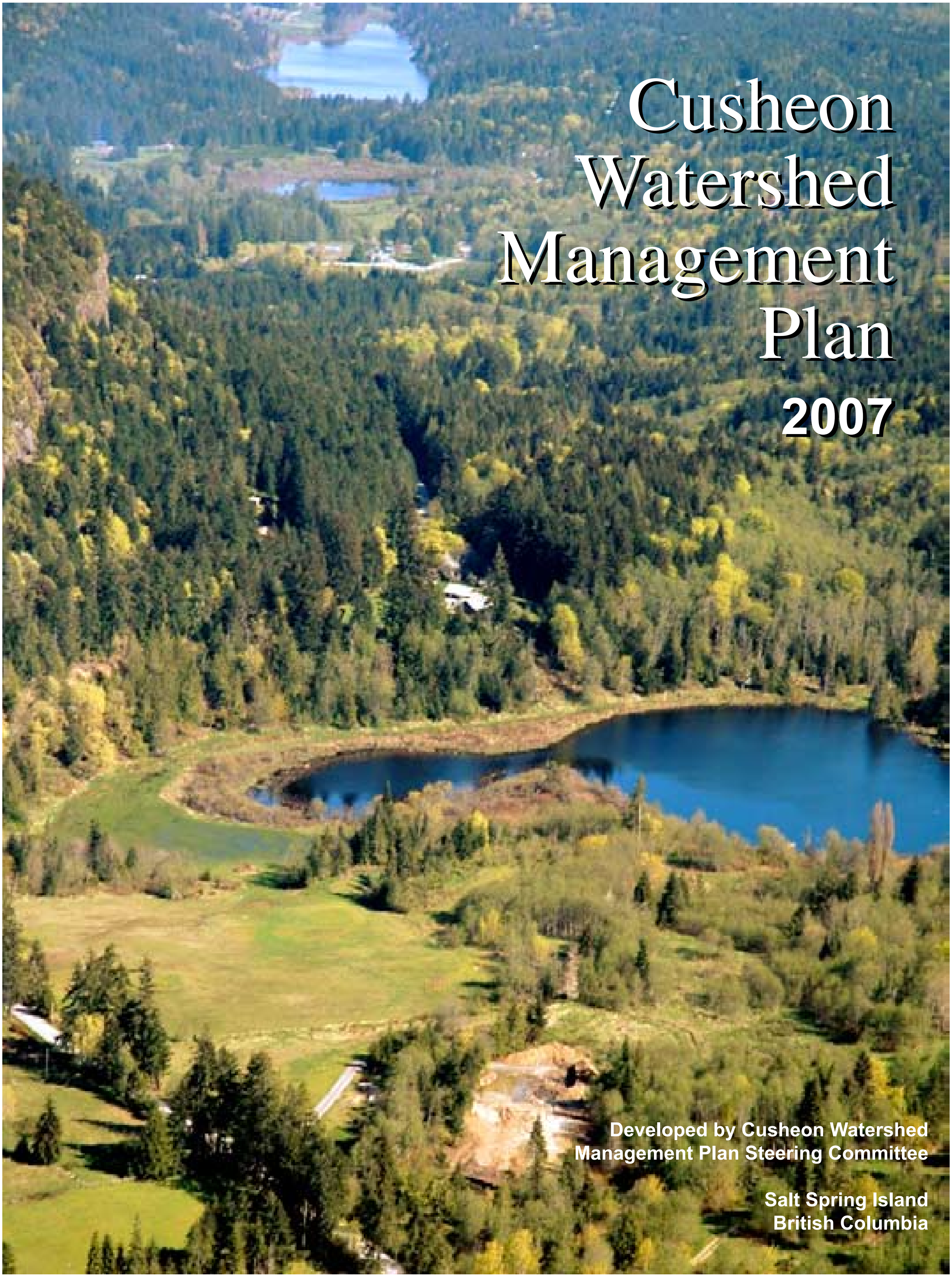

Cusheon Watershed Management Plan

2007

Developed by Cusheon Watershed Management Plan Steering Committee

Salt Spring Island
British Columbia

Acknowledgements

Many people, over many years, have put in time and effort on the protection of Cusheon Lake and its water, and they all deserve thanks. We have tried to list them below, and apologise for any omissions.

Cusheon Lake Stewardship Committee
This committee was founded and chaired for many years by Wayne Hewitt, who was its Executive Director. Many members have been active for over 10 years and have gathered important information about the lake. In addition, the Committee held public meetings.

Cusheon Watershed Management Plan Steering Committee
This committee grew out of public meetings expressing concern about the deteriorating quality of the water in Cusheon Lake. It is presently chaired by Wayne Hewitt, who has dedicated many hours to this task, and has been a driving force throughout the existence of the committee.

John Sprague has given Salt Spring Island the benefit of his background as an internationally known biologist by writing the first drafts of this management plan, conducting and evaluating a water sampling program, plus preparing background reports. Wayne Hewitt also shared his wealth of knowledge about the lake and helped John Sprague with water sampling, as did Wiebke and Wilfried Ortlepp. Carol Kelly consolidated information from members of the Committee and government sources to prepare successive drafts of the Plan. Maureen Moore edited, rewrote and shepherded many additional drafts including the final one.

Other past and current members of this committee have also contributed to the process and to the draft plan, including Kathy Reimer of Island Stream and Salmon Enhancement Society, Mark Head as a planner for Islands Trust, Maureen Moore of the Beddis and Cusheon Lake Area Residents' Association, Bob Francis of PARC, Gary Holman as CRD Director, Bob Weeden for the Salt Spring Conservancy, Deborah Epps for the Environmental Protection Division of the Ministry of the Environment, Frank Moore representing Beddis Waterworks, Tom Volquardson, Chair, Cusheon Lake Stewardship Committee and Wilfried and Wiebke Ortlepp of Cusheon Lake Farm.

Scientific and technical experts
Dr. John B. Sprague,** Sprague Associates Ltd., Salt Spring Island, formerly University of Guelph.
Dr. Carol Kelly,** Salt Spring Island, formerly University of Manitoba and Freshwater Institute, Winnipeg.
Maureen Moore, M.A.,** writer, editor, former Co-Chair, CWMP Steering Committee.
Dr. Rick Nordin, University of Victoria, formerly of B.C. MELP[1].
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Kimberly Lineger, Islands Trustee, one term, former Chair CWMP Steering Committee.

Stakeholders
Thanks to Judith Bradley, Michael Butler, and others in "The Bloomers." Also thanks to all who attended public meetings over the years to express their concern, share ideas, fill out questionaires, and help this project along.

Donors
Thanks to Water Preservation Society, CRD grant for Plan publication, Accomodation Group of SSI, Dr. Carol Kelly & Maureen Moore.

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[1]MELP = B.C. Ministry of Environment, Lands and Parks, renamed MWLAP = B.C. Ministry of Water, Land and Air Protection, and now named B.C. Ministry of the Environment

** Current member of the Steering Committee

Notes & Comments

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Summary

1) The Cusheon Watershed Management Plan Steering Committee has produced this plan with participation of volunteer groups, the Director of the Capital Regional District, Trustees, a volunteer planner from Islands Trust, and the B.C. Ministry of the Environment.

2) The goal of this plan is to restore and protect the sources of water in the Cusheon Lake watershed, so that Cusheon Lake will provide potable water after reasonable treatment, algal blooms will be reduced, and fish and wildlife habitat will be improved.

3) The Cusheon watershed is in central Salt Spring Island and contains 10.65 square kilometres. Humans have modified most of the basin; 62% has been logged or otherwise cleared, and 8% is in small-scale agriculture. Residences are scattered throughout the basin and clustered around Cusheon Lake. There is one resort, a subdivision of prefabricated homes, a golf course, a garbage transfer station, a private school and yoga centre. Only 13% of the basin is considered "natural".

4) Groundwater in the basin has not been evaluated. All creeks in the basin are intermittent.

5) Cusheon Lake ranks third in volume of water, among the nine largest lakes of Salt Spring Island. However, it ranks first in terms of water supply (the yearly inflow), with a larger supply than St. Mary Lake, which is often thought of as the major supply on the island.

6) Cusheon Lake is well used for recreation and supports appreciable populations of smallmouth bass, three-spine stickleback, cutthroat trout, and small Coho salmon.

7) Cusheon Lake is now classified as mesotrophic (moderately enriched) with excursions into eutrophic (highly enriched), and has experienced both algal and cyanobacterial blooms. These blooms have caused prohibitions on use of the water.

8) Phosphorus is the key (limiting) nutrient controlling the amount of algal growth in Cusheon Lake. An estimate of current total loading of phosphorus to the lake is 117 kilograms per year, from both external and internal sources. Modelling the sources indicates that the largest (53.5%) is land runoff, both direct and via the upstream lakes.

   Septic systems and shoreline effects from residences near the lake contribute about 23%. Internal recycling of phosphorus from bottom sediments is caused by enrichment and lack of oxygen in deep waters, and contributes about 21% of the total load. The various sources are listed below.

Upstream land and lakes	45.5 kg	= 38.8%
Cusheon land runoff	17.2 kg	= 14.7%
Shoreline residences	19.1 kg	= 16.3%
Modular home park	7.8 kg	= 6.6%
Regeneration from sediment	25.0 kg	= 21.3%
Precipitation, fallout	2.6 kg	= 2.3%

9) The estimates of phosphorus input were confirmed by a one-year study of phosphorus runoff to upper Blackburn Creek. The modelling and the field study arrived at similar estimates of phosphorus runoff from the land (close to 0.10 kg/hectare).

10) The model indicates that many, or most, of the septic systems near the lake are performing reasonably well for phosphorus control. However, direct inspection of septic systems to check for malfunctions is recommended.

11) Three-quarters of the water reaching Cusheon Lake comes from upstream lakes (Roberts and Blackburn) which are moderately enriched from land runoff. Because of this, improving the quality of Cusheon Lake must involve improvements over the entire watershed, particularly measures that reduce land erosion and creek-bank erosion, with their contributions of nutrients.

12) **To achieve the general goal, the action plan has five main objectives, as follows:**

1. Define and map Cusheon's watershed, its land uses, creeks, wetlands and the status of riparian vegetation.
2. Undertake a scientific analysis of the phosphorus sources in the watershed.
3. Reduce inputs of phosphorus from land management activities.
4. Reduce inputs of phosphorus from water management activites.
5. Monitor springtime concentrations of phosphorus.

13) Specifically, the committee recommends that the lake should be returned to its estimated natural status of nutrient levels. That would be a "low mesotropic" condition with an average springtime phosphorus concentration of 13.5 parts per billion. This would require a reduction of about 17 kilograms in the total annual inputs of phosphorus, from 117 kg down to 100 kg.

14) Riparian zone enhancement should involve protecting zones already in good condition, and restoring vegetation in areas that have been disturbed. This will reduce the escape of nutrients to the lakes, and have other advantages for water quality in the creeks. Initial parts of the program would involve inventory and mapping, extension of Development Permit Areas to fit new provincial guidelines, and eco-credits on taxation.

15) Efforts to reduce nutrient flux from the general basin should involve preventing clear-cutting and other vegetation removal, educating people on the benefits of reforestation of previously cut areas, controlling animal waste, preventing escape of commercial or organic fertilizer, and reducing direct runoff from roads and other impervious areas.

16) Responsibility for coordinating and evaluating the program should reside with local government and the Cusheon Lake Stewardship Committee. A simple defined test program should be set up to monitor improvement of the lake over future years.

1 Introduction

The Cusheon Watershed Management Plan Steering Committee (hereafter called *the steering committee*) developed this plan. The plan grew from the aspirations of a number of people (as indicated in the Acknowledgments) and particularly from the work of the Cusheon Lake Stewardship Committee.

Achieving the goals of the plan will require:

- direction and implementation by local government
- continued cooperation of people who live in this watershed
- working with different levels of government
- identifying and taking advantage of existing relevant legislation
- educating the public
- Changes to the Salt Spring Island Official Community Plan (OCP) and Land Use Bylaw (LUB) 355.

1.1 Mission statement and goal

Overview

Activities of the stewardship and steering committees were mainly prompted by excessive algal blooms in Cusheon Lake, which severely affected the quality of drinking-water taken from the lake (see section 1.2).

"Algal blooms" occur when excessive nutrients foster the growth of large populations of green algae or cyanobacteria (sometimes erroneously called blue-green algae because they are plant-like in their ability to use sunlight).

