

-  5
-  20
-  30
-  40
-  60
-  70
-  90
-  100

Reference:
Service Layer Credits:
GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.



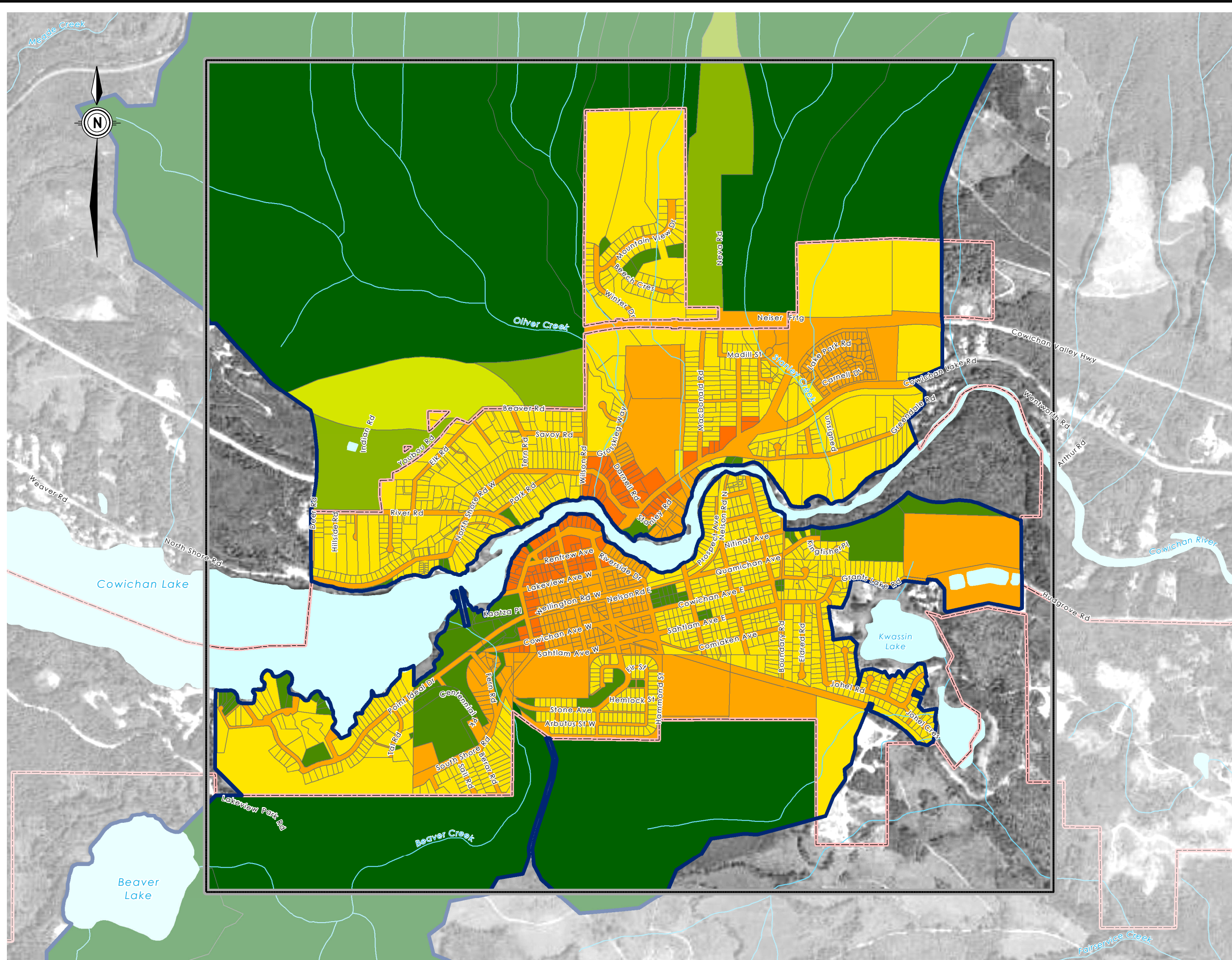
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Project No. 2218-007	Date December 2014
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
**Future Land Use
Percentage Impervious**

Figure 2-4



**Town of Lake Cowichan
Integrated Master Drainage Plan**

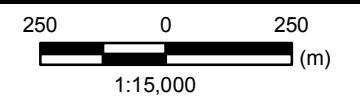
Legend

-  Municipal Boundary
-  Study Watershed Boundary
-  Area of Study Focus
-  Watercourse
- Soil Drainage Class**
-  Moderately Well Drained
-  Rapidly Drained
-  Well Drained

Reference:
 Service Layer Credits:
 GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.
 Soils mapping compiled from the BC Ministry of Environment Surveys and Resource Mapping.



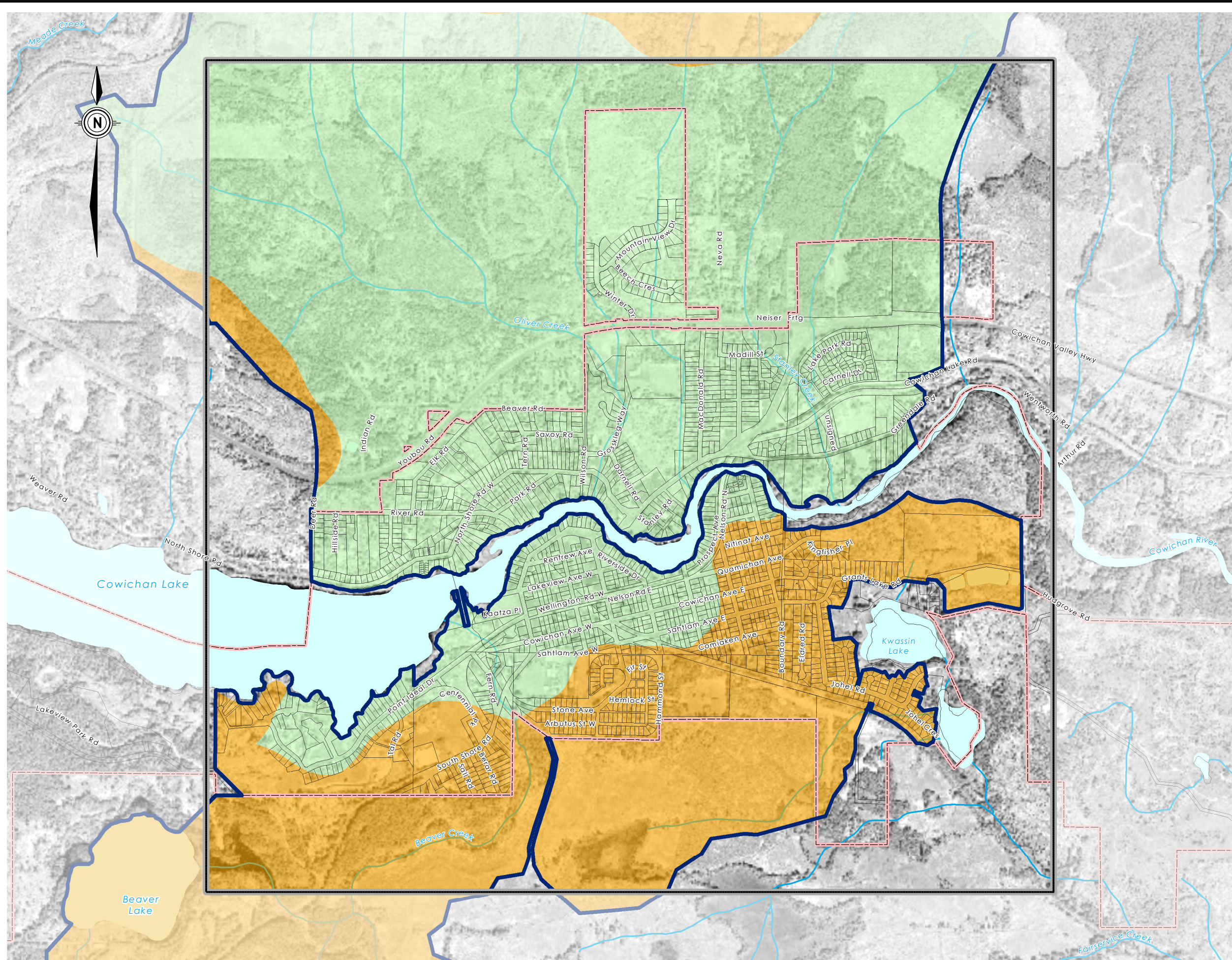
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Project No. 2218-007	Date December 2014
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**Soil Drainage
Classification**

Figure 2-5

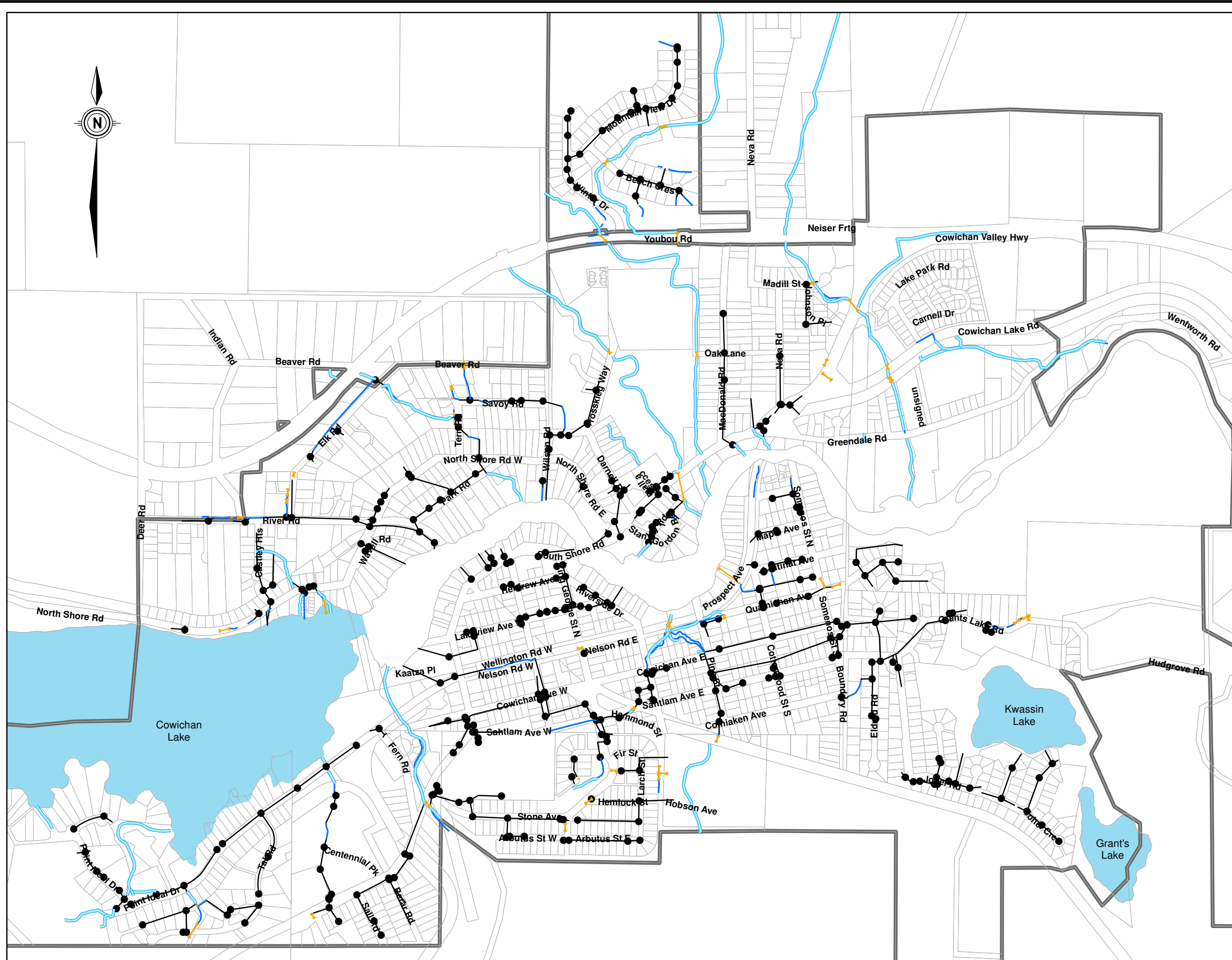


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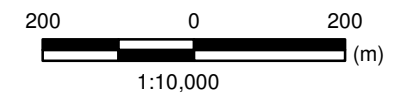
**Town of Lake Cowichan
Integrated Rainwater Management Plan**

Legend

- Storm Manhole
- Storm Main
- Culvert
- Ditch/Creek
- Creeks from Habitat Plan
- Legal
- ▭ Municipal Town Boundary
- Water body



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Project No.
2218-007









Date
April 2015

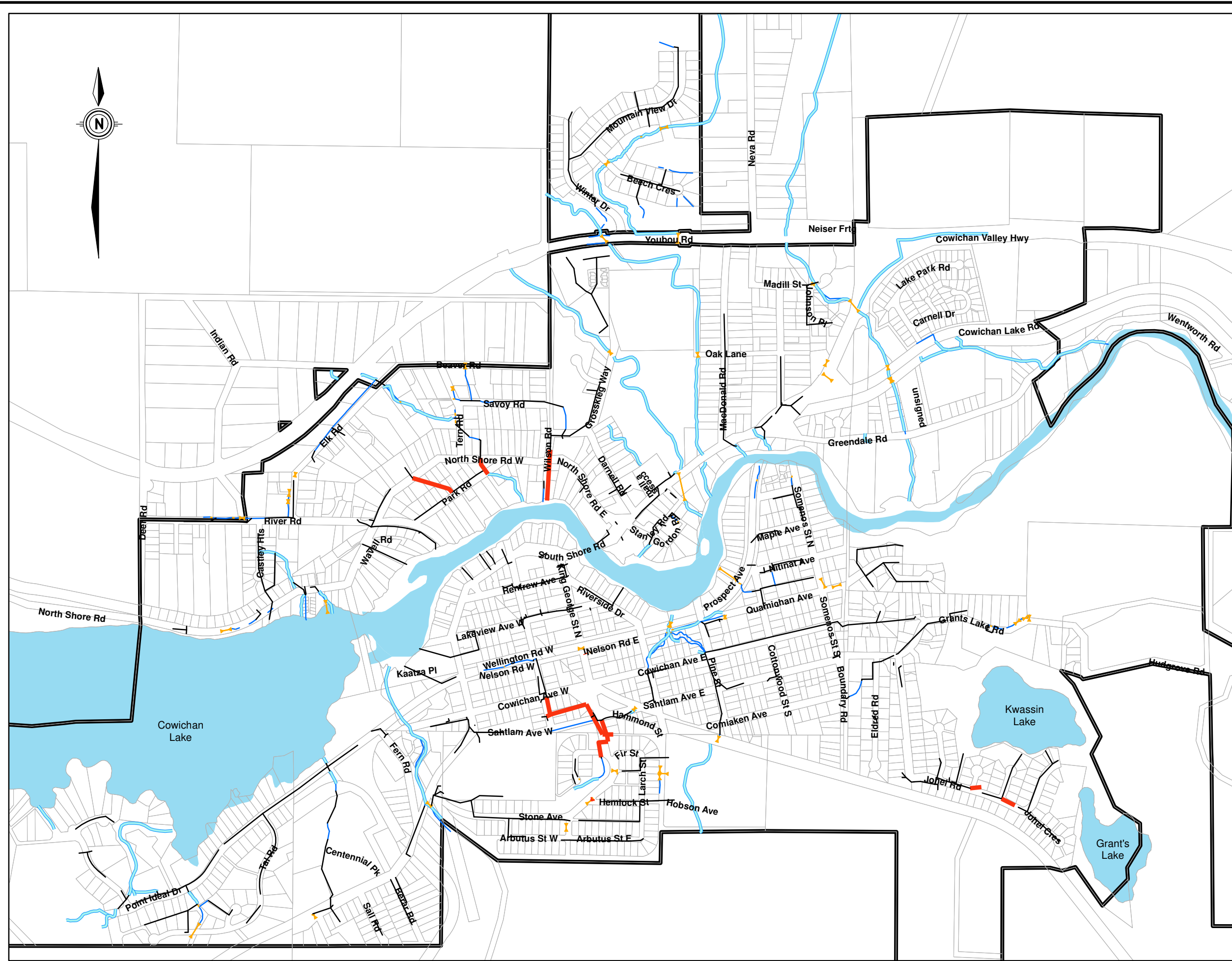
**Existing Storm Drain
System**

Figure 2-6

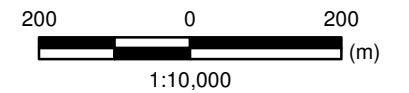
Town of Lake Cowichan
Integrated Rainwater Management Plan

Legend

-  Storm Mains
-  CCTV Storm Mains
-  Culvert
-  Creeks from Habitat Plan
-  Ditch
-  Legal
-  Municipal Town
-  Water body



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Project No. 2218-007	Date April 2015
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Extent of CCTV Inspection

Figure 2-8



3. Habitat Inventory

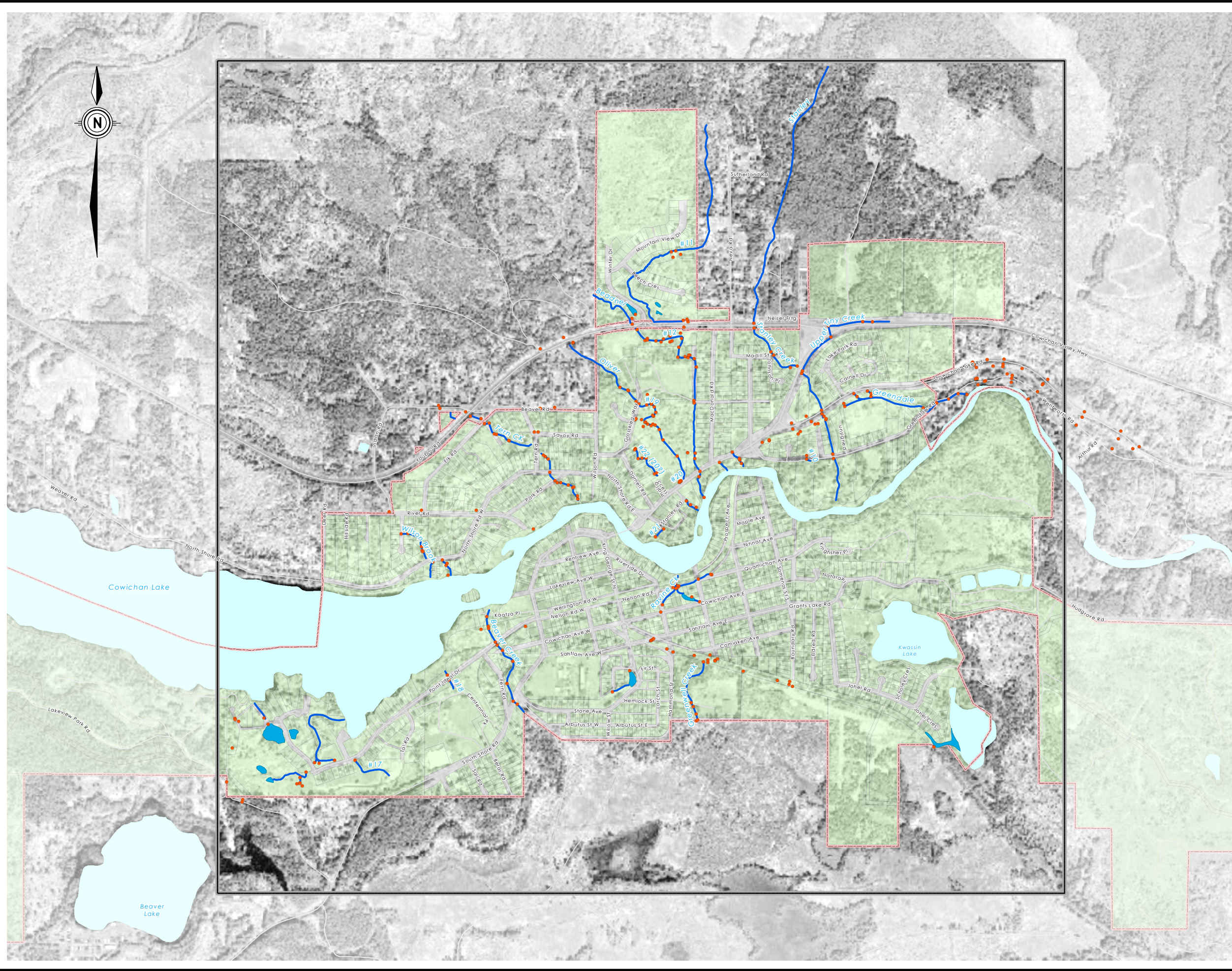
A habitat inventory has been included to provide baseline information on the current condition of watercourses and riparian habitat within the Town. Between June and December 2013, Lehna Malmkvist, M.Sc., R.P.Bio and Sara Stallard, B.Sc., ASCT, Dipl.Env.Tech. of Swell conducted field assessments and GPS mapping of local watercourses. Prior to fieldwork, applicable resources were reviewed for previous watercourse reviews and mapping. These resources included, but were not limited to:

- Town of Lake Cowichan Street Address Map, showing rights-of-way, lot boundaries, and significant information regarding stream locations, diversions, names, and historical alignments;
- KWL maps with municipal roads, infrastructure and stormwater inlets/outlets overlying air photography;
- BC government online mapping and data layers (iMap) including TRIM mapping, research mapping and stream names;
- Cowichan Valley Watershed Atlas;
- Davenport street maps; and
- A Salmonid Protection and Production Plan for the Cowichan Valley Regional District by Ted Burns (2002) (absent the mapping portion).






Highly detailed riparian area regulation surveys completed for recent large developments have not been included in this report. These reports have been provided directly to the Town by developers proposing work within or near riparian area.

The assessment area was surveyed for watercourses using marked-up mapping, air photos, ditch and pipe networks and general visual observations of vegetation and local contours. At each site, a hand-held GPS device was used to mark relevant locations such as the watercourse channel upstream/downstream of roads and driveways, tributary confluences, pipe inlets/outlets, and general points of interest. Due to time and budget constraints, watercourses were only observed at selected points, mostly from public roads or private property where permission to access could be obtained on site. Some sections in between observation points and less accessible headwaters were not assessed on the ground. A map showing the habitat inventory is included in Figure 3-1.

The stream observations included approximate channel width, substrate type and size, erosional features, bank and floodplain descriptions, large woody debris, flow estimate, relative slope, dominant vegetation type and description, and photographs. Incidental observations of fish presence, barriers to fish passage, and man-made modifications were noted. This information was summarized in a spreadsheet for the GIS database developed by KWL for the Town of Lake Cowichan (see Appendix C).



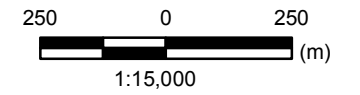
**Town of Lake Cowichan
 Integrated Master Drainage Plan**

- Legend**
-  Municipal Boundary
 -  Study Watershed Boundary
 -  Area of Study Focus
 -  Watercourse
 -  GPS Points

Reference:
 Service Layer Credits:
 GIS background layers from the Town of Lake Cowichan and the Cowichan Valley Regional District.
 Soils mapping compiled from the BC Ministry of Environment Surveys and Resource Mapping.



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Project No. 2218-007	Date December 2014
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**Habitat
 Inventory Plan**

Figure 3-1



4. Hydrologic and Hydraulic Modelling

4.1 Introduction

This section summarizes the hydrologic and hydraulic modelling analysis. The purpose of the analysis was to:

- Develop a hydrologic model to predict the rainfall-runoff response of watershed; and
- Determine peak design flow estimates at strategic locations under existing land-use and future land-use (OCP) conditions.

The model was built using the drainage inventory data to assess the existing drainage system under different design event conditions. The results of the analyses are presented in the following subsections.

4.2 Hydrologic and Hydraulic Modelling

Hydrologic and hydraulic modelling using the PC-SWMM software was undertaken for the entire study area and drainage system. The model includes 19 km of storm mains, 340 manholes, 2.3 km of ditches, and 8 km of watercourses. See Figure 4-1 for the modelled network.

Approximately 8.2 km of virtual conduits were included in the model. These conduits represent both assumed storm drains, as well as watercourses, which have been included in the model to allow water to flow through the pipe network but that have not been confirmed by field check. The locations of the assumed conduits are shown in Figure 4-1.

Models were created for both existing and future land use conditions. The model representing existing land use is used to estimate peak design flow estimates for the drainage system while the model representing future land use conditions is used to predict how peak design flow estimates could increase without implementation of rainwater management mitigation.

4.3 PC-SWMM Modelling

The software PC-SWMM was selected for hydrologic and hydraulic analysis. The model consists of representative watersheds with associated hydrologic runoff parameters and a network of representative channels, drains and culverts.

PC-SWMM Hydrologic Model Catchments

Catchments

The study area was modelled as on a lot-by-lot basis. Each legal lot within the Lake Cowichan town boundary was modelled. The undeveloped watersheds located outside of the town boundary, were discretized into large catchments using contours, field watercourse information and existing drainage information.

In total, 58 catchments were created and imported into the PC-SWMM model. Catchments were assigned the following attributes:

- Slopes, using available contour information;
- Existing impervious area, using 2010 air photographs and the 2006 Lake Cowichan Zoning figure to determine land use;



- Typical land use impervious percentage information taken from Tables 2-2 and 2-3; and
- Groundwater parameters based on typical values for soils.

Impervious Percentage and Land Use

The percentage impervious values used in the model are based on existing and future land use conditions within the study area. An outline of how the impervious areas for the land use conditions is provided in 2.3.

Groundwater and Soil Parameters

The groundwater portion of PC-SWMM was used to better estimate the groundwater and interflow portions of the runoff hydrograph.

Soils mapping, shown in Figure 2-5, suggests the Lake Cowichan study area is underlain principally by well-draining Moraine and Colluvium soils. Additional information regarding ground water and soil conditions in the study area is provided in Section 2.4. The hydraulic conductivity values and soil parameters required for SWMM were obtained from the Saxton et al. (1986) Soil Texture Triangle Hydraulic Properties Calculator and are shown in Table 4-1 below.

Table 4-1: Soil Parameters Used in PC-SWMM Hydrologic/Hydraulic Model

Land Use	Suction Head (mm)	Conductivity (mm/hr)	Initial Deficit (frac.)
Undeveloped	5	20	0.05
Forest	50	200	0.05
Developed	5	20	0.05

PC-SWMM Hydraulic Model

Boundary Conditions

The downstream water levels used in the model are based on average peak annual flood levels in Cowichan Lake and Cowichan River. Based on the historical lake level records, the average peak annual level in Cowichan Lake is El. 163.93 m.