Two main problems result from algal and cyanobacterial blooms:

- loss of oxygen from the bottom water of the lake which occurs when the organisms die, fall to the bottom, and decompose
- certain cyanobacterial blooms may produce toxins that are harmful to the nervous system and liver and may cause illness or death

These toxins cannot be removed by filtering or boiling the water. Some treatment methods, such as strong chlorination or oxidation may be effective, but chlorination can produce other harmful substances such as trihalomethanes that are associated with increased risk of cancer.

To achieve safe water quality we need to protect the quality of the lake water itself, in addition to having good treatment methods.

On a hopeful note, since algae and cyanobacteria have many of the characteristics of plants, they depend on phosphorus as an essential nutrient. If we can reduce the amounts of phosphorus reaching Cusheon Lake, the frequency and size of algal and cyanobacterial blooms will decrease. Many actions, such as improved septic field operation and control of animal waste, will not only decrease the water's phosphorus content but will also reduce the level of other pollutants that may adversely affect health. These types of actions focus on remedies for problems of past development.

An additional challenge, however, is to carry out overall reduction in phosphorus inputs to the lake while development around the lake is increasing.

Accordingly, the overall goal of this plan is:

- ***To restore and protect the quality of surface waters in the Cusheon watershed***

Achieving the goal stated above will also work toward parallel goals:

- ***To reduce the size and frequency of algal and cyanobacterial blooms***
- ***To provide potable water after reasonable treatment*** [1]
- ***To improve fish and wildlife habitat***

1 "Reasonable treatment" for a public water supply is defined as sand filtration and light chlorination. For a private residence drawing water from the lake, reasonable treatment is considered to be the use of a small commercial cartridge-type filter and ultra-violet disinfection.

Reducing the inputs of nutrients will reduce the size and frequency of algal and cyanobacterial blooms. A lake with fewer nutrients and algae will:

- relieve some problems for fish and other aquatic organisms
- reduce problems of lowered or fluctuating oxygen, which can affect fish and the smaller aquatic life forms that they eat
- reduce danger of harm to people, pets and fish from toxic cyanobacterial blooms
- enhance aesthetic and recreational value of the lake to the surrounding community
- not threaten property values.

In achieving the above goals, we anticipate Cusheon Watershed:

- will remain a rural area
- might develop according to the requirements of current zoning provisions (although we have serious concern about the concept of “build-out”)
- will continue to support a modest level of farming (which is currently low-impact) the golf course (which is currently organic) and the long-standing garbage transfer station.

1.2 History and previous activity

The problem of algal blooms in Cusheon Lake has been recognized since the 1970’s. In 1974 the B.C. Provincial Government recommended development of a watershed plan for Cusheon Lake. The Cusheon Lake Stewardship Committee was formed in 1992 with a number of general goals concerning the improvement of Cusheon Lake.

The Cusheon Watershed Steering Committee was formed in 2003 with the more specific goal of developing management directions for protection and restoration of the lake and watershed. In the same year, a sub-committee was formed (The Cusheon Watershed Management Plan Steering Committee) to work on a draft of this management plan.

Physical and chemical monitoring of conditions in the lake extends back to 1974 (McPherson 2004).

Please see Appendix 1 for a detailed history of activities.

1.3 Why is a Management Plan needed?

Many different activities affect water quality. Within a single watershed these activities are regulated by numerous departments and levels of government. For example:

- Ministry of Transportation oversees road construction and ditch maintenance
- Capital Regional District (CRD) monitors septic field performance and issues building permits
- Vancouver Island Health Authority (VIHA) tests drinking-water safety
- Islands Trust Local Trust Committee (LTC) regulates land use zoning
- The Local Trust Committee, Provincial Ministry of the Environment, and Federal Department of Fisheries and Oceans all regulate protection of areas near shoreline and streams

Some activities, such as fertilizer use, are not regulated at all.

A prime example of the need for co-ordinated activities is the problem of toxic cyanobacterial blooms that have been occurring on Salt Spring Island. **The toxins produced by these blooms are a health threat. Toxins in water have resulted in lake closures in Canada.** However, the cause is not as simple as the better-known threat of contamination of water with *E. coli*, where a single source of pollution is often the culprit, and it can be identified and corrected.

Blooms are caused by excess nutrient inputs to lakes, and these nutrients come from many different sources within a watershed. Since VIHA deals only with the final health threat, it does not address the causes. Further, since the causes are a collective result of many different human activities, the solution needs to be a collective one.

Therefore, some mechanism is needed to identify the sum total of activities necessary to protect water sources, and to foster co-operation of agencies and people. Protecting one part of the watershed will be ineffective if activities in another part negatively affect the lake or its source waters. **Therefore, a coordinated, whole-watershed approach is necessary.**

1.4 Measurement units

This plan provides measurements in only a few kinds of units. The purpose is to make it easy for the reader to compare different items on an apples-to-apples basis. All measurements are given in metric units. For readers who prefer Imperial measurements, we suggest you think yards for metres, and cubic yards for cubic metres. You will not be far wrong! Also, you can think of a kilogram as two pounds, and a hectare as two acres and again you will be close enough for understanding.

Please see Appendix 2 for a simple list of conversion factors.

PART A. ASSESSMENT

2 The Cusheon watershed

This section gives a general description of the present-day Cusheon basin, including the watershed and the lakes. It assesses what is known and not known about current conditions. This assessment is necessary for laying the groundwork to plan for improvements.

2.1 Watershed characteristics

The Cusheon basin is in the centre of Salt Spring Island, and is bisected by the main road between Fulford and Ganges. The whole basin is about 8.7 km long and has an area of 10.65 square km. [2] There are three lakes, many seasonal creeks, and six identifiable wetlands.

2.1.1 Topography, drainage, and geology

The surface drainage starts amidst Mounts Belcher, Erskine, and Maxwell. Roberts Lake is a small, shallow lake in the uppermost, northwest portion of the basin (Figures 1 and 2). From there, the drainage runs southeasterly through wooded hills and pastures to Blackburn golf course, which is close to Blackburn Lake (properly called Mitchell Lake, but universally known as Blackburn). The shorelines of that small lake classify as wetland, with a heavy growth of emergent water plants and shrubs that tolerate wet soil.

A short distance downstream is Cusheon Lake, almost 1.5 km long, with residences around the shore. Along this chain of lakes, intermittent ditches and creeks drain the north and south sides of the basin. Blackburn Creek is the main passageway for water to Cusheon Lake.

In turn, Cusheon Lake is drained by Cusheon Creek, which runs 2.5 km to the open shore of the island near Captain Passage. Flow of both of these creeks is seasonal. There is a small salmon hatchery at the outlet of Cusheon Lake, resulting in runs of Coho salmon coming up Cusheon creek in recent years when the autumn weather provides enough flow.

The Cusheon area is underlain by upper Cretaceous bedrock, chiefly sedimentary rocks of the *Nanaimo Group* (Hodge 1995). The southwest basin has *Comox* conglomerate and sandstone. The central part under the lakes is *Haslam* mudstone, and to the north is *Extension* conglomerate/sandstone. Bedrock is exposed on some slopes and hills. (The southern third of Salt Spring Island has older metamorphosed igneous and sedimentary rocks. These are south of the Cusheon basin, but come close to it near the mouth of Cusheon Creek.)

The overlying soils on Salt Spring Island are deposits from glaciers, rivers, lakes, and the sea, dating back to the last glaciation. The soil is mostly glacial till, gravel, sand, and clay (Hodge 1995). Accordingly, much of the soil is only of moderate quality for agriculture, but in places there is blacker organic soil from bogs.

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2 Measurements provided by Brett Korteling of Islands Trust, using GIS technology. Areas are calculated by a computer program from those shown in Figure 1, and are “flat”, as seen on a map.

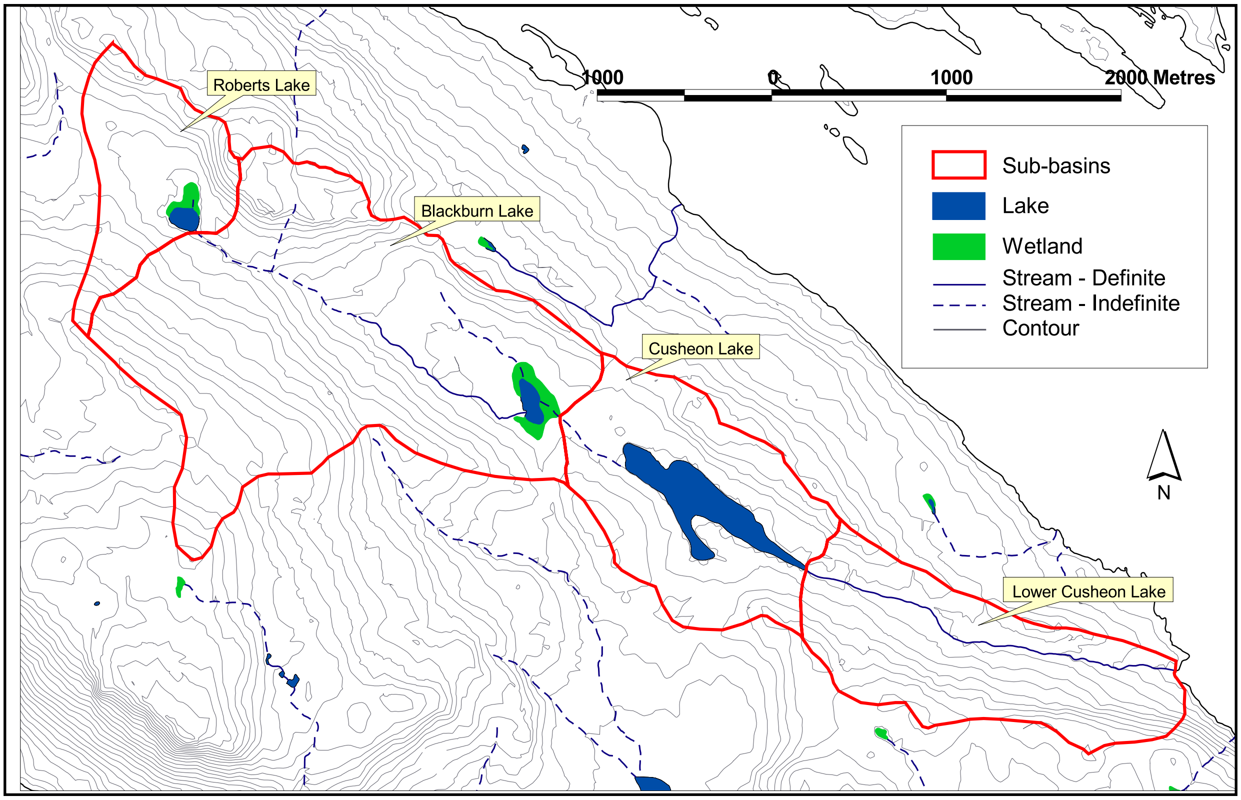

Figure 1. The main sub-basins of the Cusheon watershed. The contour interval is 20 metres. Provided by Brett Korteling of Islands Trust.

The average depth of soil for the island has been estimated as 2.4 metres (Hodge 1995). There are thicker deposits in the valleys, and thin or eroded deposits on slopes and highlands. North of Blackburn Lake, the soil deposits are up to 30 metres deep according to records from drilling wells. The Ministry of Fisheries and Agriculture estimates that the silt/loam soils used for agriculture have a water storage capacity of about 17 cm per metre depth of soil.

Since Cusheon Lake is third in a string of lakes, its watershed consists of several sub-watersheds (Figure 1 and Table 1). The areas given for the Blackburn Lake and Roberts Lake sub-watersheds are for the land that drains water directly into these two upper lakes. The Cusheon Lake sub-watershed is the area that drains directly into Cusheon Lake. All of these together contribute the total amount of water runoff into Cusheon Lake. The Cusheon Creek sub-watershed contributes water only to the Creek.

Table 1. **Areas in the Cusheon watershed, in hectares.** Determined by Brett Korteling, GIS Coordinator for Islands Trust, Victoria. These areas have been accepted as the definitive estimates, and are flat areas as seen on a map.*

	Land	Lake	**Total**
Roberts Lake sub-basin	116.5	3.44	**119.9**
Blackburn Lake sub-basin	507.7	3.08	**510.8**
Cusheon Lake sub-basin	193.1	26.9	**220.0**
Total area contributing to Cusheon Lake	**817.3**		850.7
Cusheon Creek sub-basin, downstream of lake	214.5		**214.5**
Total watershed area	1031.9		1065.2

* If the slopes of land were taken into account, the land areas for the three lakes would increase to 121.0, 521.4, and 196.8. However, the “flat” areas are more relevant because they represent the amount of rainfall intercepted and the magnitude of runoff.

2.1.2 Land classification and use

Land areas make up about 97 % of the total area of the Cusheon watershed. Locations of different categories of natural landscape areas, and of the modified landscape areas, are shown in Figure 2. The area of each type of landscape, and the percentage of the total watershed area that each comprises, is given in Table 2.

The type of land use is important, because it influences the degree of erosion, and the amounts of particulate and dissolved nutrients in water running off to the lakes. (Note that the Land Use categories in Figure 2 are not the same as zoning categories, which Islands Trust uses to indicate development allowed on properties and which are described in section 2.1.3.)

The largest area in the basin is land that has been modified by human use (83%, Table 2). That includes almost 62% of the basin that is classed as "young forest" -- land that has been logged or otherwise cleared during the last 80 years (pale green in Figure 2). It is growing back, mostly into coniferous trees.

The re-establishment of stable forested areas after logging is vitally important for two reasons. Stable forests retain water from rainfall and release it slowly, helping to prevent "flashy" surges of runoff. This reduces erosion and nutrient movement, compared to clear-cut areas. A considerable portion of the "young forest" has been logged during the last decade. This applies to much of the largest pale green area in the southwest of the basin (south of the dark green "mature forest" in Figure 2).

Also in the modified category is almost 8% of the basin dedicated to agriculture, mostly small-scale mixed farming with pasture and hay and a few cattle and horses. While the agricultural area makes up only 8% of the total, its importance in determining water quality is likely to be proportionately greater because much of this area is located adjacent to the lakes. Approximately 82.7 hectares (204.5 acres) are zoned as Agricultural Land Reserve (ALR), representing approximately 9% of the total watershed.

More important, in terms of population, is the "rural" category, which is 14% of the basin. This represents housing and its surrounding lands, and other developed areas. It includes a golf course of about 13.6 hectares, which is just upstream of Blackburn Lake, that presently abstains from using pesticides and chemical fertilizers (orange area in Figure 2).

There is also a garbage transfer station occupying about 2 hectares, northerly from the golf course and north of Blackburn Road (grey area in Figure 2). There is one private school with 30+ students, which is also the site of weekend conventions and meetings.

The watershed has about 120 household residences, plus accessory buildings. Houses in the upper sub-watershed are scattered and mostly associated with large parcels of land or hobby farms. The larger clusters of houses are around Cusheon Lake and near the mouth of Cusheon Creek. There is a park of factory-made homes, with 26 units and 1 house/office, just downstream of Blackburn Lake (seen in Figure 2, just to the south-east of Blackburn Lake and the Fulford-Ganges Road).

There are also 41 shoreline lots directly abutting Cusheon Lake, ranging in size from 0.1 hectares (0.25 acres) to 13 hectares (32 acres). The smallest lots have questionable space for drainage fields of septic tanks. Also near the lake are thirteen rental cottages, two bed-and-breakfast establishments, and a commercial property with 16 rental cabins and a house/office on a point of land that juts into the lake.

Only 13% of the basin is considered "natural" watershed area. "Woodland" makes up 5.7% of the basin, and represents open stands of deciduous trees, or mixed deciduous and conifers. Mature forest, largely Douglas fir, makes up only 2.5% of the land in the basin. Riparian vegetation makes up another 2.5%, and wetland around lakes is 1.9%.

The lakes themselves compose 3.1% of the basin. As mentioned before, Cusheon Lake is used for drinking-water, fishing, and general recreation. Blackburn Lake is used by swimmers and sunbathers at a small dock, and is a source of drinking-water for the park of modular homes mentioned above. Roberts Lake is relatively inaccessible to the public. Gas motors are banned on all Salt Spring Island drinking-water lakes.

Table 2. Existing land use of the Cusheon basin. Mark Head, Planner with Islands Trust, measured the areas from the designations on an aerial photograph (Figure 2). Total areas differ somewhat from values in Table 1.

Type of landscape	Area, hectares	Percent of total basin
Modified landscape		
Young forest	569.5	61.6 %
Rural	129.1	14.0 %
Agriculture	72.6	7.9 %
Sub-total, modified landscape	771.2	83.3 %
Natural landscape		
Woodland	49.9	5.7 %
Mature forest	23.5	2.5 %
Riparian	22.8	2.5 %
Wetland	17.9	1.9 %
Herbaceous	3.5	0.4
Sub-total, natural landscape	117.6	12.7 %
Lakes		
Cusheon Lake	29.6	
Blackburn Lake	3.6	
Roberts Lake	2.8	
Subtotal, lakes	36	3.9%
Total Watershed Area	924.8	100 %

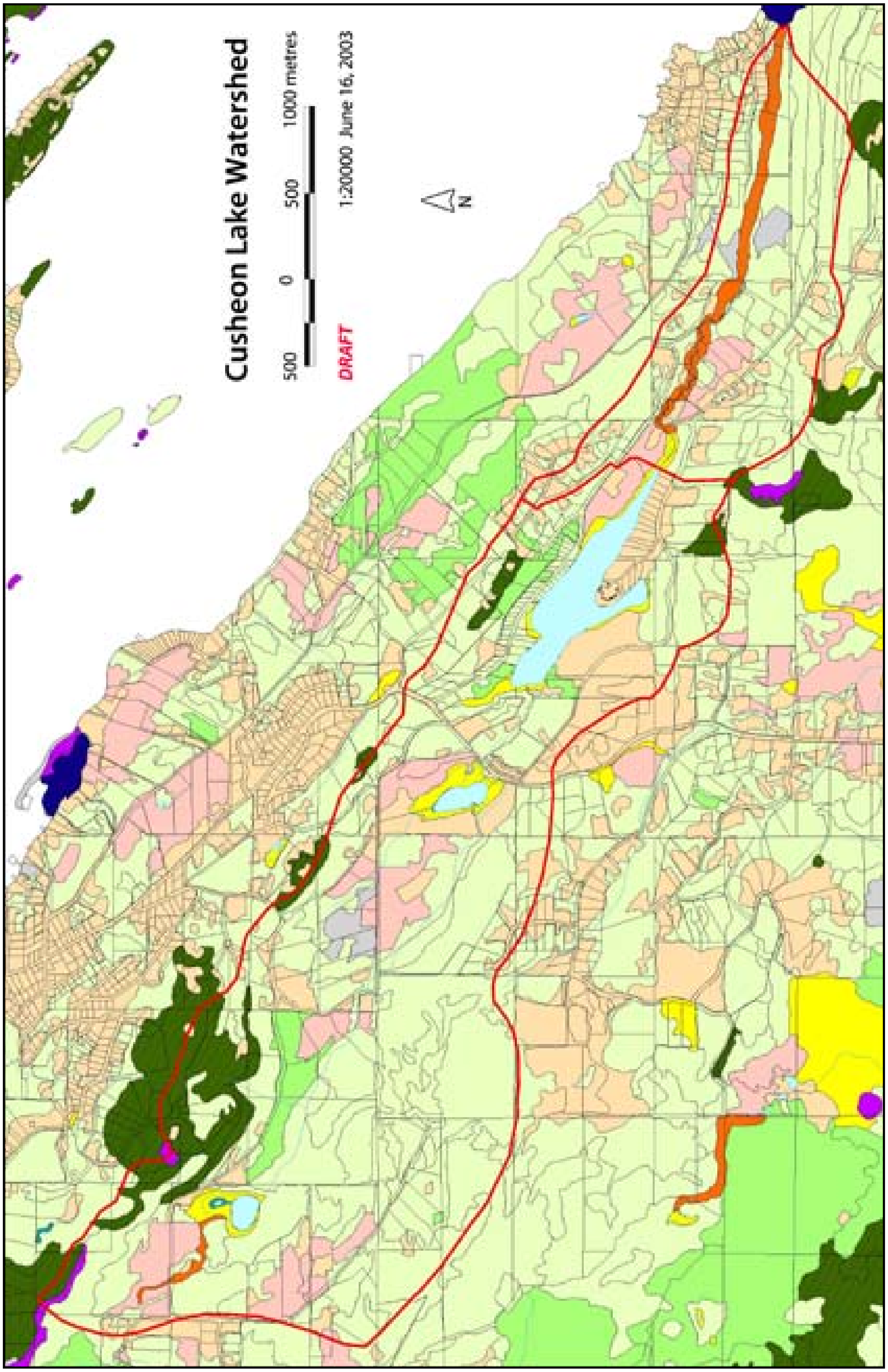
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Figure 2

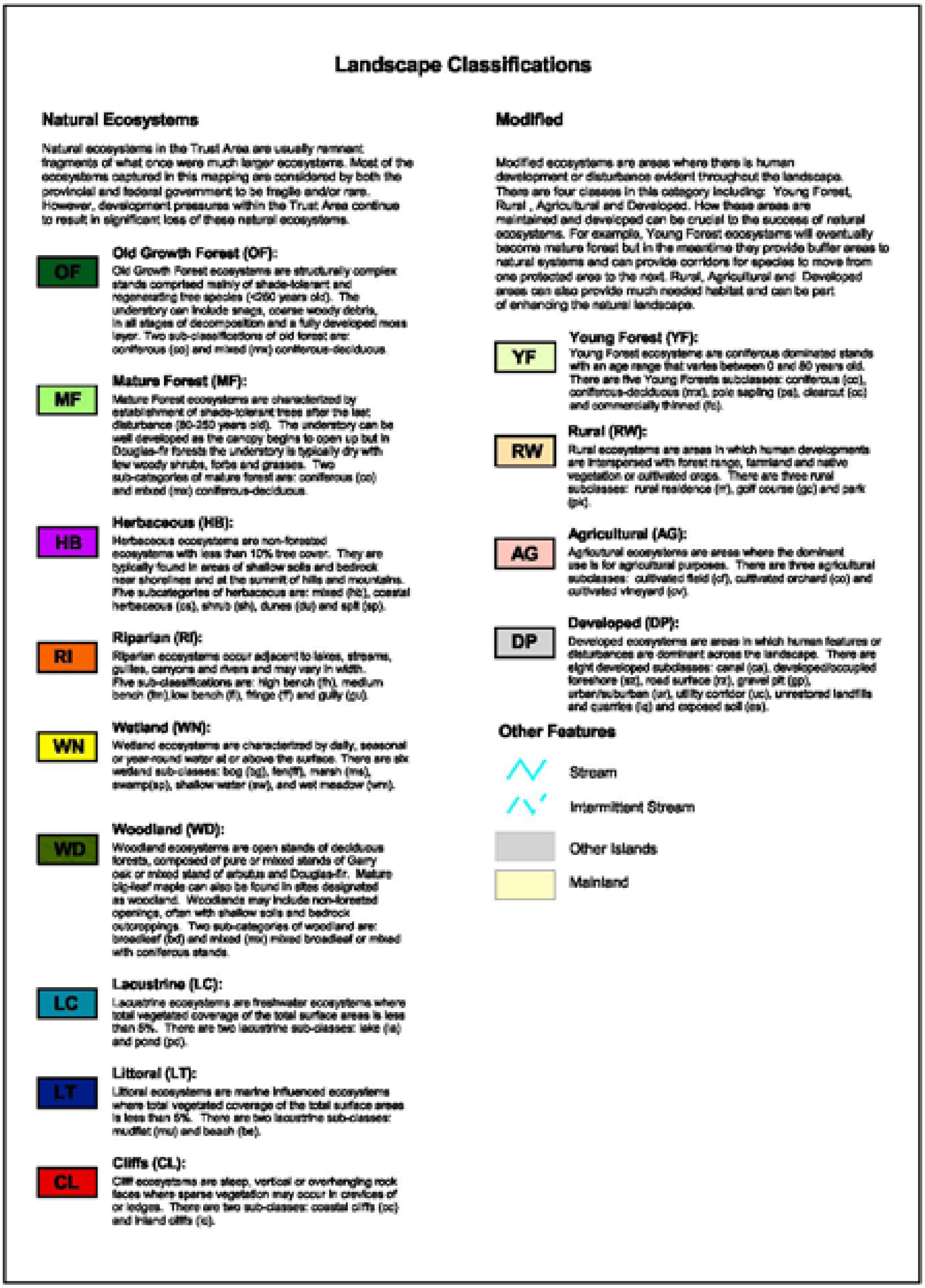


Figure 2 Legend for map of preceeding page. Existing landscape classifications in the Cusheon watershed. A continuous red line outlines the approximate basin. Provided by Islands Trust in 2004.