A hydraulic model previously developed for the outlet of Cowichan River was rerun for the lake level of El. 163.93 m condition yielding a discharge of 120 m³/s in the river. Downstream water levels were extracted from the model to be used as downstream boundary water level conditions at the various outfall locations. Water levels range from El. 163.93 m at Cowichan Lake to El. 163.0 m at Greendale Trestle. These levels were then used as boundary conditions in the models.

For the purposes of this study, during the sizing storm drains near the outlets, the downstream boundary water level was assumed to be lower than outlet elevation such that the system is free draining by gravity.



Design Storms

A review of available rainfall data in the region indicates that an Intensity-Duration-Frequency (IDF) rainfall curve is available through Environment Canada for the Lake Cowichan Environment Canada Climate Station (1012055). However, the IDF curves for Lake Cowichan have been developed based only on data for the period from March to October. Given that the period used does not include higher intensity rainfall events which occur during the winter period (November to February), a re-analysis of the IDF curve to include higher intensity rainfall was required.

A review of regional weather stations was carried out to identify a station which is representative of the precipitation conditions at Lake Cowichan and provides full year of precipitation records. The Environment Canada Port Alberni Climate Station (1036206, derived with 23 years of recorded data between 1969 and 1993) was selected as it has similar climatic characteristics as Lake Cowichan and has sufficient period of record to carry out extreme value analysis to establish design rainfall intensities. The design storms were developed using IDF curves from Port Alberni climate station, and adjusted with the 24-hour rainfall ratios between the Cowichan Lake Forestry Station (1012040) and the Port Alberni station for the overlapping period of record.

A Huff 1Q storm distribution curve was selected and used to generate short duration design storms and SCS Type 1A distribution curve were selected to generate long-duration design storms. These curves were used to provide distribution of rainfall over time based on a total rainfall depth for specific duration. Both distributions were selected as they provided a best-fit compared to distribution of recorded rainfall at the Lake Cowichan station. Snow melt was also considered and included in the design storm hyetographs for the Lake Cowichan study. These have been calculated for the storm events based on the US Army Corp of Engineers snow melt equation.

See Appendix D for calculation tables for the design storms.

Table 4-2 shows precipitation amounts for various durations for these storm events while Table 4-3 shows snowmelt rates used in design storms. A copy of the updated IDF curves is shown in Figure 4-2 while a comparison of the design storm shapes is included in Figure 4-3.

Table 4-2: Total Precipitation Amounts for Design Storms

Duration	Total Rainfall (mm)			
	2-Year Return Period	10-Year Return Period	25-Year Return Period	100-Year Return Period
1-hour	13.1	19.9	23.2	28.3
2-hour	22.0	29.4	33.0	38.3
6-hour	46.4	59.0	65.0	74.0
12-hour	71.4	96.0	107.3	125.0
24-hour	102.7	145.1	165.8	197.1

Note: Design rainfall based on re-analysis using Port Alberni Climate Station data as Lake Cowichan IDF Curve based on data only for the period from March to October.
 Snowmelt rates shown in Table 4-5 were added to these rainfall amounts for the design storms

The rainfall depths used for this assessment are higher than the IDF curve generated using the data from the Lake Cowichan climate station (1012055) alone. The updated 24-hour design rainfall depths range from 9.6% to 25% greater for the 2-year return period and 100-year return periods, respectively. This increase is due to the fact that the original IDF curve for the Lake Cowichan station is based only on rainfall data from March to October.









Table 4-3: Design Snow Water Equivalent and Snow Melt Rate








Duration	Snowmelt Rate (mm/hr)		
	10-Year Return Period	25-Year Return Period	100-Year Return Period
Less than 12 hour	2.9	3.0	3.2
12-hour to 24 hour	2.6	2.7	2.9
	Total Snow Water Equivalent (SWE) on Ground at Start of Design Storm (mm)		
	10-Year Return Period	25-Year Return Period	100-Year Return Period
Design SWE	24.1	35.8	43.5
Note: Snowmelt rates calculated using US Army Corp of Engineers snow melt equation (USACE Engineering Manual 1110-2-1406, March 1998).			

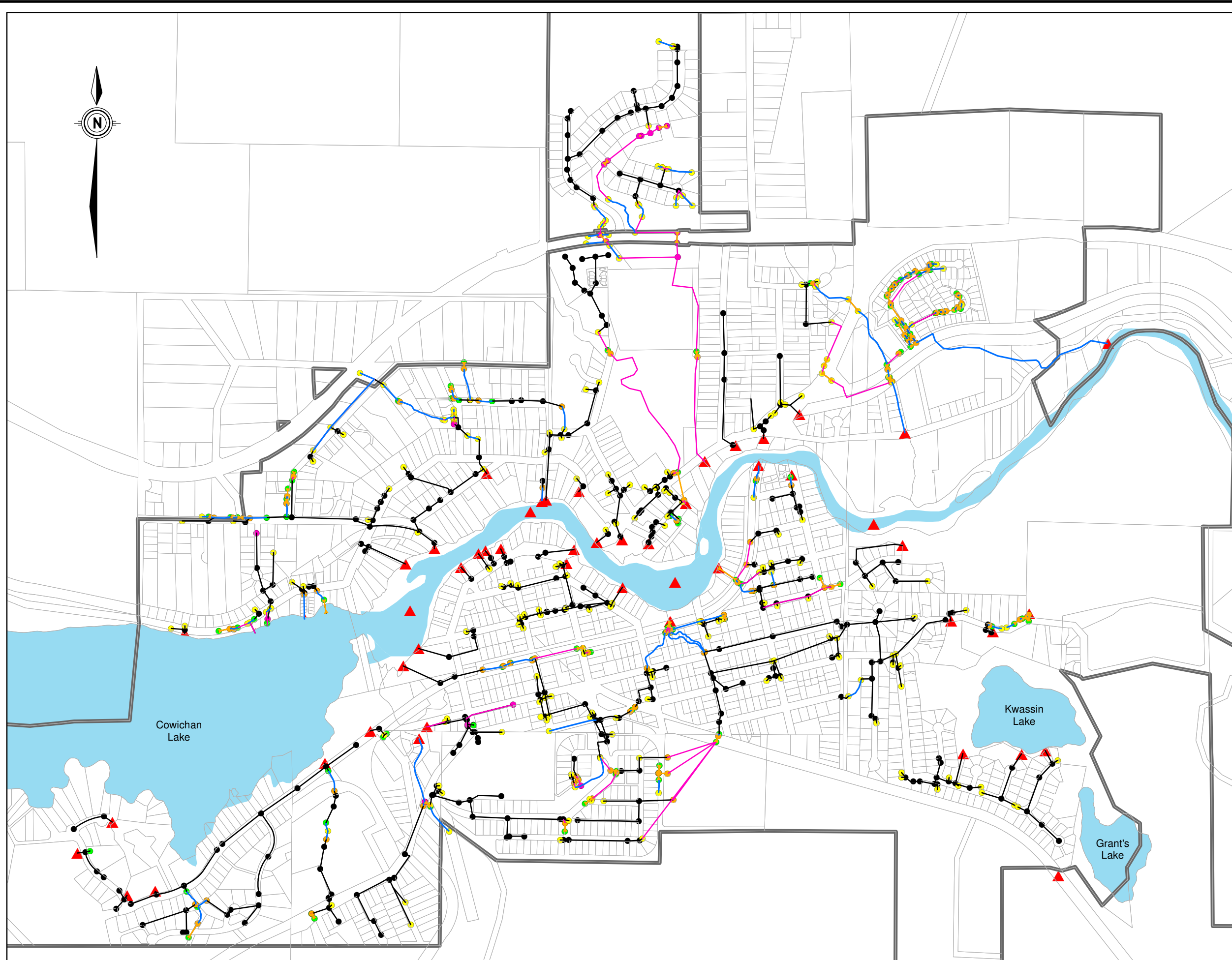
**Town of Lake Cowichan
Integrated Rainwater Management Plan**

Legend

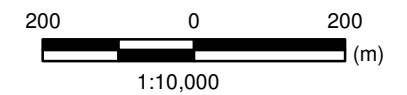
-  Culvert
-  Ditch/Creek
-  Assumed Connection
-  Storm main
-  Legal
-  Municipal Town Boundary

Modelled Junctions

-  Manhole Node
-  Inlet Node
-  Outlet Node
-  Virtual Node
-  Assumed Node
-  Water body
-  Outfalls



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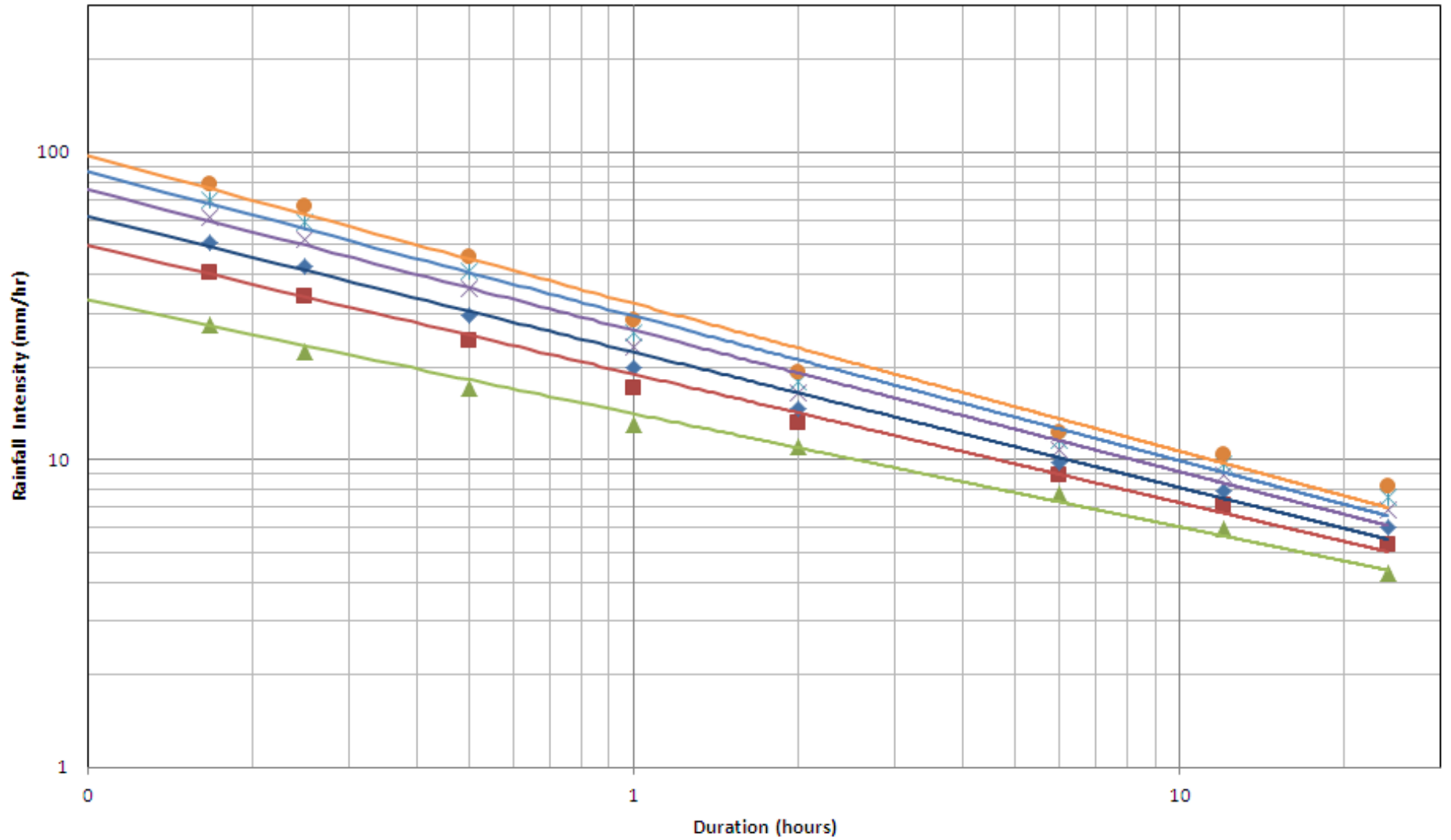
Date
March 2015

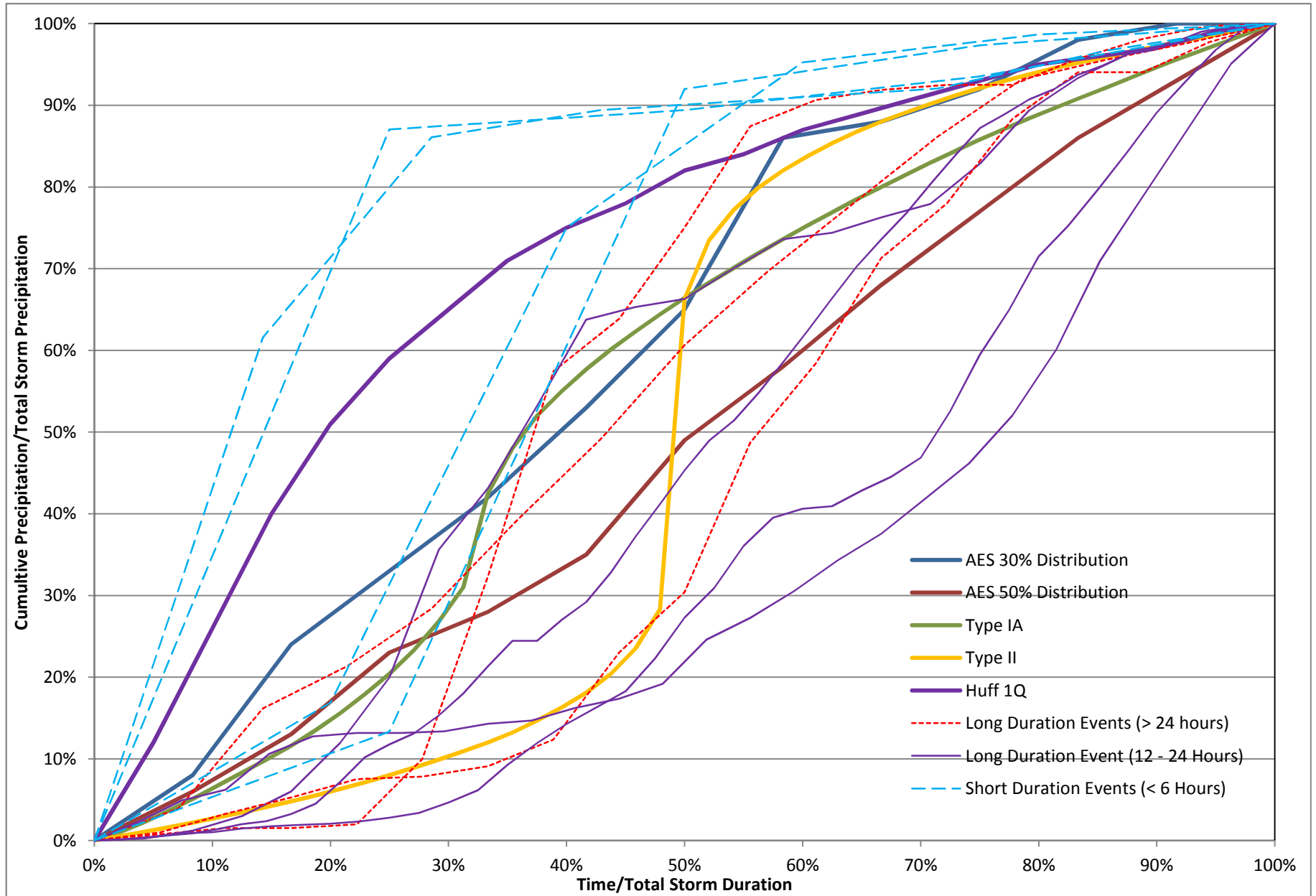
**Modelled Storm Drainage
Network**

Figure 4-1

Updated Intensity-Duration-Frequency Curve Town of Lake Cowichan

▲ 2-Year ■ 5-Year ◆ 10-Year × 25-Year ✖ 50-Year ● 100-Year







5. Drainage Assessment

5.1 Introduction

This section summarizes the drainage system assessment, evaluating the conveyance capacity of the storm drain system to safely pass large rainfall events. A review of the model indicates that the limiting factor in the conveyance system is the storm drain system, not the open channel sections. Therefore, only the capacities of the storm drain system and culvert crossings were assessed.

5.2 Drainage Design Criteria

The drainage system is composed of the minor drainage system (storm sewers and ditches) and the major drainage system (major culverts, creeks, overland flow routes). These networks collect both stormwater from impervious surfaces such as roads and roofs and some stormwater that infiltrates into the ground. All storm sewer pipes, creeks, and ditches contained in the storm sewer database are included within the model. The major system is assessed using 100-year peak flows. The minor storm sewers and culverts are assessed using the 10-year and 25-year peak flows depending on their diameter as shown below.

Storm Drain and Culvert Design Criteria

- Storm Drains and Culverts 900 mm and smaller – No surcharge during 10-year return period; and
- Storm Drains and Culvert greater than 900 mm – No surcharge during 25-year return period.
- Culverts crossing major roads and highways (Highway 18, Lake Cowichan Way and South Shore Drive) – No Surcharge during 100-year return period.

As an alternative to upgrading storm drain and culverts to safely convey peak discharge of design storms, detention storage could also be used to reduce post-development peak design storms to the existing downstream culvert and storm drain capacity. Detention storage should be included as part of future development where significant lengths of existing storm drains and culverts are required to be upgraded to meet post-development design flows.

Allowance for Climate Change

Results from other drainage and climate change impact studies recently completed in the Capital Regional District, Metro Vancouver and in Washington State show that rainfall intensity during storm events will likely increase and result in higher peak discharges. A summary of allowance factors used in drainage system studies in the region is shown in Table 5-1.



Table 5-1: Summary of Climate Change Allowances used for Drainage Systems in the Region

Study	Percent Increase in Peak Precipitation	Percent Increase in Peak Flow
Bowker Creek ISMP, 2008	15% increase in 10-year and 25-year 1-hour rainfall	15% to 30% increase in peak flow ¹
Central Saanich ISMP, 2009	10% increase in 10- year and 25- year 1-hour rainfall	10% to 20% increase in peak flow
Metro Vancouver Vulnerability to Climate Change, 2008	17% increase in max. daily rainfall	N/A – Rainfall totals only
City of Seattle, 2006	15% increase in 10-yr daily rainfall	N/A – Rainfall totals only
Note 1: For Bowker Creek ISMP, increase also includes increased flows as a result of change in impervious area of about 5%.		

Modelling with future climate change based on changes in precipitation was not performed in this study. However, to account for potential increases in peak discharges as a result of climate change, the following criteria were proposed to size storm sewer and culvert upgrades:

- Where existing storm sewers and culverts have sufficient capacity for current climate design flows (without climate change), no upgrades are recommended; and
- Where existing storm sewers and culverts do not have sufficient capacity for current climate design flows and upgrades are recommended, the recommended culvert size will be increased to the next available standard pipe size if the current climate modelled peak flow is equal to or greater than 80% of the recommended culvert size capacity.

5.3 Existing Drainage System Assessment

Peak Flow Estimates

The models for existing and unmitigated future land use conditions with saturated soil conditions typical of winter conditions yielded the following peak flows estimates.

Table 5-2: Peak Flow Estimates for Existing and Future Land Uses

Watercourse	Peak 10-Year Flow (m ³ /s)		Percentage Total Impervious Area	
	Existing Land Use	Future Land Use	Existing Land Use	Future Land Use
Tern Creek	1.18	1.32	39.5%	46.0%
Stanley Creek	4.79	5.31	8.3%	9.5%
Beadnel Creek	1.76	3.36	10.0%	19.3%
Greendale Creek	2.15	2.53	35.2%	49.1%

Impacts of Development on Peak Flows

Comparing the existing and unmitigated future peak flow estimates indicates that the future land use could result in significant increases to 10-year peak flows in certain watersheds (up to 190% in Beadnel Creek for instance). Unmitigated, these changes could result in both flooding as a result of limited downstream capacity of existing storm drain systems and increased potential for channel erosion and stream habitat degradation. To mitigate these impacts both upgrades to the existing drainage network and implementation of stormwater management best practices will be required. The following sections outline assessment of the minor and major drainage system to identify where existing system does not have sufficient capacity to safely convey design storm events.



Minor System Assessment

The existing minor drainage system was assessed to determine its ability to convey the 10-year return period design flows and 25-year return period design flows for culverts and storm drains less than 900 mm diameter and greater than 900 mm diameter, respectively. Figure 5-1 and Figure 5-2 schematically show the conduits that appear to be undersized and surcharged during the 10-year return period event and 25-year return period event under the existing land use (2010) scenario and future land use scenario (OCP), respectively. The figure classifies the storm drains based on percentage of full capacity or if surcharge or flooding would occur. Flooding is defined as the hydraulic grade line being above ground elevation. Surcharge is defined as water levels exceeding the pipe crown by more than 30 cm and for more than 15 minutes. Using this height above crown and duration criteria eliminates many conduits that may briefly surcharge without consequence, reducing the capital upgrades program.

It is important to note that the analysis assumes that there are no constrictions upstream of those identified and therefore the flow peaks were able to reach these pipes. In reality, the predicted flow may only reach these pipes once the upstream conveyance system is upgraded.

Additional downstream sewers may also need to be upsized to adhere to the drainage design criteria which states that the downsizing of downstream storm sewers will not be accepted for sizes 600 mm diameter or less. This avoids the potentially dangerous situation where a larger pipe (with a flatter slope) is placed upstream of a smaller pipe (with a steeper slope). The concern is that a large object may be carried down the larger pipe but will block the smaller pipe downstream. The Drainage Criteria does allow for the consideration of a maximum downsizing of two pipe sizes for storm sewers larger than 600 mm diameter.

Major System Assessment

Overland flow and major flow paths provide a flow route for large events. Storm sewers along the major flow paths are required to convey the 100-year event if the overland route cannot convey the large flows or where it crosses private property. A plan showing the areas of overland flooding for existing and future land use conditions is shown in Figure 5-3. In areas where the overland flow does not have a proper outlet and poses a flood hazard to adjacent building structures, catch basins and storm sewers should be designed to capture and convey the 100-year flow. The current standard of practice is to provide redundant catch basins with side inlets to allow large flows to enter the pipe system. To minimize clogging of inlets, side inlet catch basins are recommended.

Drainage Assessment Findings

The results of the drainage assessment are summarized in Table 5-3. For existing land use conditions, approximately 44% of the length of the system meets the design criteria and has sufficient capacity to safely convey the peak flow of design flood events while about 25% of the system does not have sufficient capacity to convey peak flow of design flood events which would result in overland flooding. The remaining 31% of the system has sufficient capacity to convey peak design flow but exceeds the 80% pipe full capacity allowance for climate change and other uncertainties.

For future land use conditions, peak flows increase such that the length of the system meets the design criteria and has sufficient capacity to safely convey the peak flow of design flood events reduces to 34% while the length of system that does not have sufficient capacity to convey peak flow of design flood events increases to 33%. The remaining 33% of the system would have sufficient capacity to convey peak design flow but would exceed the 80% pipe full capacity allowance for climate change and other uncertainties.



Table 5-3: Drainage System Assessment Results Summary

Criteria	Existing Land Use		Future Land Use	
	Length of Conduit (km)	% of Drainage System Length	Length of Conduit (km)	% of Drainage System Length
Less than 80% Full Capacity	7.94	44	6.22	34
80% or more Full Capacity	2.43	13	3.01	17
More than 100% Full Capacity	3.2	18	2.83	16
Doesn't meet design criteria	4.51	25	6.01	33

One of the reasons why a relatively large percentage of the existing drainage system does not meet the design criteria is due to the 10% to 25% increase in design rainfall intensity as a result of updates to the design IDF curves for Lake Cowichan. As previously discussed in Section 4.3, the original IDF curves were based on rainfall data from March to October which did not include the period of typically higher precipitation from November to February.

In order to meet the design criteria and provide safe conveyance for peak design flows to protect private and public property, those parts of the drainage system that are undersized will need to be upgraded. The IRMP implementation plan outlined in Section 9, recommends upgrade priorities and estimates costs to upgrade those parts of the drainage system which do not meet the design criteria.

**Town of Lake Cowichan
Integrated Rainwater Management Plan**

Legend

Drainage Capacity

- 0% - 80% of Full Capacity
- 80% - 100% of Full Capacity
- Over 100% of Full Capacity
- Flooding (min 15 Minutes Flooded and Surcharged Depth greater than 0.3 m)

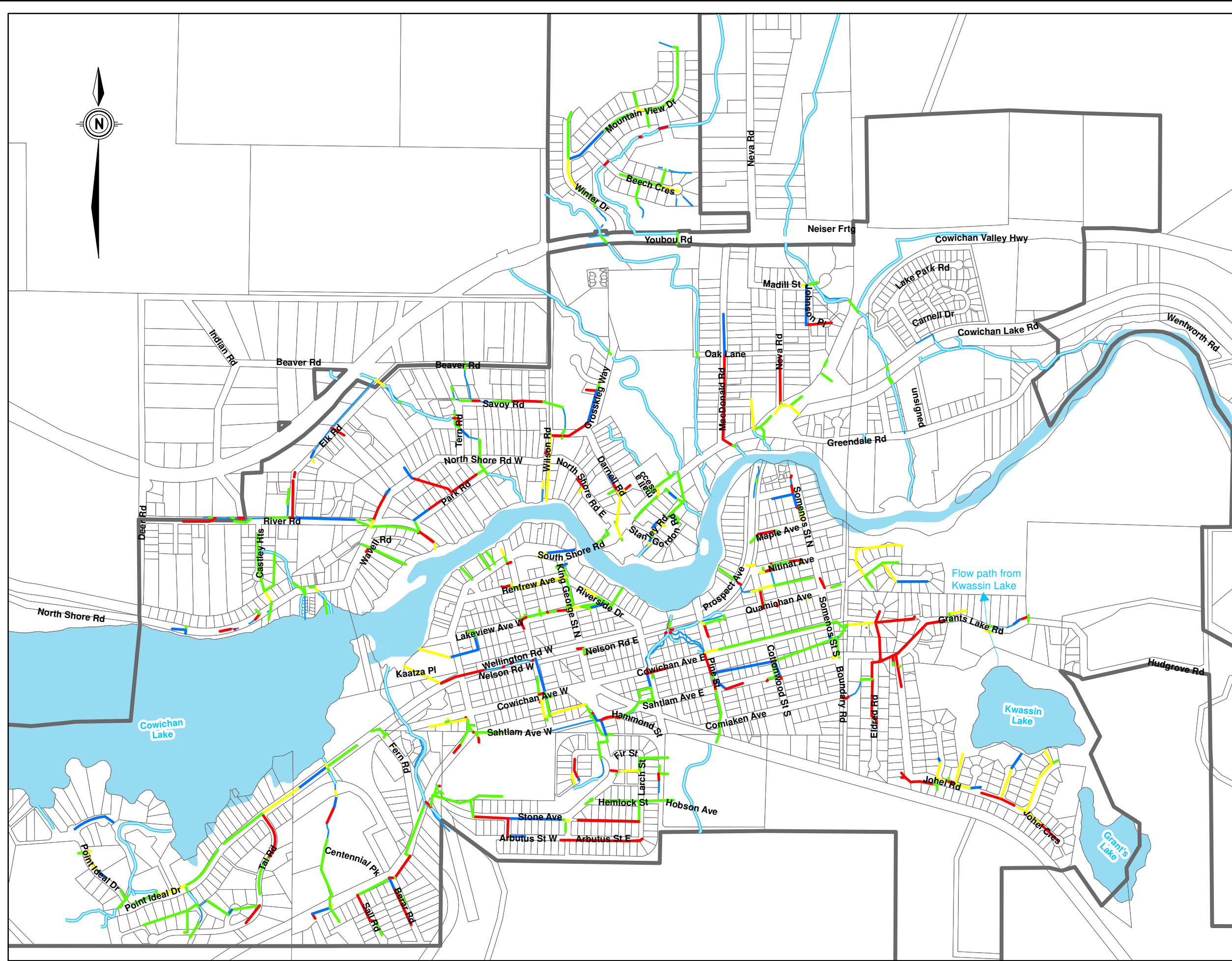
- Creeks from Habitat Plan
- Ditches/Creeks
- Legal
- Municipal Town Boundary
- Water body