2.1.3 Land zoning

Regulations concerning present and future uses of land within Cusheon watershed are contained in the Islands Trust Land Use Bylaw 355. A map showing the different land zones on Salt Spring Island is available from Islands Trust. The Cusheon Lake watershed area is excerpted and shown in Figure 3.

The watershed boundary shown in Figure 3 is taken from the Natural Areas Atlas map (CRD 2002), may differ slightly from Figure 1, and is not meant to be a legally defined boundary, or geographically correct in all details. Rather, it shows the boundary's approximate location, and indicates which properties are within the Cusheon watershed, and which are on or near the boundary.

While it might be expected that all properties within the watershed of this drinking-water lake would be zoned as "watershed" or "shoreline", this is not the case. There are fourteen different zoning classifications within the Cusheon watershed, with many zones reflecting usage that was in place before the development of current zoning categories. They include: Agricultural 2 (**A2**), Commercial Accommodation 3 and 5 (**CA3 and CA5**), Forestry 2 (**F2**), Industrial 2 (**In2 (a)**), Parks and Reserves 5 and 6 (**PR5 and PR6**), Rural (**R**), Residential 3 (**R3**), Rural uplands 1 (**RU1 and RU1(c)**), Rural watershed 1 (**RW1**), and Shoreline 6 and 8 (**S6 and S8**). S8 is the most restrictive shoreline zoning category, with the only permitted use being navigational.

The most important areas for the protection of water quality are those that are located closest to the waterbodies. The land adjacent to both Roberts and Blackburn Lakes is zoned A2, with the shorelines zoned S8. A2 land is permitted to have farm buildings and structures, one additional dwelling unit, and permitted activities are processing and sale of farm products and operation of a home-based business. An exception is the location of Blackburn Golf Course in this zone. Commercial guest accommodations and seasonal cottages are not permitted.

The areas immediately adjacent to Cusheon Lake are zoned A2, S8, S6, RW1, CA3, R3, and PR6. A2 and S8 have already been described. S6 is restricted to navigational uses, and private floats, docks, and buoys. Most of the properties around Cusheon Lake are zoned RW1, which may have single-family dwellings, agriculture, and home-based businesses, with a minimum lot area of 4 hectares.

Many of the lots next to Cusheon Lake and zoned RW1are smaller than this, because they were created before the current zoning regulations were in place. One lot is zoned CA3, and has a resort with 16 individual cabins. R3 allows single-family homes and home-based businesses, with a minimum lot area of 0.3 hectares. PR6 is zoned for passive recreation. There are four highway right-of-way corridors to the shoreline of Cusheon Lake, not currently developed, one with a dock.

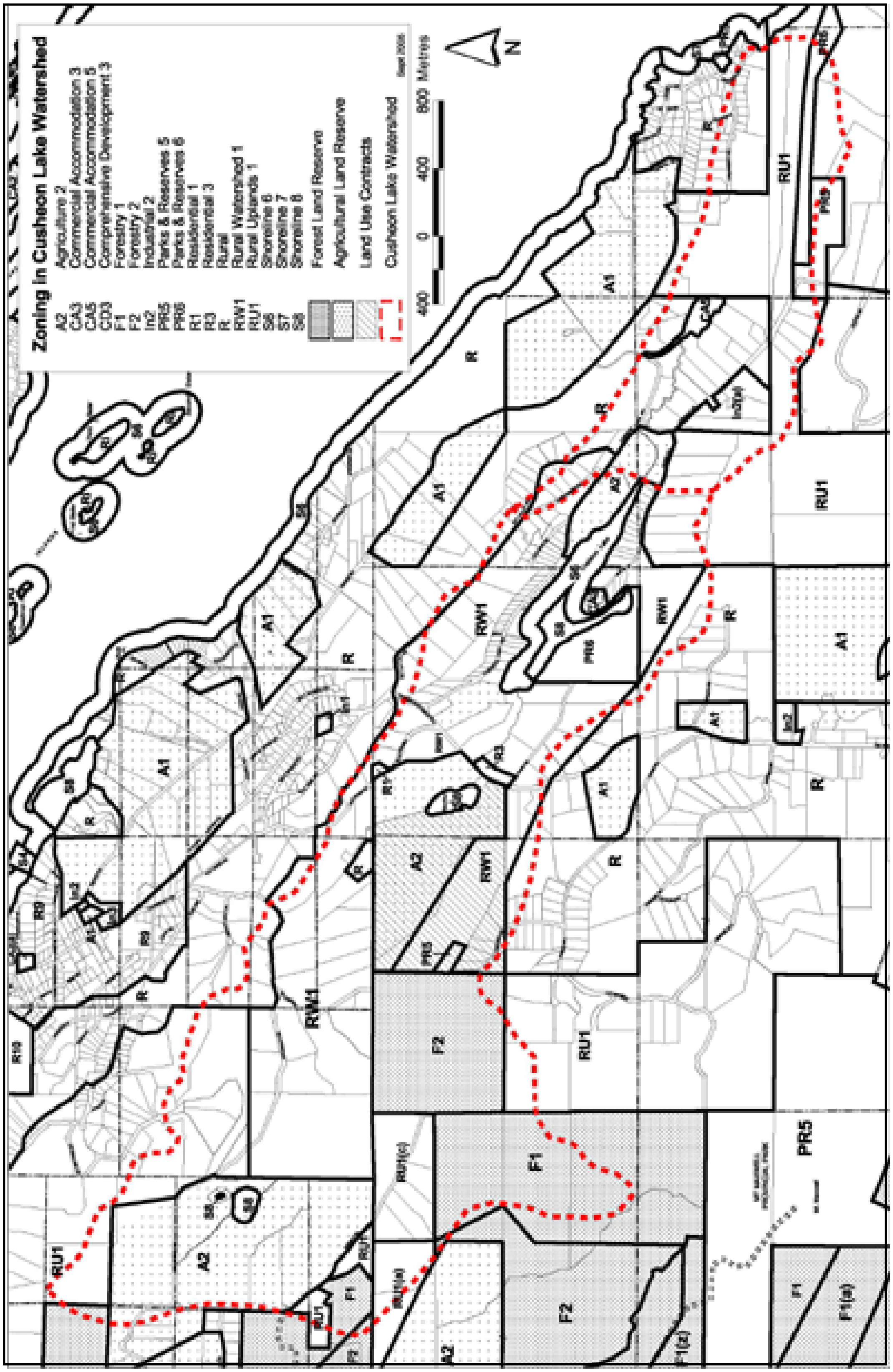


Figure 3. Land use bylaw zones within the Cusheon watershed. The irregular dotted line shows the boundary of the watershed. (Taken from the Natural Areas Atlas (CRD 2002)).

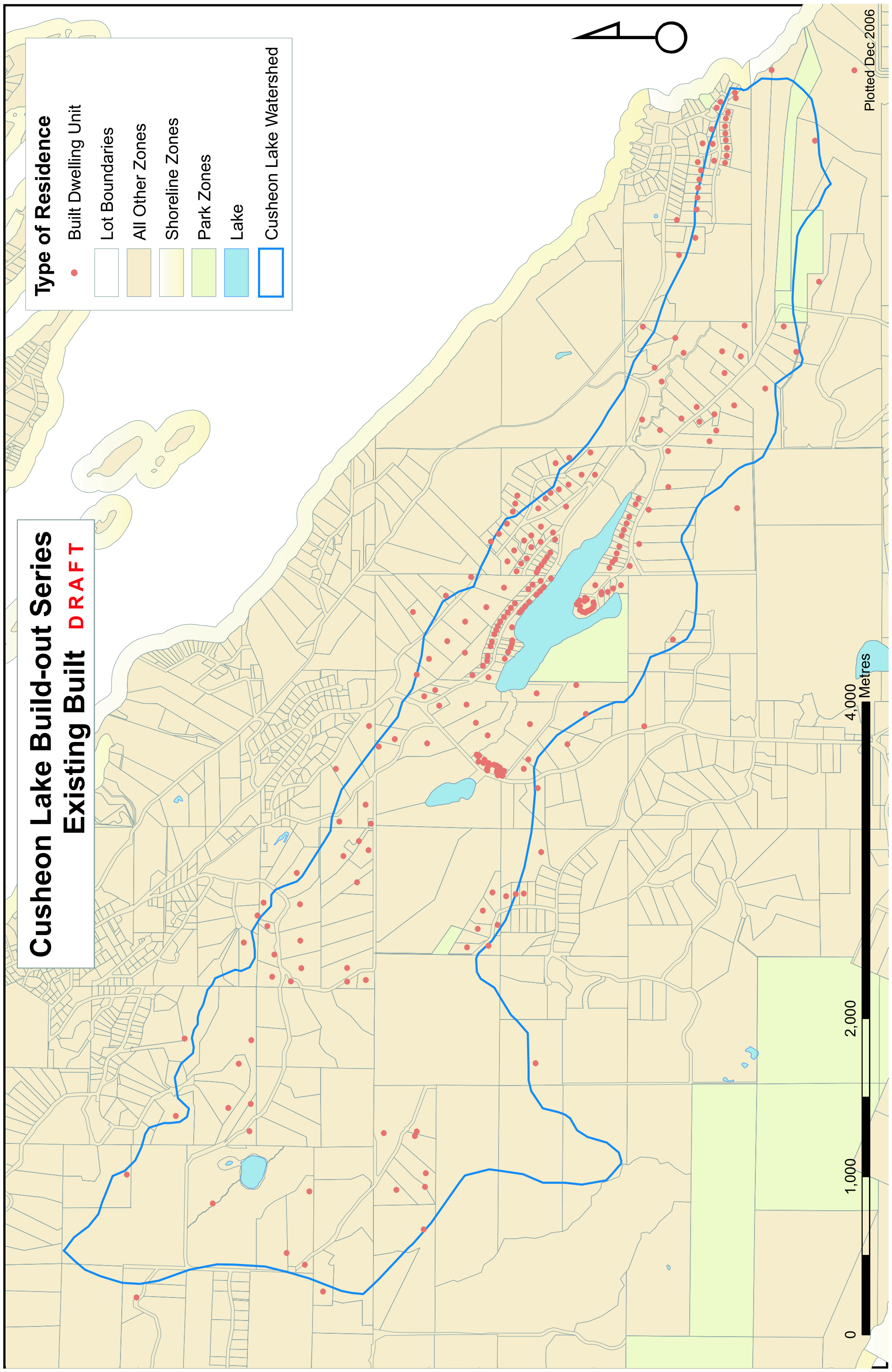


Figure 4. Current development on properties within the Cusheon watershed.

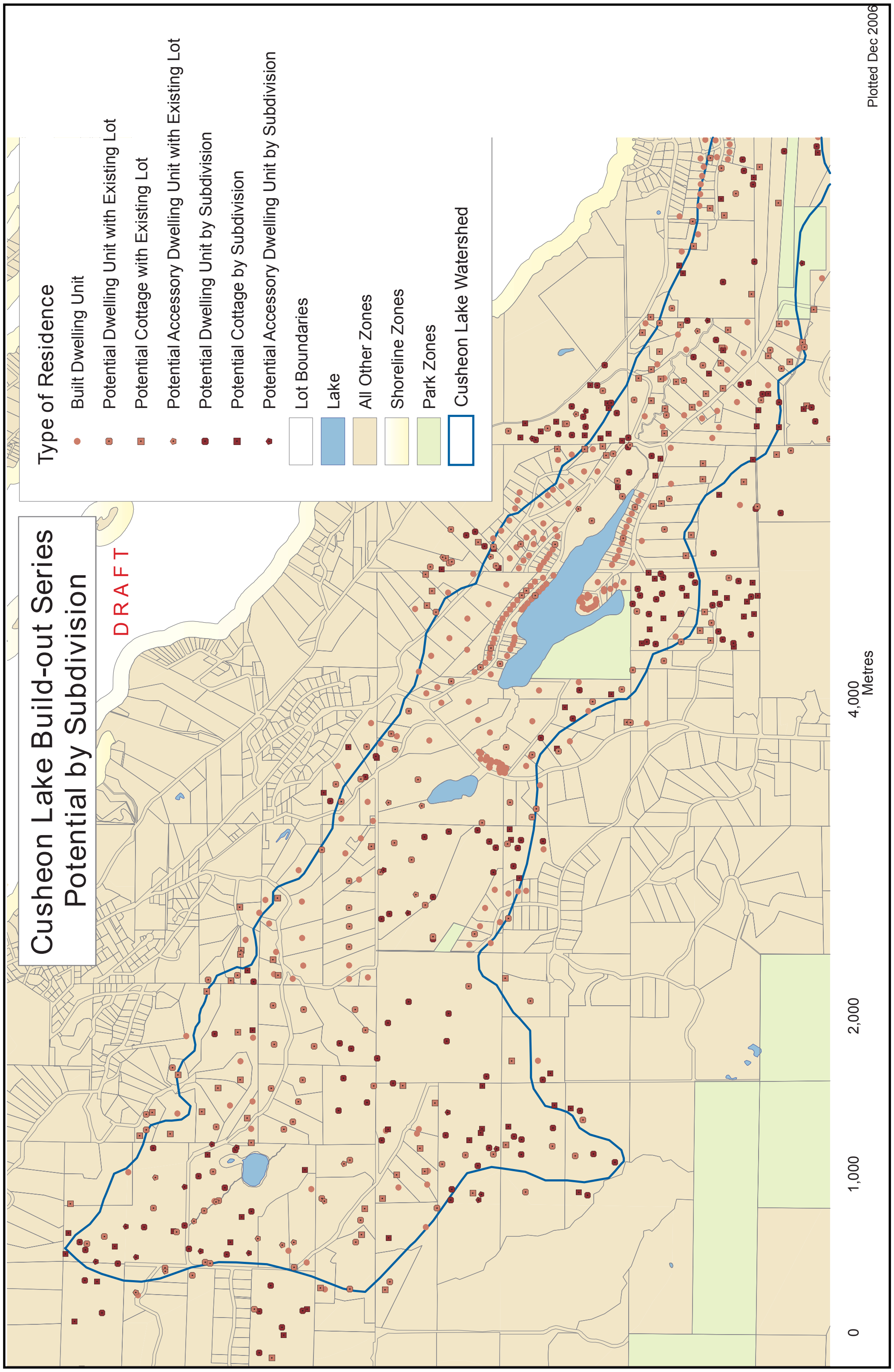


Figure 5. Future development potential within the Cusheon watershed.