Note: Drainage Design Criteria

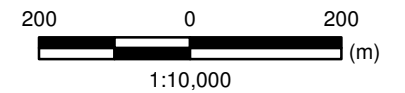
Pipe Diameter < 900 mm =
10-Year Return Period Peak Flow

Pipe Diameter > 900 mm =
25-Year Return Period Peak Flow

Major Road Crossing Culvert =
100-Year Return Period Peak Flow



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**Drainage Assessment
Existing Land Use (2010)**

Figure 5-1

**Town of Lake Cowichan
Integrated Rainwater Management Plan**

Legend

Pipe Capacity

- 0% - 80% of Full Capacity
- 80% - 100% of Full Capacity
- Over 100% of Full Capacity
- Flooding (min 15 Minutes Flooded and Surcharged Depth greater than 0.3 m)

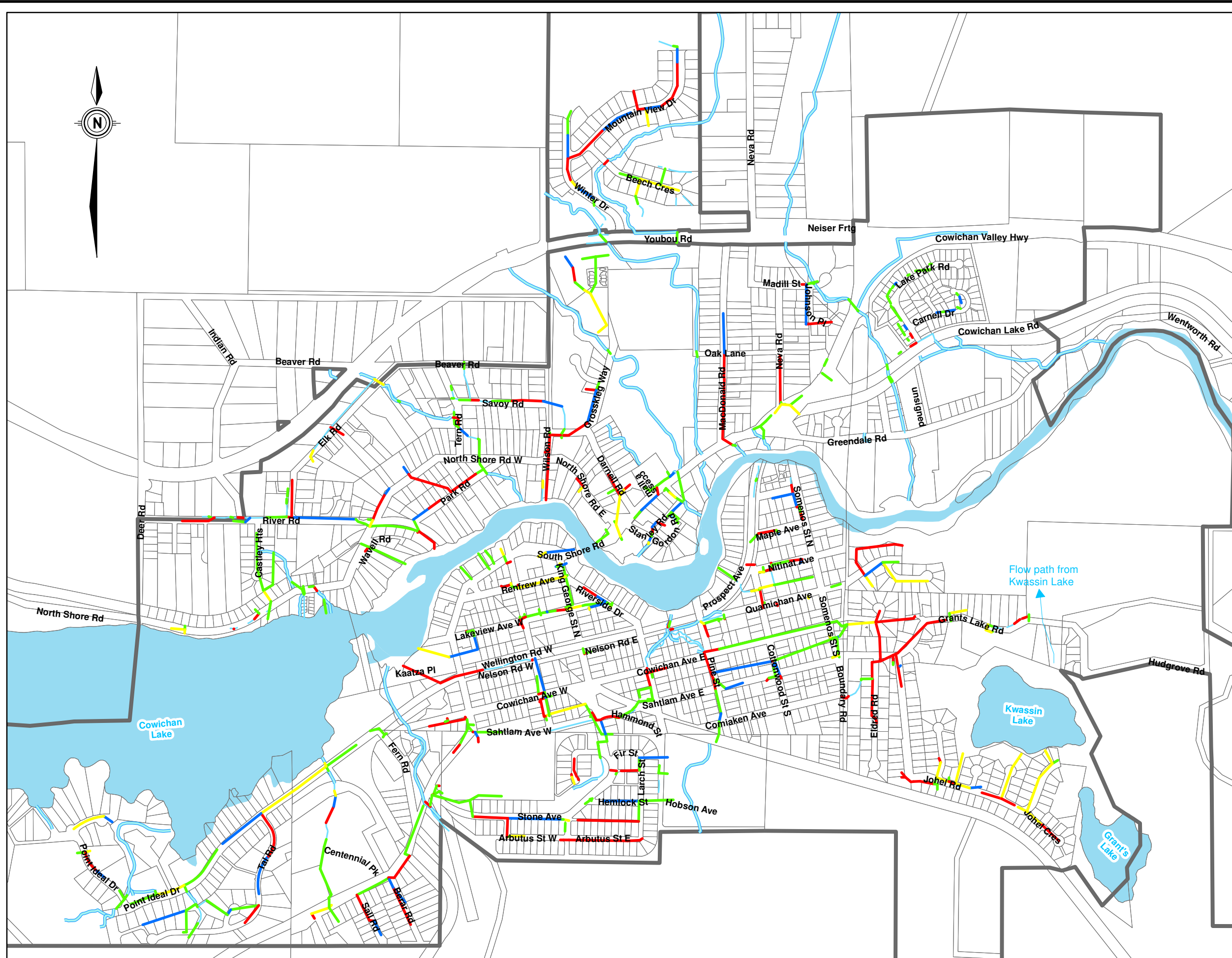
- Creeks from Habitat Plan
- Ditches/Creeks
- Legal
- Municipal Town
- Water body

Note: Drainage Design Criteria

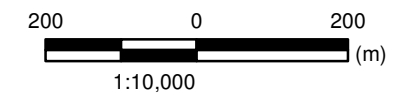
Pipe Diameter < 900 mm =
10-Year Return Period Peak Flow

Pipe Diameter > 900 mm =
25-Year Return Period Peak Flow

Major Road Crossing Culverts =
100-Year Return Period Peak Flow



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June 2015







**Drainage Assessment
Future Land Use (OCP)**

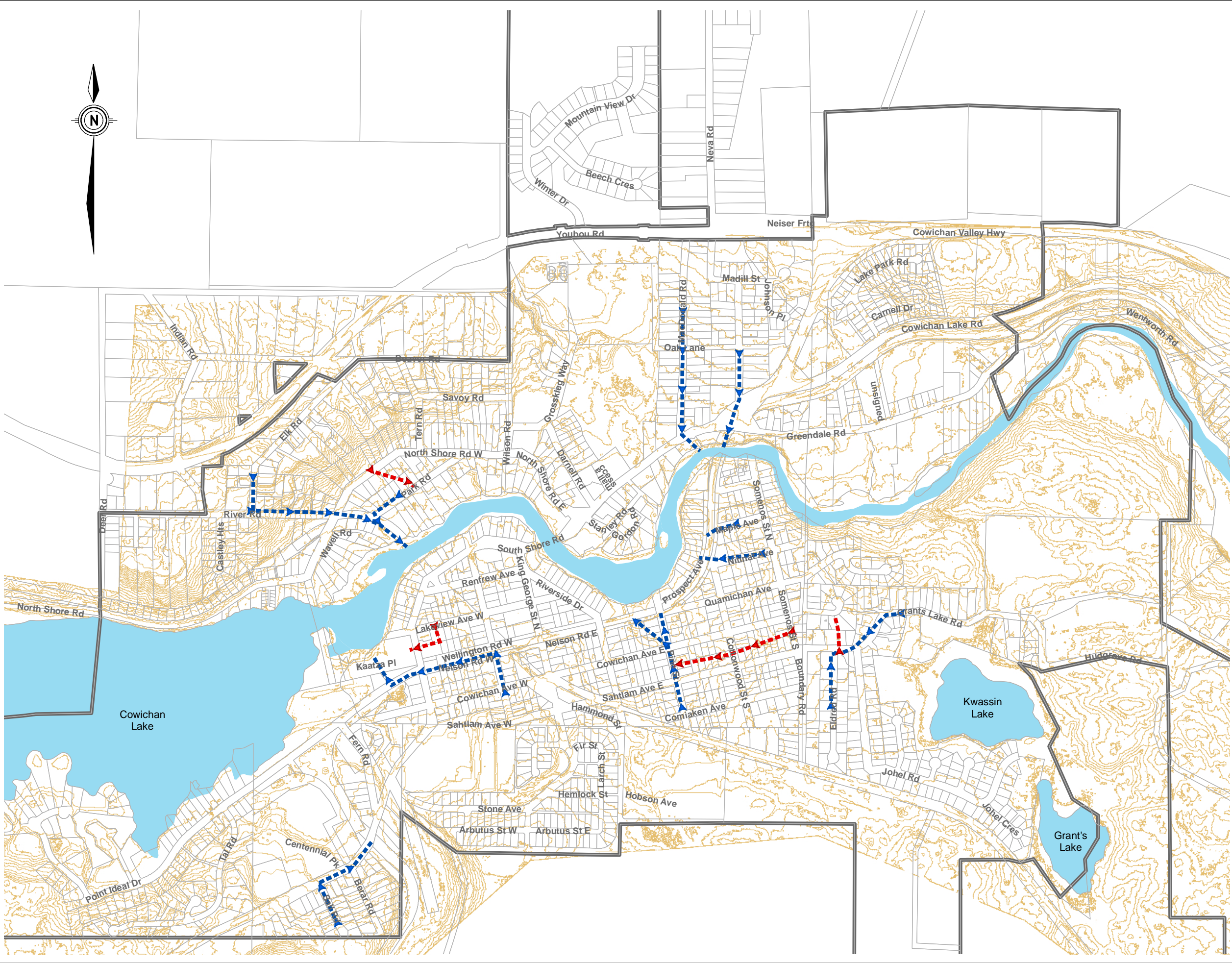
Figure 5-2

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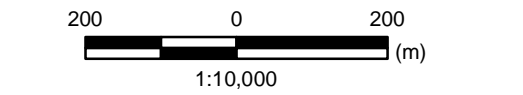
Town of Lake Cowichan
Integrated Rainwater Management Plan

Legend

-  Municipal Town Boundary
-  Legal
-  Water body
-  Contour (2m Interval)
- Overland Flood Routes - Existing Drainage**
-  Safe Overland Route Along Roads
-  Overland Flood Route Through Properties



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**Overland Flood Routes
Existing Drainage**

Figure 5-3

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6. Mitigative Measures to Protect Watershed Health

6.1 Introduction

Ecological Health of Urban Waterways

Scientific research on urban streams indicates that four primary factors affect its ecological health. They are listed, in order of importance, as follows:

- Changes in hydrology;
- Disturbance to the riparian corridor;
- Disturbances to fish habitat; and
- Deterioration in water quality.

‘Changes in hydrology’ can be viewed as the paramount factor because it can impact the other factors. Increases in hydrology (flows and volumes and the frequency of their occurrence) accelerate natural rates of erosion and sedimentation, degrades or washes out aquatic and riparian habitat, and deteriorates water quality.

By the time pollutant loading is a significant water quality problem affecting fish survivability, the higher frequency of occurrence of increased flows resulting from land use densification have already degraded or disturbed the physical features associated with productive fish habitat.

Importance of Imperviousness

“*The Importance of Imperviousness*” (Schueler, 1994) that evaluated stream stability in developed and undeveloped watersheds and showed that when impervious cover in the watershed exceeds 10%, the stream begins to show signs of instability. In general, the relationship between impervious cover and stream quality or health can be described as shown in Table 6-1 below:

Table 6-1: Impact of Impervious Area on Streams*

Watershed Impervious Cover	Stream Quality Potential
1 – 10%	Sensitive
11 – 25%	Impacted
26 % +	Degraded (Non-Supporting)
*based on Schueler, 1994	

According to this research, development that allows more than 25% impervious coverage creates unsustainable impacts on the health of the receiving stream.

Additional research supports the correlation proposed by Schueler. Research from the University of Washington (Booth, 1997), (Booth D. , 2000), (Horner, 1997) that focused on watersheds and development trends in King County, Washington found that, in general, the impervious cover relates directly to stream health in a watershed, and the 25% impervious cover threshold as a distinguishing point between “impacted” and “degraded” streams appears to hold true in the Pacific Northwest region.

Studies by the Greater Vancouver Regional District (GVRD) also looked at the link between impervious coverage and stream health for watersheds with the Metro Vancouver region. This work (GVRD, 1999) categorized the stream health differently, separating it into Good, Fair and Poor categories, but the relationship between impervious coverage and stream health was again reinforced.



Lake Cowichan Imperviousness

As outlined in Section 2, the total impervious area in the Town is expected to increase from 40% under existing (2010) land use to 62% under full OCP build-out. This is within the Town boundary. The impervious thresholds mentioned above are based on watershed imperviousness. Therefore, it is important that measures be taken to protect watershed health as outlined in Table 6-2 below.

Table 6-2: Stormwater Best Management Practices for Environmental Protection

Best Management Practices
Planning Measures and Low Impact Development Techniques
<ul style="list-style-type: none"> • Protection of interception/evapotranspiration/infiltration processes in forests and forest soils • Reduction in road density and road width • Protection of soil structure during development • Increased building density to allow for enhanced riparian forest or terrestrial forest protection
Source Controls
<ul style="list-style-type: none"> • Rain gardens, vegetated swales, pervious pavement, infiltration facilities, absorbent landscapes, green roofs • Oil/grit separators for high-risk sites (surface parking areas, commercial sites, etc.)
Best Management Practices (BMPs)
<ul style="list-style-type: none"> • Water quality sedimentation ponds • Detention ponds • Diversions

Importance of Riparian Corridors

Riparian corridors provide many and varied features, functions and conditions that are vital for maintaining stream health and productivity, including:

- Sources of large organic debris, such as fallen trees and tree roots;
- Areas for stream channel migration;
- Vegetative cover to help moderate water temperature;
- Provision of food, nutrients and organic matter to the stream;
- Stream bank stabilization; and
- Buffers for streams from excessive silt and surface run-off pollution.

In addition, they provide important greenways within the community which protect:

- Wildlife habitat and migration corridors;
- Community green spaces which can provide noise buffering, improved aesthetics and community amenity; and
- Urban forest which can provide benefits such as sequestering gaseous air pollutants and particulates, energy conservation through transpirational cooling and shading.

6.2 Measures to Mitigate the Environmental Hydrologic Impacts of Development

The following stormwater management measures can be implemented to mitigate the hydrologic impacts of development:

- **Low Impact Development (LID) techniques** such as reduced road widths, reduced building footprints, reduced parking standards, limiting surface parking, pervious parking surfaces, building compact communities, and preserving naturally significant features;
- **Source Controls** such as absorbent landscaping, surface infiltration facilities, bio-retention facilities, sub-surface infiltration facilities, green roofs, rainwater harvesting, and re-use;
- **Water Quality Treatment BMPs** such as biofilters, urban forests and leave strips, infiltration systems, constructed wetlands, and wet settling ponds. Oil and grit separators are suitable for spill control and removal of floatable petroleum-based contaminants as well as coarse grit and sediment from small areas, such as gas stations, automotive service areas and parking lots. Oil and grit separators have limited application in large-scale stormwater runoff applications, and should be limited to small area generation sites;
- **Construction Best Practices** for any site or subdivision work must include measures to prevent the release of silt, sediment, sediment-laden water, raw concrete, concrete leachate, or any other deleterious substance into any ditch, watercourse, stream, or storm sewer system. The work area should be isolated from flowing water as much as possible and diversions around the site should be provided for overland flow paths. Ensuring that all equipment used on-site is in good working order, and having a ready spill containment kit and staff trained in its use, are also critical measures; and
- **Rainwater Detention Systems** to limit the post-development runoff to the pre-development rate, volume, and approximate shape of the hydrograph for the 6-month/24 hour and 2-year/24-hour storm events and to maintain, as closely as possible, the natural pre-development flow pattern in the receiving watercourse.



Rain gardens at Cowichan Lake Sports Arena installed in 2011

Rainwater Infiltration Systems can retain runoff, recharge groundwater and control peak flows. The soil, through which the stormwater runoff passes, also acts as a filter removing a large percentage of the common pollutants normally discharged to the stream or creek. Infiltration can recharge local groundwater which in turn feeds smaller streams and creeks through seepage. Groundwater which is slowly discharged back into streams and can constitute all or part of a stream's baseflow. This baseflow can be critical for fish and fish habitat during extended periods of little or no precipitation and runoff. It maintains preferred spawning conditions for several salmon species which key on groundwater seepage areas for spawning and egg incubation.



In areas with well-draining soils, stormwater runoff from a site can be collected and discharged into an infiltration system where there are no conventional stormwater removal systems, or infrastructure, which reduces the costs of providing offsite conveyance.

Protection and enhancement of riparian areas is also imperative to watershed health.

6.3 RWM Criteria for Environmental and Erosion Protection

The RWM criteria for watercourse ecological protection are summarized as follows:

<p>Capture and infiltrate up to 90% of average annual runoff (Size rainwater management facilities to capture 63 mm of rainfall or 72% of 2-year 24-hour total rainfall depth based on Lake Cowichan Climate Station).</p> <p>Maximum release rate should limit the post-development 2-year peak flow to pre-development peak flow (natural forested conditions).</p> <p>Treat up to 90% of average annual runoff to meet (80% Total Suspended Solids removal based on 50 µm particle size)</p> <p>Protect/Enhance riparian setbacks.</p>

These criteria shall be used to size source controls.

6.4 Source Control Example for Lake Cowichan

Source Controls

Source controls reduce runoff volumes (and downstream erosion) and provide water treatment. In addition, source controls have the benefit of providing groundwater recharge and maintaining baseflow in the creek.

Selection of appropriate source controls for a particular site is dependent on the proposed land use, surficial soil type, and ground slope. The effects of these parameters are as follows:

- Surficial Soil Type: The surficial soil type is used to calculate the infiltration rate and therefore the size of infiltration source controls. Surficial geology and infiltration and bio-retention potential is shown on Figure 2-5;
- Ground water table: Infiltration and retention facility should be located a minimum of 1m above groundwater table; and
- Ground slope: On steeper grades, rain gardens can be stepped but may require additional geotechnical/hydrogeological engineering considerations for slope stability and to ensure there is not potential for seepage into neighbouring properties.

Rain Garden Example

Assuming the native well-draining sandy soil has an infiltration rate of 25 mm/hr, the following source controls are proposed:

- Rain garden with overflow (capture and detention of **63 mm of rainfall (72% of 2-year 24-hour total rainfall depth)**), provided through available storage volume in the rock pit and infiltration);
- 300 mm absorbent soils on all landscaped areas; and
- Runoff from paved areas directed to grass areas for water quality treatment.

Given these parameters, the rain garden size per unit of impervious area is estimated to be 584 m²/ha with a requirement for 670 m³/ha of capture volume.

For the minimum single family residential lot, area of 667m³, maximum lot coverage area of 30% plus 10% allowance for driveways and other paved surfaces, a rain garden would have to be sized for 15 m² area with 18 m³ capture volume. This equates to a rain garden approximately 4 m x 4 m with average of 0.3 m deep surface storage with 0.5 m thick layer of topsoil over a 0.4 m deep layer of trench rock. An overflow drain connected to the storm drain system is required for all rain garden installations.

Disconnected roof leaders to pervious lawn areas can be very effective on larger lots to encourage infiltration, however in this example; there is not enough lawn area to accept the volume of roof runoff.

6.5 Preservation of Riparian Areas in Accordance with RAR

The Riparian Areas Regulation (RAR) applies to watercourses that are considered to be fish-bearing or potentially fish-bearing, including watercourses that flow into fish-bearing waters. The RAR stipulates methods and requirements for calculating the Streamside Protection and Enhancement Areas (SPEA) or “setback” from streams when new or re-development occurs. All of the watercourses identified in this report flow into Cowichan Lake or Cowichan River, therefore, they are considered to be fish-bearing or potentially fish-bearing, and therefore are subject to the Riparian Areas Regulation. Figure 6-1 shows proposed 30 m watercourse and streamside protection areas based on watercourses identified as part of the habitat inventory mapping.

Watercourses in this assessment were delineated in broad terms only, to note channel width and the distinction between wetlands, stream channels and narrow ditch-like tributaries. The channels were not assessed in their entirety, therefore approximate SPEAs have been assigned conservatively. The designation for “ditches”, which has specific definition and setbacks under the RAR, has not been assigned in this report and default SPEA setbacks for watercourses have been applied. The results of the assessment are the delineation of the Riparian Assessment Area (RAA), a conservative, approximate SPEA and a set of measures to protect the integrity of the SPEA and watercourse (See Appendix F).

In the event that a site specific detailed RAR assessment is prepared for an individual property by a Qualified Environmental Professional (QEP), the resulting SPEA and measures from the report would take precedent over those described within this report.



Example of riparian encroachment – Tern Creek



Example of healthy riparian zone – Oliver Creek



7. Land-use Planning, Bylaws and Standards Review

7.1 Review of Bylaws and Planning Documents

The following summarizes the Town's bylaws and planning documents relative to rainwater and stormwater management.

Official Community Plan

The "Town of Lake Cowichan Official Community Plan Bylaw No. 910-2011" (OCP) was adopted in October of 2011 and provides guidance on key management goals and objectives with regards to protecting the natural environment. Chapter 4 of the OCP relates to the natural environment and its stated goal is:

"To preserve, maintain and enhance areas which are of natural, scenic, cultural, heritage and recreational value."

The objectives of Chapter 4, *The Natural Environment* of the OCP include:

- 4.3 a) *"To identify, protect and enhance natural areas, including stream corridors, for the long term benefit of natural ecosystems, including fish, wildlife and plant habitat."*
- 4.3 c) *"To reduce and prevent air, land and water Pollution."*
- 4.3 d) *"To maintain the water quality of Cowichan Lake and the Cowichan River."*
- 4.3 f) *"To ensure a healthy water balance approach to rainwater management for all development."*

A number of policies have been developed to achieve the goal and objectives. These policies, detailed below include the requirement of a water balance model for all development and providing retention to reduce runoff and improve water quality. The policies relating to the protection of watercourses and for which a rainwater and stormwater management bylaw would be applicable to can be found below.

- 4.4.2 *All development and land alteration within the Watercourse Protection Development Permit Area (DPA-1) will be carefully scrutinized in accordance with the development permit area guidelines.*
- 4.4.3 *To reduce the threat of flooding, in evaluating all development proposals within the Plan area where it is believed there may be some potential deleterious impact on neighbouring watercourses, the developers shall be required to:*
 - i) *Provide details of the anticipated increased runoff from land clearing and site development;*
 - ii) *Outline a program of storm water retention by which an increase in site runoff from the subject parcel may be prevented or minimized, and water quality and quantity improved; and*
 - iii) *Undertake any other environment impact assessments or geotechnical studies as may be required.*
- 4.4.4 *New development and land alteration on steep slopes over of 30% shall be restricted with respect to the degree of "cut and fill," slope stability, hydrological considerations and aesthetic considerations in accordance with the Natural Hazards Development Permit Area (DPA-2) guidelines.*
- 4.4.5 *All development proposals will achieve a water balance in a manner that maintains pre-development hydrology.*
- 17.4 *Watercourse and Streamside Protection Development Permit Areas (DPA1) have been identified in the Official Community Plan. The purpose of these areas is for protection of the natural environment, its ecosystems and biological diversity and for promoting the reduction of greenhouse gas emissions.*



17.4.3 Objectives

- a) *To protect watercourses and their riparian areas, and the adjacent upland areas that exert an influence on watercourses, from development.*
- b) *To restore and enhance watercourses and their riparian habitat for wildlife movement and the natural features, functions and conditions that support fish and wildlife processes.*
- c) *To create an awareness among Town residents and residents of adjacent Electoral Areas of the significance and importance of fish habitat.*

The OCP restricts development within the Streamside Protection and Enhancement Area except for:

- Works authorized by the Department of Fisheries and Oceans or a regulation under the Fisheries Act (Canada); and
- Works and activities that comply with the laws, regulations and best management practices of the Water Act, for example bank repairs, stormwater outfalls, road crossings, footbridges and pipeline crossings.

Subdivision Bylaw No. 276

Subdivision Bylaw No. 276 lays out guidelines for the design of storm sewers but does not address stormwater or rainwater management such as rate control (detention) or volume control (infiltration) criteria.

Zoning Bylaw No. 935

The Zoning Bylaw No. 935 makes mention of riparian corridor protection but as per the Subdivision Bylaw, it does not address stormwater or rainwater management for differing land uses.

7.2 Bylaw Recommendations

Based on the goal, objectives and policies in the current OCP and the lack of supporting criteria in the subdivision and zoning bylaws, a new overarching Rainwater Management Bylaw is proposed.

The bylaw would be most beneficial with specific directives relating to on-site retention, peak flow attenuation and treatment to allow the Town to meet its goal and objectives with regards to protecting the natural environment.