2.1.4 Current and future development

If development proceeds to the maximum permitted by current zoning, considerable future development could occur in the Cusheon watershed. This is of concern since **land clearing associated with development will worsen water quality in the lake.**

Recent mapping by Islands Trust established that there are about 219 residential structures on properties within Cusheon watershed, and about 62 more on properties located partially within the watershed (Figure 4). The build-out estimate for Cusheon watershed is 346 to 475 dwelling units for lots as they are currently configured and zoned, and 432 to 703 dwelling units if all currently allowed subdivisions took place, and dwellings were built (Figure 5).

The range of numbers reflects whether properties partially within Cusheon watershed are included in the count. The build-out numbers do not include cottages. Other possible development (in terms of present zoning) includes buildings such as studios, accessory buildings, and impervious surfaces like paved driveways and tennis courts.

The accuracy of the information in Figures 4 and 5 is provisional at the time of writing (March 2007) and could be adjusted as more information is brought to bear on the mapping process. The main point is as mentioned above, that zoning presently would allow considerable development within the Cusheon watershed. **Increases in the number of new houses and in the proportion of land covered by impervious surfaces are both of grave concern for protection of water sources.**

2.1.5 Groundwater

Salt Spring Island obtains its fresh groundwater from rain and snowfall, like other islands surrounded by the sea. Precipitation percolates downward and fills the pores in soils and the fractures in rock. About 48% of the precipitation runs off the land (Sprague, 2006a), leaving the remaining half to satisfy annual recharge of groundwater, evaporation from the land, and transpiration from trees and other plants.

The upper level of groundwater tends to follow the height of the land (Figure 6). Fresh water also balloons down below the island because of pressure from the water column above it. Fresh water moves down and outward, pushing seawater ahead of it, but finally mixing with it. Thus there is an “inverted mushroom” of fresh water below the island, so wells can be drilled below sea level, yet obtain fresh water.

Excessive pumping can lower the water table, reduce hydrostatic pressure, and eventually cause the lower “mushroom” to retract, allowing seawater to intrude. If continued, wells can pump salty water. This has happened at some northerly parts of the island including Fernwood and Scott Point.

Much of the winter rainfall does not sink into the ground, but runs off into creeks, fills lakes, and flows out to sea. The water table within a hill can create springs on the hillside. Because the water table is higher than the spring, water is pushed out through any passages onto the hillside (Figure 6). Springs can contribute groundwater to creeks until the water table drops below the springs, often in early summer.

Cusheon Lake would be expected to lose water to the ground, rather than gain water from springs. The lake is 108 metres above sea level, but the groundwater is lower, at about 60 m above sea level, judging by records of wells in the vicinity (Hodge 1995).

The Cusheon basin appears to have an adequate groundwater supply at the present time. By 1992, 62 wells had been recorded in the basin and they were thought to draw about 20% of the available groundwater storage in any given year (Hodge 1995). Withdrawals do not generally create a problem until they reach about 75% of the resource. (Some areas of Salt Spring appeared to be overdrawing the available groundwater. Scott Point was apparently pumping twice the available supply in 1992, hence the seawater intrusion. Less serious problems were predicted by the year 2000 in four other areas: Long Harbour, Trincomali Channel, Ganges Harbour, and Eleanor Point (Hodge 1995).)

If there are problems of quality of groundwater and/or wells in the Cusheon basin, they do not appear to have been recorded.

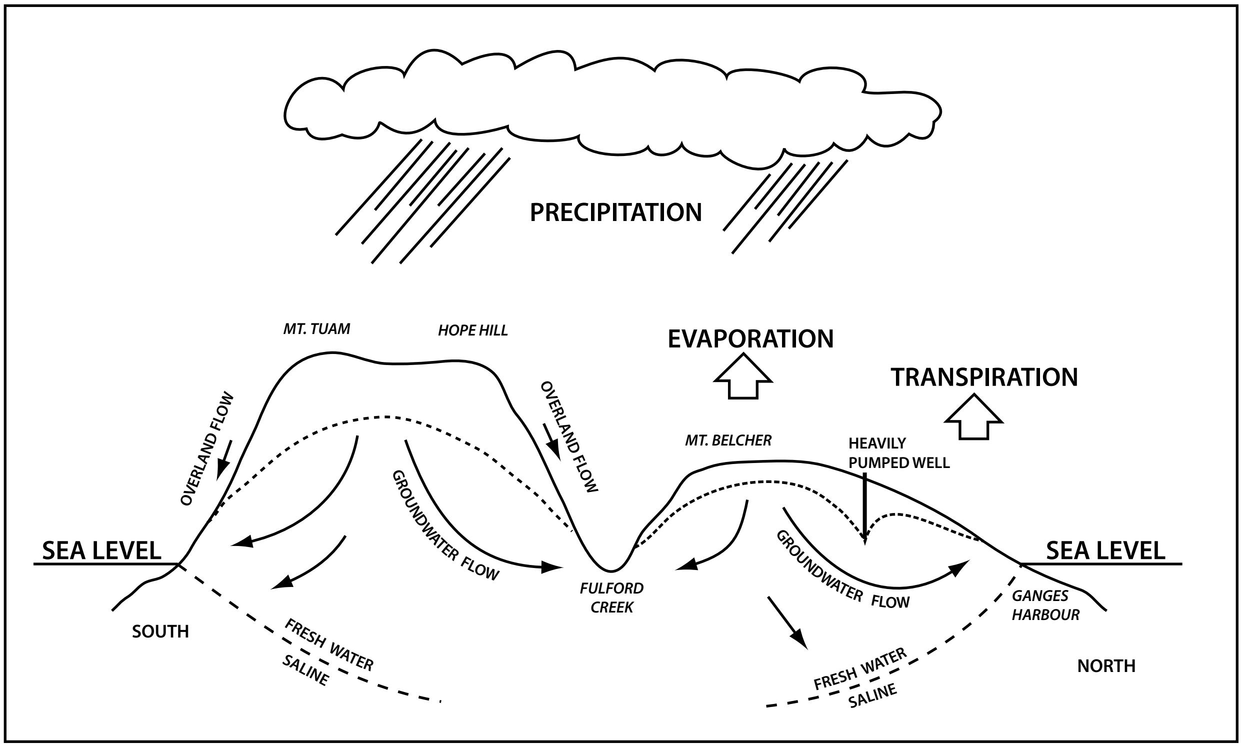


Figure 6. A diagram of the hydrological cycle on Salt Spring Island. Hypothetical upper and lower levels of fresh groundwater are indicated. After Hodge (1995)

2.1.6 Riparian zones

Riparian zones are areas of land along the banks of a creek or lake that have direct influence on the biological habitat and on the quality of water that runs off into the creek or lake. These areas are identifiable by the unique vegetation and soils that occur in them, which are different from the soils and vegetation in upland areas.

A well-vegetated riparian area is important for a number of reasons (Figure 7). The root systems of streamside plants provide stability for the soil, helping to prevent erosion. Overhanging plants provide cover for protection, shade to maintain cool water temperatures, and food for fish and wildlife.

Streamside plants also help to filter sediments and other materials from surface water as it flows to a creek or lake. Thick mature woods on a stream bank reduce soil erosion and soak up the runoff from precipitation like a sponge, releasing it gradually over weeks. This helps to reduce flooding.

The actual width of riparian zones depends very much on topography, primarily the steepness of the banks.

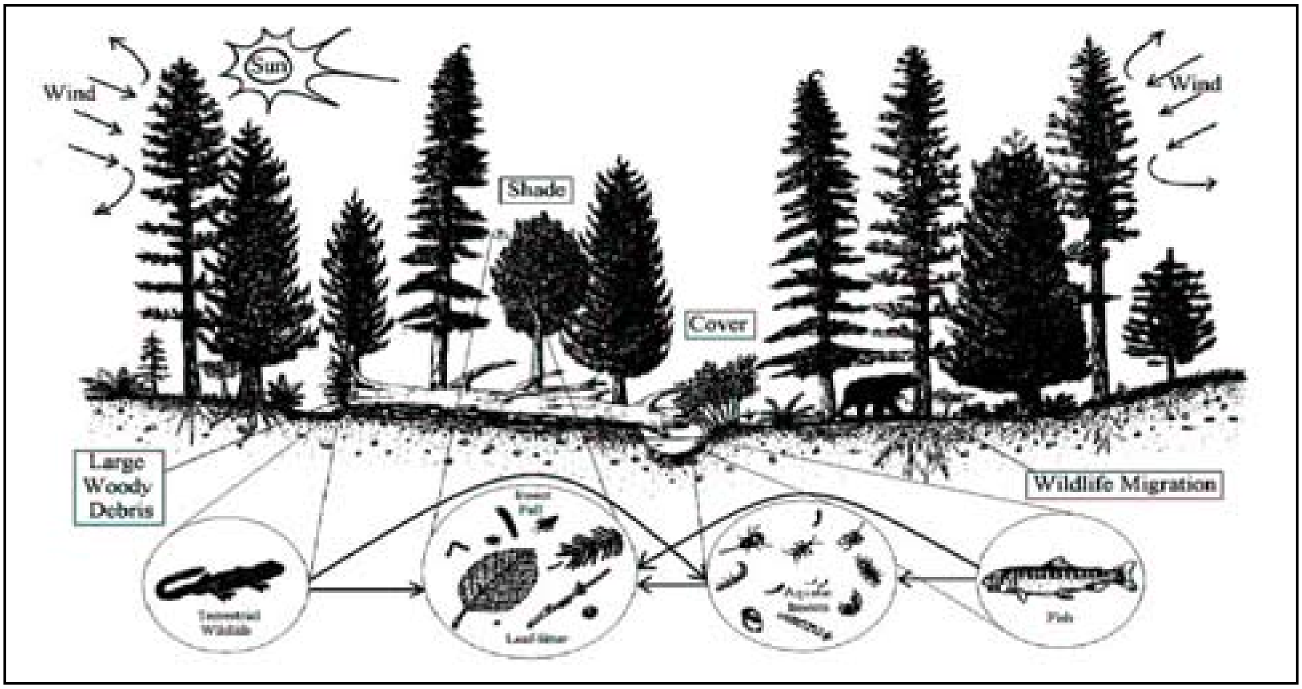


Figure 7. Functions of riparian zones of streams and lakes. The width of the natural riparian area varies according to the steepness of the stream or shoreline, and the type of vegetation. (Diagram reproduced from the Riparian Areas Regulation Implementation Guidebook, MWLAP, 2005)

Riparian areas are of primary concern for water quality. Lack of vegetation promotes erosion of the stream bank, escape of nutrients to the water, and the likelihood of algal blooms in downstream lakes.

There is good scientific evidence that phosphorus travelling with eroded silt is of major importance in Canadian watercourses. In particular, such stream-bank erosion must be important for the input of phosphorus to Cusheon Lake, 53.5% of which comes from upstream, mostly land drainage (Sprague 2006a, b).