To ensure continuity throughout the bylaws, an update to the Subdivision Bylaw and the Draft Zoning Bylaw would be beneficial to reference the new rainwater management bylaw. Applicable rainwater management criteria for the proposed new bylaw are summarized in Table 7-1:



Table 7-1: Summary of Rainwater Management Criteria

Category	Rainwater Management Criteria	
Flood Protection	Minor Drainage System	Safe conveyance of the 10-year return period (for < 900 mm diameter pipes) and 25-year return period (for > 900 mm diameter pipes) storm flows ¹ .
	Major Drainage System	Safe conveyance of the 100-year return period storm flows.
Environmental Protection of Watercourses	Volume Reduction	The 90% average annual runoff volume ² shall be captured and infiltrated to ground. ² Can be estimated by the 6-month 24-hour return period event) 72% of the 2-year, 24-hour return period total rainfall depth (62 mm based on Lake Cowichan Climate Station Data).
	Water Quality	Source Controls or approved alternatives shall be sized to treat the 90% average annual runoff volume. (80% Total Suspended Solids removal based on 50 µm particle size) ³ Limit construction discharge water quality to the lesser of turbidity of 25 NTU or total suspended solids of 25 mg/L at all times expected in the 24 hour period following significant rainfall events (≥25 mm/day) at which time the turbidity can be up to 100 NTU. ³
	Rate Control	Detain 6-month ⁴ and 2-year, 24-hour post-development flows to pre-development levels (natural forested conditions) ³ for all new or redevelopment.
	Riparian	Establish riparian setbacks to comply with RAR requirements. ⁴
<ol style="list-style-type: none"> 1. Town of Lake Cowichan Subdivision Bylaw No. 276 & MOTI, 2007 2. Stormwater Planning, A Guidebook for B.C., MOE, May 2002 3. Land Development Guidelines for the Protection of Aquatic Habitat, Fisheries and Oceans Canada, Sep 1993. 4. Riparian Areas Regulation (RAR), 2006 <p> Apply to all water bodies – streams, wetlands, lakes Apply to streams susceptible to erosion</p>		






Adopting a new rainwater management bylaw with the above criteria would allow the Town to move towards meeting its goal and objectives with regards to protecting the natural environment, maintaining water quality in Lake Cowichan and the Cowichan River as well as maintaining summer base flows through retention and infiltration of the 6-month, 24-hour runoff volume.

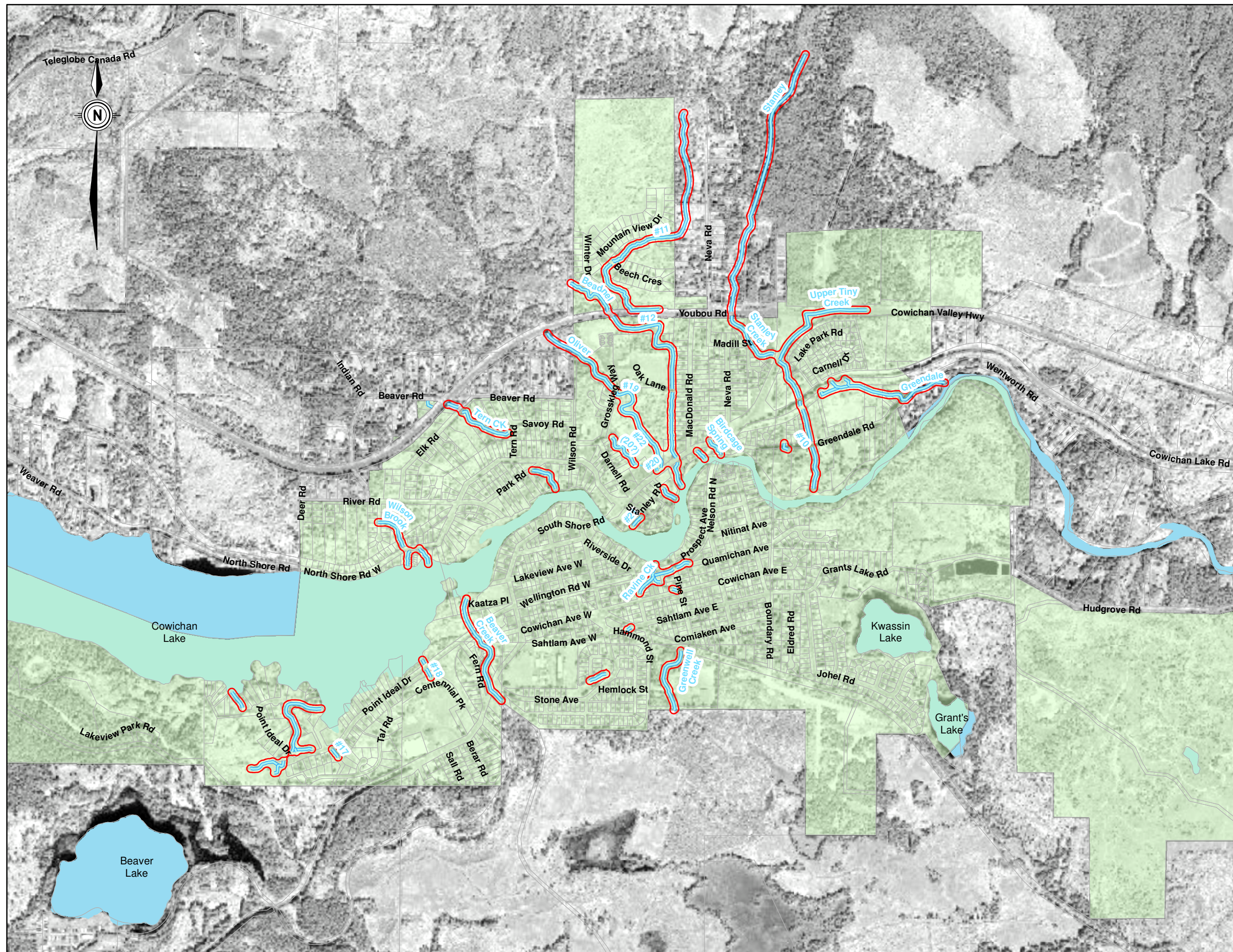
In addition to providing rainwater management criteria, the new bylaw could provide design guidance as to the type of measures (i.e., rain gardens, absorbent landscaping, rock trenches, swales, green roofs), who would be responsible for maintenance and where they should be located. Refer to Metro Vancouver’s *Stormwater Source Control Guidelines, 2012* for descriptions and sizing guidance for these measures.

The bylaw could either be performance-based, where only targets are provided with no direction as to how to meet the criteria or prescriptive-based, where specific design standards are provided to assist development with design. Some municipalities have adopted bylaws that use a blended approach where prescriptive standards are provided for smaller less complicated developments while performance-based specifications are provides for larger or more complicated developments.

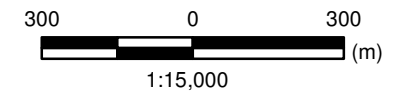
**Town of Lake Cowichan
Integrated Rainwater Management Plan**

Legend

-  Creeks from Habitat Plan
-  Watercourse and Streamside Protection Areas (30 m wide riparian buffer)
-  Legal
-  Municipal Town Boundary
-  Water body



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2218-007

Date
April 2015

**Watercourse and
Streamside Protection
Areas**

Figure 7-1



8. Proposed IRMP Strategy

8.1 IRMP Guiding Principles

The primary objective of the IRMP is to provide “on the ground” solutions for rainwater management issues in the watersheds. The solutions address the three primary goals of the IRMP:

1. Protect public safety and private property from flooding;
2. Improve and protect stream and riparian habitat; and
3. Improve and protect water quality for instream aquatic habitat, public health and receiving waters.

The following sub-sections outline proposed strategies for each of these goals. An overview of the recommended strategies and the goals they strive to achieve is shown in Table 8-1. More detailed discussion of specific projects required to implement these strategies are outlined in Section 9 – Implementation Plan.

8.2 Traditional Urban Drainage versus Integrated Rainwater Management

Traditional urban drainage systems were designed to protect public safety and property from flooding. They were designed to efficiently carry runoff away from development and discharge into the receiving waters. These systems include paved roads, gutters, catch basins, ditches, and storm drains. Design criteria typically required systems to be designed to convey large flood events that do not occur regularly (i.e., between 10-year and 100-year events).

Since traditional drainage systems are very efficient at transporting runoff, they accelerate the runoff process and increase peak discharges and volumes. This can and often does have negative impacts on the receiving watercourses in the form of channel erosion, habitat degradation, reduced baseflow and reduced water quality. These systems are still a very important part of the flood conveyance system, but now there is more emphasis on the frequently occurring events and protection of watercourse health and stability.

An integrated approach considers the entire hydrological regime from large storm events that rarely occur to small rainfall events that occur on a regular basis to baseflows supporting habitat during dry periods. The *BC Stormwater Planning Guidebook* divides the hydrological regime into three components:

1. Rare extreme events (peak flow greater than 2-year return period) that should be efficiently carried away to protect public safety and property from flooding;
2. Infrequent large events (peak flow up to 2-year return period) that should be detained and released at pre-development rates to protect stream and riparian corridors from erosion and habitat degradation; and
3. Frequent small events (flow volume up to 72% of the 2-year return period) that should be captured and infiltrated on-site to protect baseflows and reduce erosive runoff volume.

72% of the 2-year return period total rainfall target equates to 90% of the average annual rainfall volume (62 mm for Lake Cowichan Climate Station) being returned to natural hydrologic pathways (evapotranspiration and infiltration). In addition to runoff controls, land use in the watershed should be managed and planned to protect streams and riparian corridors.



8.3 Protection of Public Safety and Property from Flooding

To protect public safety and property from flooding, the drainage system should have the capacity to convey the drainage design events – 10-year, or 25-year return period events depending on culvert or storm drain pipe size. For major road crossings, on Lake Cowichan Highway, South Shore Road and Lake Cowichan Way culverts shall be sized for the 100-year return period event. Recommended storm drain upgrades are summarized in Table 8-1 and shown in Figure 8-1.

Table 8-1: Proposed Storm Sewer and Culvert Upgrades for Existing Land Use Conditions

Priority	Length of Upgrades (m)	% of Total Length
Highest (Overland Flooding)	577	6%
High (Surcharging)	5,951	53%
Medium (Upgrade by more than one diameter)	3,061	27%
Low (Upgrade by one diameter)	555	5%
Minimum Requirement	987	9%
Total Length of Upgrades	11,131	

Floodplain Levels

In addition to storm system upgrades, reducing risk of flooding from Cowichan Lake and the Cowichan River should also be addressed through adoption of the policies in the Natural Hazard Lands Development Permit Area outlined in the Town’s OCP. The OCP guidelines state that no development or redevelopment of lands which fall within the floodplain shall be undertaken without proper site specific mitigations measures being implemented. Council requires any redevelopment work being undertaken within the floodplain to undertake site specific engineering, biological or other studies to define constraints, limitations or mitigation strategies to limit risks to proposed development or redevelopment. The primary mitigation factor should be to limit re-development such that minimum habitable floor level is at or above the 200-year floodplain level shown in the provincial floodplain maps for Cowichan Lake and Cowichan River prepared in June 1984 (84-33 Drawing 6). A copy of which can be found at:

http://env.gov.bc.ca/wsd/data_searches/fpm/reports/keyplans-html/cowichan-lk.html

The designated 200-year floodplain level ranges from 167.33 m-GSC near the lake to 166.1 m-GSC at Greendale Trestle.

8.4 Protection of Stream Channel and Riparian Habitat

The second goal of the IRMP is to protect stream channel and riparian habitat. This can be achieved through stormwater volume reduction controls and rate controls, and riparian area protection.

Stream Channel Habitat

The strategies used to achieve the goal of protecting and improving stream channel habitat include:

- Implementing on-site source controls as part of an Rainwater Management Bylaw (Section 6); and
- Riparian corridor protection and habitat enhancement through implementation of the Watercourse and Streamside Protection Development Permit Area outlined in the OCP (Section 6).



As outlined in Section 6, a new rainwater management bylaw should be developed to require source controls to be implemented as part of new development. The source controls should:

1. Capture and infiltrate the 6-month, 24-hour return period storm event (72% of 2-year return period, 24-hour event); and
2. For those developments draining to tributary watercourses, sufficient detention volume should be provided for the 2-year, 24-hour return period

In addition to implementation of source controls as part of redevelopment, the Town should also implement a Green Roads Policy which requires implementation of source controls as part of any future road upgrades to meet the stream channel protection criteria.

Riparian Habitat

The primary method to protect riparian habitat is through implementation and enforcement of the streamside protection and enhancement areas (SPEAs). In addition, the following activities can also be implemented to protect riparian habitat. Some strategies for protection of SPEA are outlined in Section 7.5 and in Appendix F.

8.5 Protection of Rainwater Quality

The final goal of the IRMP is to protect and improve rainwater quality for both watercourses and receiving waters. Implementation of the development and Green Roads source controls to capture and treat the 6-month storm event will provide a strong basis for improvements to stormwater quality.

This IRMP could also provide the basis to protect receiving water quality as part of a larger Liquid Waste Management Plan (LWMP), which would also address water quality issues from sanitary sewer and other sources. Some of the strategies related to stormwater quality that should be addressed as part of the LWMP should include:

- Require sediment and water management BMPs to be implemented during construction and site development;
- Street sweeping and catch basin cleaning programs;
- Public education and outreach;
- Develop emergency spill response plans for both municipal activities as well as private construction or site redevelopment;
- Develop and implement Contractor Education/Training Program for sediment management and construction of rainwater management infrastructure (rain gardens, infiltration, etc.);
- Use of industrial BMPs (such as oil/grit separators) for protection of water quality where appropriate;
- Develop and implement a cross-connection prevention program; and
- Reduce or eliminate pesticide and herbicide use.

Many of these recommendations would likely be included as part of a LWMP; however, they should be implemented as part of rainwater management and stormwater quality bylaw updates which could occur prior to completion and adoption of the LWMP.



9. IRMP Implementation

9.1 Introduction

The IRMP outlined in Section 8 provides measures to meet IRMP goals and tasks. The following section outlines priorities and costs for implementation of the plan.

9.2 Drainage Improvement Priorities

The priority of drainage system upgrades follows the following criteria for existing land use conditions:

- Highest Priority (Major Drainage System): Existing storm drain flooding (more than 15-minutes duration or more than 0.3 m ponding depth) with no safe overland flood route for existing land use conditions;
- High Priority (Minor Drainage System with Flooding): Existing storm drain flooding (more than 15-minutes duration or more than 0.3 m ponding depth) for existing land use conditions;
- Medium Priority (Minor Drainage System with Surge Upgrade Two Standard Pipe Diameters): Existing storm drain surcharging (more than pipe capacity but with HGL less than ground level) requiring upgrade of two or more standard pipe sizes to prevent surcharging;
- Low priority (Minor Drainage System with Surge Upgrade One Standard Pipe Diameters): Existing storm drain surcharging requiring upgrade of only one standard pipe size to prevent surcharging; and
- Minimum Standard: Existing storm drain not surcharging but less than minimum standard diameter of 200 mm.

For storm sewers and culverts that meet the criteria under existing land use but surcharge under future land use, upgrades will be required at time of development or will require detention to reduce peak flows to meet design flows within the downstream system.

A plan showing the location of the priorities for upgrades is shown in Figure 8-1.

9.3 Implementation Costs

Budgetary cost estimates have been provided for the short, medium and long term drainage upgrades. The total estimated cost for drainage upgrades are shown in Table 9-1.

Table 9-1: Estimated Drainage Improvement Implementation Costs

Priority	Description	Total Upgrade Length (m)	Sum of Replacement Cost (\$)
Highest	Flooding with no safe overland flood route – (Major Drainage System)	577	\$287,000
High	Flooding (Minor System with Flooding)	5,951	\$1,869,000
Medium	Surcharging requiring upgrade of two or more standard pipe sizes (Minor system with surcharge [2 diameters])	3,054	\$1,316,000



Priority	Description	Total Upgrade Length (m)	Sum of Replacement Cost (\$)
Low	Surcharging requiring upgrade of one standard pipe size Minor system with surcharge (1 diameter)	555	\$135,000
Minimum Standard	Pipe size requiring upgrade to minimum pipe diameter of 200 mm	759	\$132,000
Major Culverts	Upgrade of Bear Creek Culvert to meet 100-year return period flood.	20	\$350,000
Grand Total		10,916	\$4,089,000
Note: Flooding is defined as hydraulic grade line above ground level. The modelling assessment flags pipe sizes as inadequate if surcharging for a minimum of 15 minutes or at least 0.3 m above the crown of the pipe. Refer to Appendix E for cost estimate breakdowns by pipe. Costs shown are for drainage upgrades required to safely convey flood discharges for the existing land use condition. Drainage improvements under future land use would be covered either under development cost charges for new development to upgrade drainage system downstream of development or through detention sized to reduce peak flows from new development to predevelopment levels.			

The costs are conceptual and are considered to be suitable for capital planning purposes. They are based on typical current 2015 costs for design and construction of similar projects. They are based on typical unit rates for drainage upgrades for both under grass and under paved surfaces. The costs do not include any additional related works such as rain gardens or other road improvements. Detailed breakdown of cost estimates for specific upgrades is included in Appendix G.

9.3.1 Funding Opportunities

Highest Priority Upgrades

Both the highest and high priority upgrades should be implemented as soon as possible. The total cost to upgrade these sites is estimated to be approximately \$2.156 Million. The Town should investigate and apply for funding of these upgrades through available infrastructure grants. Table 9-2 summarizes the funding opportunities which exist to assist with implementation of IRMP projects. An updated list of available funding sources can be found on the Civicinfo BC website.

Table 9-2: Available Funding Sources

Name	Agency	Cost Share	Amount
Infrastructure			
Building Canada Fund	Infrastructure Canada	Varies	Varies
Gas Tax	Infrastructure Canada	Varies	Varies
Green Municipal Fund	Union of BC Municipalities	Up to 50%	Up to \$350,000
Infrastructure Planning Grant Program	BC Ministry of Community Development	Up to 50%	Up to \$10,000
Source: Civicinfo BC – www.civicinfo.bc.ca – Accessed July 2014			



Lower Priority Upgrades

The medium, low and minimum standard upgrades should be implemented as opportunity arise through collection of Development Cost Charges or as part of other capital plan projects such as road upgrades, watermain replacements or sanitary sewer replacements.

Maintenance Replacements or Upgrades

It should be noted that the priority of drainage upgrades is based solely on drainage assessment results. These results assume full capacity of the storm system is available. As noted earlier, CCTV inspections of the drainage system carried out as part of this study have identified that parts of the drainage system have considerable debris, accumulation of sediment or collapse of existing pipes. These potential upgrades should be implemented as part of other capital projects with CCTV inspections of storm system occurring as part of planning for other municipal infrastructure upgrades.

9.4 On-going Monitoring and Adaptive Management

To measure the success of rainwater management and other mitigation measures, the following adaptive management plan is proposed. The implementation plan and schedule should be monitored continuously and reviewed annually to assess:

1. How education/permitting/enforcement by the Town is progressing once the IRMP is adopted. Are developers being instructed to incorporate proposed mitigation measures?
2. How development is incorporating the proposed mitigation measures. Are developers incorporating the measures properly?

The monitoring strategy will include the following performance indicators and the duration and frequency associated with each:

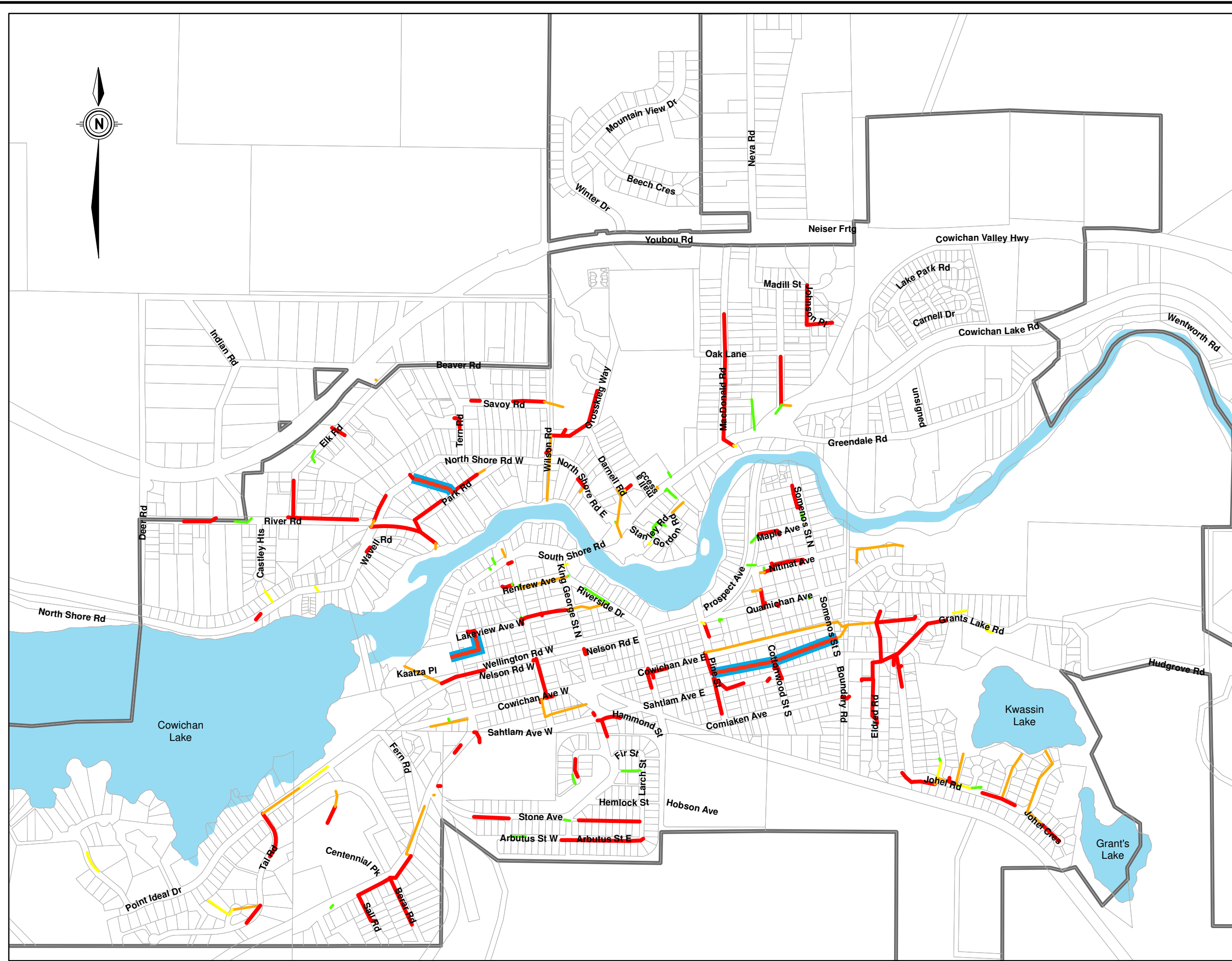
1. Implement a water quality monitoring program at key locations in the Town in partnership with CVRD and local stewardship groups;
2. Monitor identified erosion sites every ten years to assess on-going stability of channel morphology; and
3. Prepare bi-annual “State of Integrated Rainwater Management” report to monitor implementation and report success of the plan. These reports should include a brief summary of the previous two years activities including programs or projects implemented, the status of future projects as well as a summary of the performance monitoring results.

Town of Lake Cowichan
Integrated Rainwater Management Plan

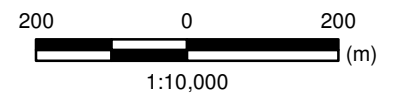
Legend

Priority Ranking

- Increase Diameter to Minimum Standard (200 mm)
- Low - Upgrade Diameter by One Size
- Medium - Upgrade Diameter by more than One Size
- High - Flooding (min 15 minutes and/or Surcharge Depth greater than 0.3 m)
- Highest - Flooding with No Overland Flow Route
- Legal
- Municipal Town Boundary
- Water body



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Project No.
2218-007

Date
April 2015

**Priority of Drainage
System Improvements**

Figure 9-1

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10. Recommendations

Based on the foregoing, it is recommended that the Town:

Goal 1: Protection of Public Safety and Private Property

1. Implement drainage upgrades starting with highest priority upgrades followed by high priority upgrades through grant funding or other funding sources;
2. Implement drainage upgrades for medium, low and minimum priorities as part of planning for other capital infrastructure projects such as road upgrades, watermain replacements or sanitary sewer replacements.
3. Require future development to either provide detention to limit runoff to meet design maximum design flows for existing land use (pre-development) conditions in downstream drainage system or upgrade downstream drainage system, such that pipes do not surcharge as a result of increased runoff from development for the 10-year return period or 25-year return period depending on pipe diameter; and
4. Continue CCTV inspections of existing storm drain system to identify other potential blockages as part of planning for other capital infrastructure projects such as road upgrades, watermain replacements or sanitary sewer replacements.

Goal 2: Protect Riparian and Aquatic Habitat

1. Develop and adopt a Rainwater Management Bylaw to supplement the existing subdivision and development bylaw, the zoning bylaw and the OCP bylaw to specify design criteria and detail requirements for rainwater management source controls within development;
2. Implement and enforce the requirements of the Riparian Areas Regulation, as part of new development or re-development of lands in the watersheds;
3. Require a minimum of 63 mm rainwater capture (72% of 2-year, 24-hr event Lake Cowichan Climate Station), including requirements for on-lot BMPs and minimum 300 mm topsoil depths;
4. Require detention of 2-year storm event to pre-development levels except in those areas draining directly to Cowichan Lake or the Cowichan River; and
5. Implement a Green Road policy which requires implementation of source controls for road runoff meeting the same requirements as those for development.

Goal 3: Protect Watercourse and Receiving Water Quality

1. Encourage low impact development practices and source controls including bio-swales, rain gardens, and reduced pavement widths as part of new development or re-development;
2. Encourage use of innovative rainwater BMP designs and LEED™ development in buildings including permeable pavement, green roofs, and rainwater harvesting;
3. Develop a comprehensive street sweeping and catch basin cleaning program;
4. Develop public education and information on protection of water quality and impacts on receiving waters. Encourage landowners to retrofit their property to benefit aquatic ecosystems (rain gardens, bioswales, rainwater capture, permeable driveways, etc.), and reduce use of deleterious substances such as fertilizers, cleaning agents and other toxic chemicals;



5. Require comprehensive erosion and sediment control plans as part of land development and construction;
6. Require development of emergency spill response plans for Town operations and new land development or construction projects; and
7. Develop and implement Contractor Education/Training Program for sediment management and construction of rainwater management infrastructure (rain gardens, infiltration, etc.).

Monitoring and Adaptive Management

1. Prepare annual “State of Rainwater” report to monitor implementation and report success of the plan. This plan will include a brief summary of the previous year’s activities, including programs or projects implemented and status of future projects as well as a summary of the performance monitoring results;
2. Review and update IRMP plan every ten years to include new techniques, technologies or lessons learned and work completed; and
3. Review and update model every ten years to provide indication of success of plan implementation.



10.1 Report Submission

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Revision History

Revision #	Date	Status	Revision	Author
0	June 2014	Final	Final Report	CS
A	December 2014	Draft	Draft Report Submission	CS