Roberts Lake is partly surrounded by woods and brush, with some selective logging, cleared areas, fields and some erosion. Blackburn Lake retains its edge vegetation and is ringed with wetlands of water lilies (*Nuphar polysepalum*) and emergent marsh vegetation. Cusheon Lake is quite different, with approximately 70% of the shoreline opened up for housing and agriculture.

Preserving and increasing areas with natural vegetation on all riparian zones is one crucial remedial measure to help reclaim Cusheon Lake. Because our knowledge of the riparian vegetation is incomplete, an early survey of the status of these zones will guide future remedial efforts.

2.1.6.1 Existing riparian zone regulation and protection

Currently, protection of Cusheon watershed riparian zones is provided by:

- Zoning regulations that specify building setbacks (Salt Spring Island Land Use Bylaw No. 355)
- Other requirements that govern a variety of activities, such as land clearing, in special Development Permit Areas in the Salt Spring Island Official Community Plan

In addition, the province has recently developed new regulations for the protection of riparian zones (see MWLAP, Riparian Areas Regulation Implementation Guidebook, 2005). Protection is also provided in provisions of the federal Fisheries Act, prohibiting activities that result in the harmful alteration, disruption or destruction of fish habitat where fish-bearing waters are affected.

The zoning setbacks of the Salt Spring Island Land Use Bylaw No. 355 require all buildings and structures to be set back a minimum of 15 metres (approximately 50 ft.) from the natural boundary of any waterbody. These setbacks would take effect from the shorelines of Cusheon, Roberts, and Blackburn Lakes, as well as from the natural boundaries of Cusheon and Blackburn Creeks.

Additional setback regulations are included for septic systems, requiring setbacks for tile fields of 60 metres (200 ft.) from the natural boundary of the three lakes, and 30 metres (98 ft.) from the natural boundary of any other waterbody. A setback of 60 metres from the lakes applies to any confined livestock areas containing more than 4550 kg. of livestock, poultry or farmed game, any barn containing manure-based mushroom cultivation, and any storage area for agricultural waste. Setback requirements from waterbodies are determined by legal survey of natural boundaries. [3, 4]

Zoning setbacks by themselves do not ensure that natural vegetation is retained within the riparian zones, because they refer only to the location of buildings and septic fields. The Local Government Act also includes provisions that can be used to protect natural communities. Section 919.1 allows local governments to designate Development Permit Areas (DPAs) in their Official Community Plans. The scope of the development permit authority allows establishment of environmental protection DPAs along creeks, streams, shorelines and wetlands and gives local government the discretion to include guidelines that restrict or prohibit soil disturbance and clearing of vegetation.

In 1998, new guidelines were introduced in the Salt Spring Island Official Community Plan to provide protection of riparian zone vegetation within 10 metres of designated streams and lakes. The areas included are designated "Development Permit Area 4". Unfortunately, not all streams are included; the ones that are included are shown on Islands Trust Map 21. An excerpt of this map, showing the Cusheon watershed area, is in Figure 8.

It is estimated that 18.5 hectares (46 acres) or approximately 1.6% of the Cusheon watershed is protected within DPA 4. This includes areas along the natural boundaries of the three lakes and the major creeks that connect them and run to the ocean (Blackburn and Cusheon Creeks). However, the minor tributaries, seasonal wetlands and intermittent creeks of the watershed are not protected or even mapped.

For land contained within DPA 4, there is a requirement to apply for a permit for tree cutting or other vegetation removal (i.e. shrubs and ground cover) that results in the exposure of more than nine square metres of bare soil[4]. Permits are also required for works within designated streams or that take place below the natural boundaries of lakes and for development of impervious surfaces within 10 metres of natural boundaries.

Permits for such activities are only issued if the objectives of the development permit (to protect fish habitat, water quality and sensitive riparian habitat) are satisfied. Exemptions are included in the guidelines to permit vegetation removal to within three metres of natural boundaries for farming practices, provided that such land clearing is consistent with normal farm practices under the Farm Practices Protection Act (Right to Farm) Act.

A number of private land covenants have been successfully registered through the Salmon Enhancement Society's Stewardship Program. In these covenants, the private landowner agrees to leave riparian vegetation in an undisturbed state.

Covenants can provide protection (in addition to that provided by DPA 4 regulations), by covering a larger distance from the water edge than the 10 metres specified in DPA 4, and/or by specifying more stringent protection criteria. The existence and number of these covenants needs to be verified. In addition, covenants must have a "rent charge" penalty to be effective and must stay on the land in perpetuity.

3 "natural boundary" means the visible high water mark of the sea, lake, stream, or other waterbody where the presence and action of water are so common and usual and so long continued in all ordinary years as to mark upon the soil or rock of the bed of the waterbody a character distinct from that of the land in respect to the vegetation and soil.

4 The 9-square-metre exemption is to allow minor alterations or narrow path clearing without the need for permit approvals or exemptions from the Islands Trust.

One of the primary difficulties in protecting riparian areas is that landowners may make changes such as clearing trees and vegetation or infilling shoreline areas, without seeking a permit first, and by then the damage is done. There are no local or provincial fines for doing this; rather, the landowner is required to seek a permit after the fact, and may then be required to take actions to mitigate the damage. If someone has carried out an activity that harms fish habitat, they could be charged under the federal Fisheries Act. **It is crucial to create penalties to act as a deterrent. Otherwise covenants are useless.**

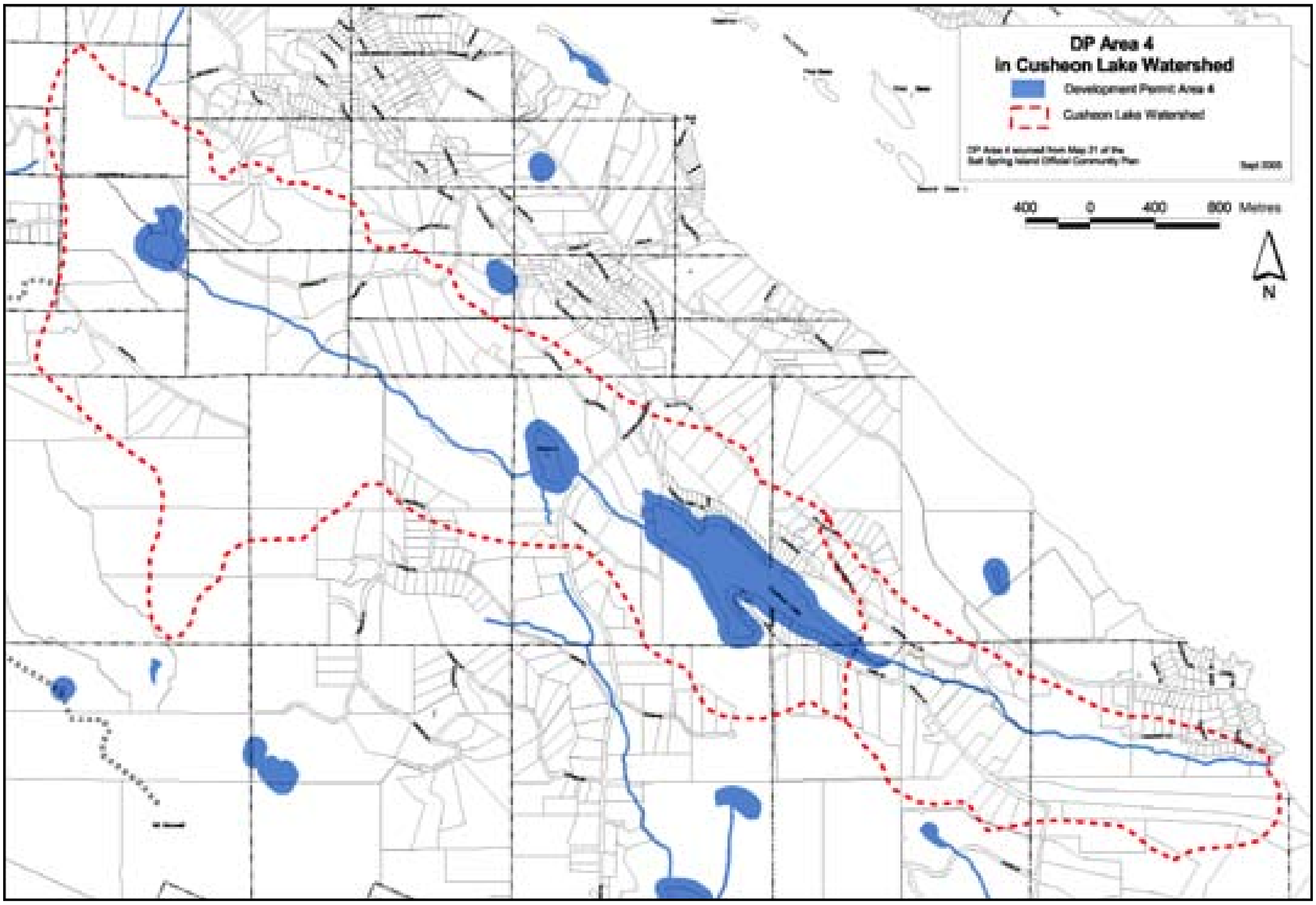


Figure 8. Location of areas covered by Development Permit Area (DPA) 4 (shaded blue).

The Ministry of Environment (MOE)) recently developed regulations for riparian areas of any "waterbody that is connected by surface flow to a waterbody that provides fish habitat" (MOE 2005). Since Cusheon Lake contains fish, this legislation affects all water sources draining into it. These new provincial regulations cover a wider area on each side of a stream bank than specified by Islands Trust DPA 4 (Figure 9).

In addition to covering a wider area, the new provincial regulations also cover a wider range of types of activities than the DPA 4 regulations:

- Primary construction activities (building construction, creation of impervious or semi-impervious surface, or subdivision)
- Ancillary activities (removal or alteration of vegetation, soil disturbance, flood protection works, construction of roads, trails, docks, sewer and water services, drainage systems, or development of utility corridors)

Prior to doing any of these things, the landowner must obtain an assessment by a Qualified Environmental Professional, and register the assessment with the Ministry. If there is an assessment that fish habitat will be harmed, then mitigation procedures must be developed.

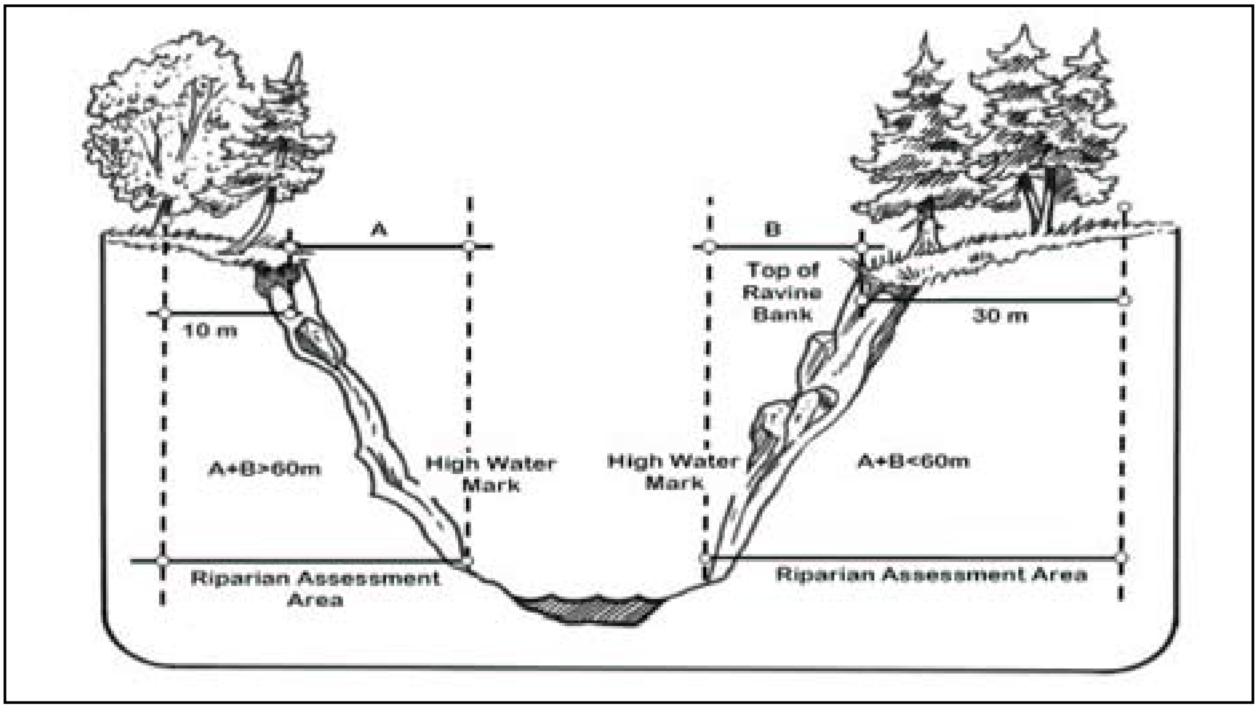


Figure 9. Riparian zones covered by provincial guidelines.

The provincial riparian assessment area is a strip 30 metres wide on both sides of a stream (exceptions for farmland), measured from the high water mark; or, for a ravine that is less than 60 metres wide, from the top of the ravine to a spot 30 metres beyond the top of the ravine; or, for a ravine that is more than 60 metres wide, a strip 10 metres wide from the top of the ravine. Islands Trust Development Permit Area 4 covers a distance only 10 metres wide on each side of the high water mark of a stream or lakeshore.

One of the requirements of this new provincial legislation is that local bylaws be brought up to the same standards, i.e., Islands Trust will need to pass a new bylaw requiring the same level of protection for riparian areas as outlined in the "Riparian Areas Regulation Implementation Guidebook" (MOE, 2005).

This would have positive effects for the protection of water in Cusheon Lake, because all the streams draining into the Lake, or into the lakes above it, would be protected to a greater degree. Please see Appendix 3 for more details.

2.1.7 Wetlands

Wetlands are important areas for biodiversity, providing habitat for a variety of plants, animals and birds. They store and release water, acting as seasonal stabilizers. They serve as natural filters for a range of organic and inorganic pollutants in incoming water. Similarly, they are *nutrient sinks*, i.e., they take up nutrients and store them long-term, helping to avoid enrichment of any downstream lakes. The term “wetlands” is specific enough for this plan, although it is possible to sub-classify them as bogs, fens, swamps, or marshes.

In the Cusheon basin, wetlands surround Blackburn Lake, some of Roberts Lake, and a small part of Cusheon Lake. Other small wetlands are located in the little valleys of seasonal creeks.

2.1.8 The Lakes

Cusheon Lake is one of the nine largest lakes on Salt Spring Island. It ranks third in volume of standing water, after St. Mary and Maxwell Lakes (Figure 10). However, **in terms of drainage basin size and yearly inflow of water, Cusheon Lake is the largest on the island**, with Ford Lake as a close second (Figure 11).

Cusheon Lake has a larger annual flow-through, or supply, than does St. Mary Lake, which is the island’s major source of drinking-water. Cusheon Lake has a far larger annual supply than another well-known source of drinking-water, Maxwell Lake, which in its natural state has the smallest supply of the nine lakes. **Accordingly, Cusheon Lake represents a valuable resource for scarce drinking-water on a small island, and it is a very worthwhile goal to raise its quality to match the quantity**.

Cusheon Lake, like all the lakes on Salt Spring Island, receives most of its inflow during the wet season (November to May) and little or none during the dry season (June through October). The importance of this is discussed in detail in section 2.2, Water Supply and Use.

The comparatively smaller volume and greater flow of Cusheon Lake give it a fairly rapid replacement of water. On the average, we would expect it to renew 95% of its water molecules in 11 months (Table 3) [5]. For comparison, St. Mary Lake would take 14 years to replace 95% of its water.

5 If a lake could somehow start from empty, inflowing water would fill the lake about three times as fast as the 95% replacement values, and that is shown in the third to last column of Table 3. However, the lakes do not start from empty, so the 95% replacement times give a better appreciation of what is happening. When the lake is full, incoming water gets mixed with old water, and so it takes longer to push out all of the old molecules.

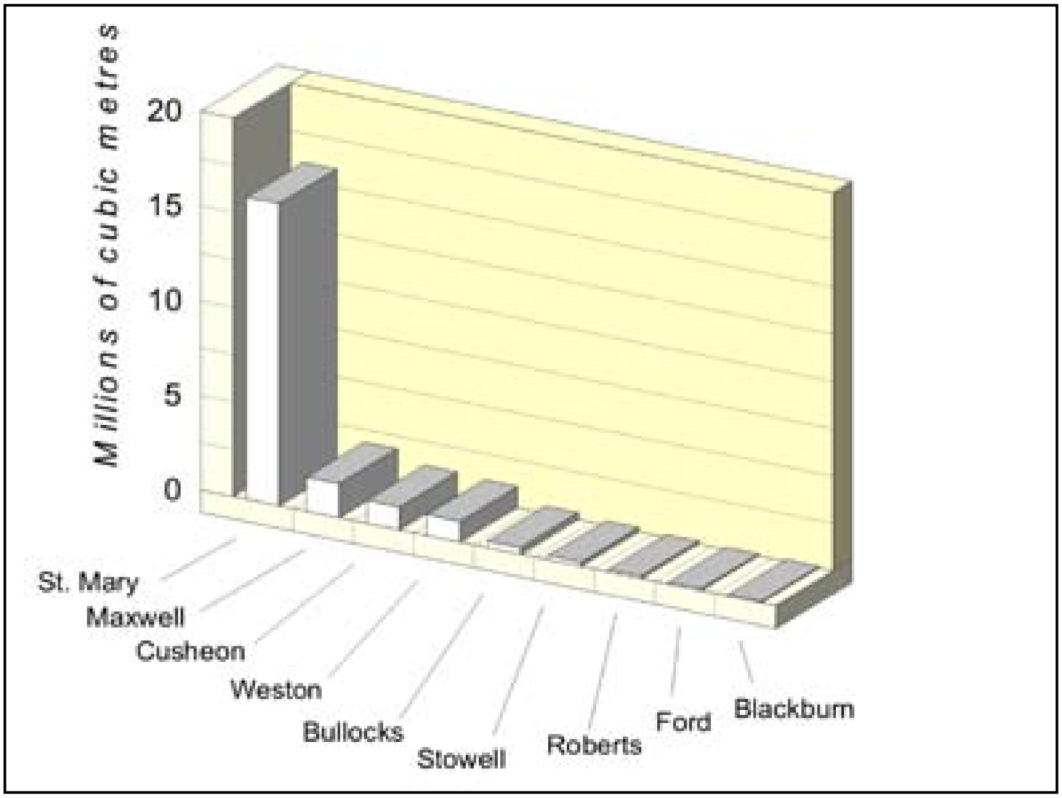


Figure 10. Standing volumes of the nine largest lakes on Salt Spring Island.

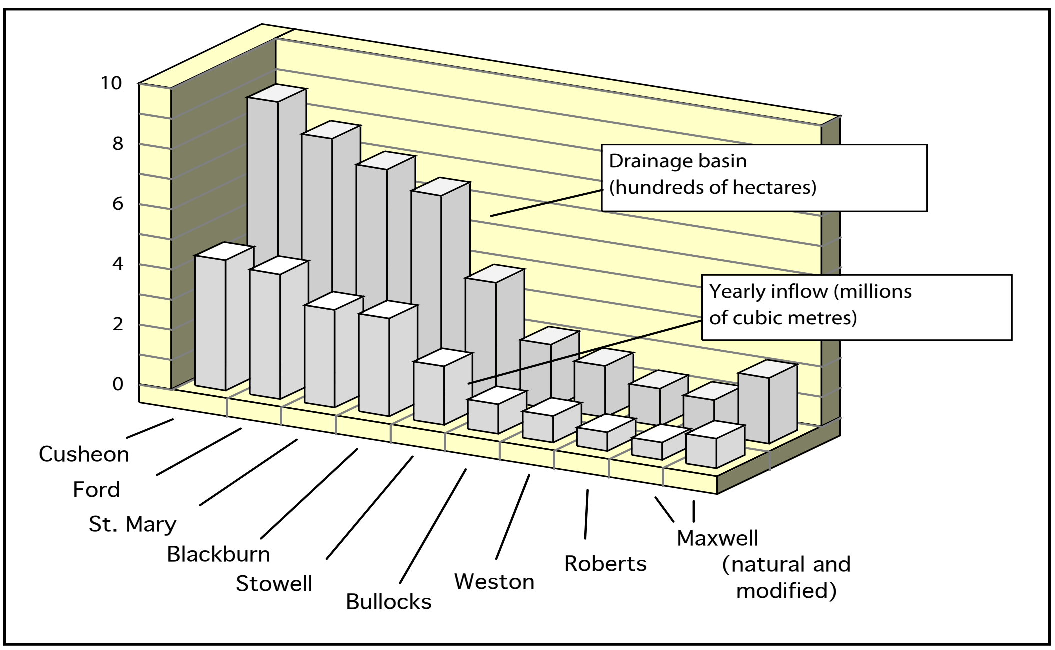


Figure 11. Size of drainage basins and the yearly inflows, for the nine largest lakes on Salt Spring Island.

Table 3. Physical characteristics of the larger lakes on Salt Spring Island. Lakes are listed in order of the size of their drainage basins. Information was obtained from government surveys of lakes and from the reports and communications listed in a footnote to this table***. These estimates updated and tabulated by J.B. Sprague, September 2006.

Lake	Depth (metres)		Surface area (hectares)	Volume (thousands of m^3)	Drainage basin including lakes (hectares)	Yearly inflow (thousands of m^3)*	Time to fill if empty (years)	Time for 95% replacement of water	
	Mean.	Max.						Years	Months
Cusheon	4.5	9.1	26.9	1,214	851**	3,958	0.31	0.92	11
Ford	3.0	3.5	4.25	127	780	3,915*	0.032	0.097	1.2
St. Mary	8.8	16.7	182	15,960	707	3,350*	4.8	14	172
Blackburn	3.0	5.0	3.08	92.4	631**	2,976	0.031	0.093	1.1
Stowell	4.6	7.5	4.57	210	389	1,806*	0.12	0.35	4.2
Bullocks	3.9	7.0	9.40	370	212	1,005*	0.38	1.1	13
Weston	5.9	12.2	18.5	1,090	170	789*	1.4	4.1	50
Roberts	4.1	8.2	3.44	140	120**	562*	0.25	0.75	9.0
Maxwell									
Original	6.5	17.0	27.7	1,810	115	533*	3.4	10	122
Modified	7.7	19.2	29.9	2,310	217	910*	2.5	7.6	91

* Inflows for lakes marked with an asterisk are estimated from sizes of the drainage basins, on the basis of annual precipitation in that area, and an average island value for runoff from that precipitation (Sprague 2006a). These are natural flows, not allowing for any human withdrawls.

** Brett Korteling of Islands Trust definitively measured the drainage basins of the Cusheon system. Values given for the basins of Cusheon and Blackburn Lakes include those of the upstream lake(s).

*** The B.C. government web site http://srmapps.gov.bc.ca/apps/fidg/bathyMapSelect.do provides maps and data for government lake surveys (Cusheon 1972, Ford 1978, St. Mary 1978, Blackburn 1972, Stowell 1960, Bullocks 1981, Weston 1960, Roberts 1972, Maxwell 1981). Precipitations for areas of Salt Spring Island were provided by Aston (2006), Environment Canada (2006), Hodge (1995), and Nordin et al. (1983). Other information on lakes and flows was given by Barnett et al. (1993), Hamilton (1998), Holms (1999), McKean (1981), Nordin (1986), Nordin et al. (1983), Sprague (2006c), and Watson (2006a,b).

Blackburn Lake has an extremely fast molecular replacement time of about one month because it is quite small and is fed by a relatively large drainage basin. Ford Lake has a similar fast average replacement time of five weeks. Roberts Lake has a 95% molecular replacement time of about nine months, faster than Cusheon Lake.

The large area of the Cusheon watershed means that there is a large amount of input water from land runoff. Even under pristine conditions this means that the lake would receive more nutrients on an annual basis than a lake with a small drainage basin. On the other hand, the rapid turnover of water in Cusheon Lake helps it to resist the effects of human-induced nutrients such as direct inputs from septic fields located near the lake. Even so, it can still become eutrophic if the phosphorus loading is high enough (see later discussion).

2.1.9 Vegetation, fish, and other wildlife

A number of emergent plants grow along the shoreline area of Cusheon Lake. Water lilies (*Nuphar polysepalum*) are one of the most obvious. In addition, the following species were identified from samples sent to the MWLAP in March, 1999:

- *Chara* sp., *Nitella* sp., *Elodea canadensis*
- *Ceratophyllum demersum* (hornwort)
- *Cicuta douglasii* (Douglas water hemlock)
- *Myosotis lax* (forget-me-not)
- *Potamogeton amplifolius and Potamogeton robbinsill* (two kinds of pondweed)
- *Oenanthe sarmentosa* (Pacific water parsley)

Plants are an important part of fish habitat, and *Potamogeton* species are common and important foods for muskrats and waterfowl. *Chara* and *Nitella* are algal species that look like macrophytes. *Elodea canadensis* is commonly known as Canadian or American waterweed and is what many people commonly think of as "that aquarium plant." Residents are often annoyed by this plant and try to remove it. However, any small plant fragment that remains in the lake can send out a fine white root from the surface and attach to the bottom. The south bay by Cusheon Lake Resort is sometimes completely filled with this plant.

It is difficult to say how much the current plant species are the same or different from what the "natural", or pre-settlement, plant community of Cusheon Lake might have been. It's also not known how much the plant community changes from year to year.

Cusheon Lake continues to support appreciable fish populations. In addition to Coho salmon, which spawn in Cusheon Creek, Cutthroat trout are found in waters all the way from Roberts Lake to the outlet of Cusheon Creek at the ocean. This species includes both wild and hatchery fish, as the province stocks Cusheon Lake each year. Smallmouth bass were stocked in both Blackburn and Cusheon Lake in the past, but this is not currently being done. Native species of stickleback, crayfish and mussels are found in Cusheon Lake.

Many insects, which are food for fish and birds, begin their life cycle in an aquatic habitat. Bird species frequent the lake, wetland and stream habitats, as well as the riparian areas. Small numbers of breeding ducks use the lake, and it is also a wintering haven for various waterbirds. The wetland edges of the lake are home to a variety of semi-aquatic birds, other wildlife, and insects. A list of "almost certain" and "likely" bird species is given in Appendix 4.

The spawning and feeding habits of fish species in the lakes and streams are important to know in order to protect their habitat. Coho salmon adults do not feed in fresh water, but they spawn in river tributaries, usually from November to January. The newly hatched young Coho stay about a year in fresh water, usually in streams, where they eat invertebrates.

Smallmouth bass are predatory, eating invertebrates and fish when they are adults. Bass move into deeper, cooler water in the summer but they do not require cold water to the same degree as lake trout or whitefish. They prefer a summer temperature of around 20 C.

Cutthroat trout can live in both salt water and fresh water. They spawn in streams in the spring, and eat mainly invertebrates. They are cool-water, but not cold-water, fish.

The resident stickleback species is the three-spine stickleback. They live and spawn in lake shallows and eat invertebrates. They do not need deep, cold water for habitat. Spawning can take place any time from April to September, but is most likely in early summer.

2.2 Water supply and use

The main human use of Cusheon Lake water is domestic consumption. The lake is also used for swimming, fishing, and recreational boating. A restriction on this lake, as well as other lakes on Salt Spring Island, prohibits operation of boats with gasoline motors. However, canoes, rowboats, and boats with electric motors are allowed. In addition, the lake is an aesthetic asset for people living near the shore and as a tourism asset

All significant sources of water in the basin have been licensed for human use. This includes the three lakes, some creeks (Cusheon Creek, Caswell Creek, Tyler Brook), and a number of springs (Jameski, Marcotte, McGrigor, Paradise, Tarrasoff, and Yule (Barnett et al. 1993).

The Beddis Water District draws water from Cusheon Lake and supplies drinking-water to households near the lake and in the Cusheon Creek valley. Of 138 parcels that are licensed to draw water from the District, 122 households use Beddis water (personal communication, Andrew Peat, Beddis Waterworks).

The two largest water licences are held by Beddis Water Works District (see Table 4 for these and other licences). There are 39 other households holding individual licences to draw water directly from the lake (each for 500 gallons per day). Also there is one domestic licence and one enterprise licence (Cusheon Lake Resort) for larger amounts. About 20 households take water from the lake but do not have a licence. Finally, for Cusheon Lake, there are three irrigation licences for substantial amounts of water (Table 4).

On Cusheon Creek, downstream of Cusheon Lake, there is one domestic licence and two land improvement licences. Fisheries and Oceans Canada has a “conserve” of water for a minimum flow of water from Cusheon Lake into the creek; the amount is almost half of that licensed to Beddis Water District (Table 4). The Fisheries conserve is approximately 10% of mean annual discharge of the creek, considered necessary to support salmon spawning and maintain fish habitat during the low-flow period.

Blackburn Lake and Creek have fewer licences: two domestic, one enterprise (Cedar View Trailer Court), and one irrigation licence. For Roberts Lake, there is one irrigation and one storage licence (Table 4).

Water licences have been given in a variety of different units, depending on the purpose; these have been converted to one standard unit in Table 4, for easier comparison of the different volumes permitted.

Cusheon Lake is considered to be fully utilized, according to Salt Spring Island’s Water Allocation Plan (Barnett et al. 1993). This is because the natural summertime outflow to fish-bearing Cusheon Creek falls below the minimum Fisheries conserve (10% of mean annual discharge, see Figure 12).

Table 4. Cusheon watershed water licenses, as of 2005.

	m^3/year	m^3 during dry 5 months
Roberts Lake		
1 irrigation licence @ 30 acre-feet	37,005	37,005
1 storage licence @ 30 acre-feet	37,005	15,419
(Subtotal)	(74,010)	(74,010)
Blackburn Creek		
1 domestic licence @ 500 gal/day	830	346
Blackburn Lake		
1 enterprise licence @ 7000 gal/day (Trailer Court)	11,615	4,840
1 domestic licence @ 500 gal/day	830	346
1 irrigation licence @ 2 acre-feet/yr	2,467	2,467
1 irrigation licence @ 8 acre-feet/yr	9,868	9,868
(Subtotal)	(24,780)	(24,780)
Cusheon Lake		
Beddis Water Works* 2 licences totaling 62000 gal/day	102,878	42,866
39 households direct lake use @ 500 gal/d each	32,357	13,482
1 domestic licence @ 1000 gal/day	1,659	691
1 enterprise @4500 gal/day	7,467	3,111
3 irrigation licences		
18.34 acre-feet/yr	22,622	22,622
2 acre-feet/yr	2,467	2,467
1 acre-feet/yr	1,233	1,233
20 unlicensed households allowed @ 500 gal/day each	16,593	6,914
Fisheries conserve 0.056 cubic feet/sec	50,008	20,837
(Subtotal)	(237,285)	(114,224)
Cusheon Creek		
1 domestic licence @ 500 gal/day	830	346
2 land improvement licences @ 0.5 acre-feet/yr	1,233	514
(Subtotal)	(2063)	(860)
Totals for Whole system (Roberts L. to ocean)	336,500	214,219

*Beddis Water Works serves 122 households

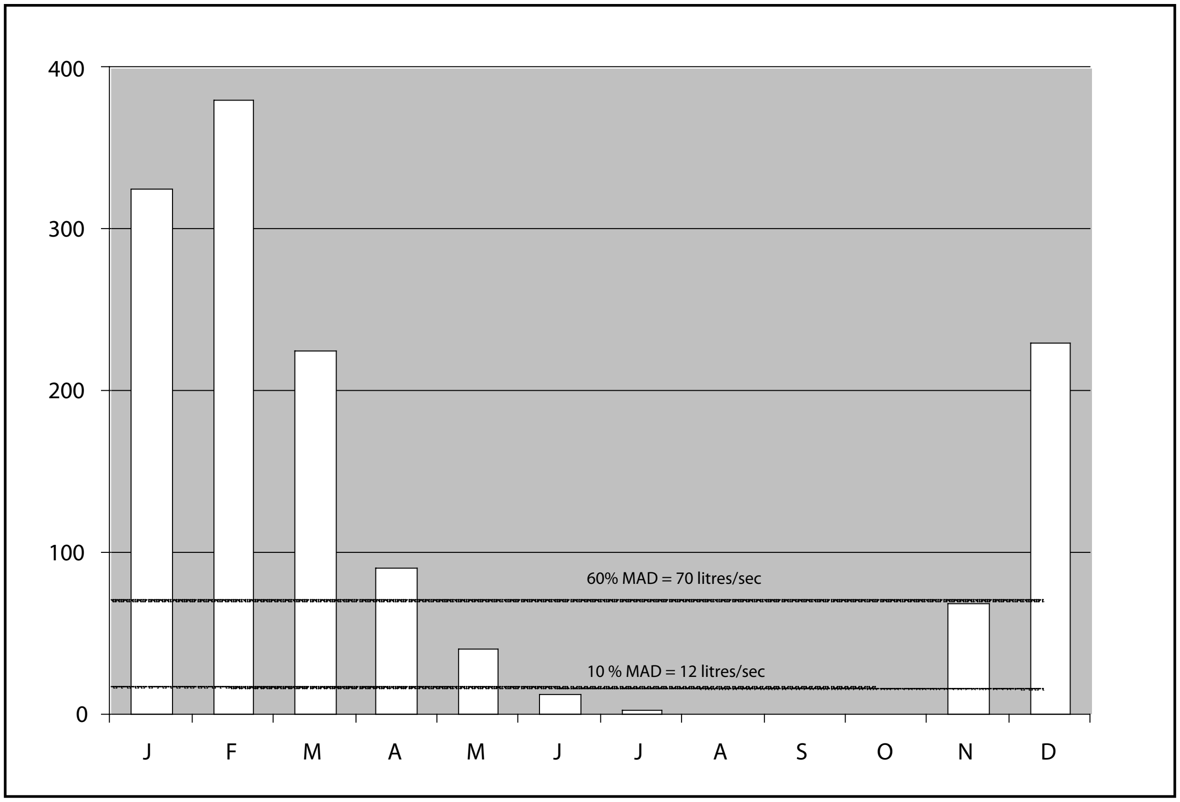


Figure 12. Mean monthly discharge in Cusheon Creek. This diagram is slightly modified from Hodge (1995) and is based on data for 1970 to 1992. The Mean Annual Discharge (MAD) is 116 litres per second.

2.2.1 Lake drawdown in summer and early fall

The subtotals in Table 4 show the licensed demand from each part of the Cusheon watershed. For Cusheon Lake itself, the annual demand is 237,285 m^3/year. This is only a small part of the total annual inflow (about 3,958,000 m^3, Table 3). Thus it would appear that Cusheon Lake could easily meet the licensed water demands.

However, on Salt Spring Island the rainfall and inflow to lakes occurs mostly during the winter months. Monitoring of flow in Cusheon Creek, which is the outflow from Cusheon Lake, shows there is almost no outflow from June through October (Figure 12). There is also almost no inflow to the lake. **During the five dry months, any water taken from Cusheon Lake draws down the lake level**.

Because of the seasonal pattern of water inflow described above, the last column of Table 4 shows the licensed amounts pro-rated to the amount that could be used during the five dry months (June through October). Calculations for domestic purposes assume usage will be the same per month for all months of the year. Calculations for irrigation assume all usage for the year will occur during the dry months.

The last column of Table 4 shows that the biggest withdrawal from Cusheon Lake is for domestic use (total of approximately 67,000 cubic metres during the five months). Irrigation is next with about 26,300 cubic metres, and the Fisheries conserve follows with 20,800 cubic metres.

For Cusheon Lake, with a surface area of 269,000 square metres, a withdrawal of 114,000 cubic metres during the five dry months would draw down the lake level by about 0.4 metres. Evaporation also draws down the lake level. This has been estimated for Salt Spring lakes by Hamilton (1998), using equations based on temperature, and temperature data from Saanichton over a 20-year period. For the period June-October, this would be about 0.4 metres. This agrees exactly (0.40 m) with a more recent extimate by Watson (2006a) for St. Mary Lake which would be similar to Cusheon Lake in ambient temperatures. Thus the total potential drawdown during the June-October period would be about 0.8 metres.

It is important to remember that other factors also influence lake levels. In different years, the water level will be affected differently by such things as rainfall amounts, the timing of rain events, and whether beaver activity is blocking the outflow.

In recent years, the actual domestic use of the Beddis Water District has only been about 33% of the licensed amount (Andrew Peat, personal comm.). Independent domestic withdrawals can also be expected to be about one-third of the nominal licence value used in Table 4 (Sprague, 2006a). If the five-month withdrawal from Cusheon Lake is recalculated on that basis, the drawdown in depth would be 0.26 metres, plus evaporation, for a total of 0.66 metres. This estimate agrees well with actual lake level changes. In 2003 the level dropped 0.52 metres from June 24 to Oct 18, and in 2004 it dropped 0.5 metres from July 3 to September 1 (data from Wayne Hewitt, Cusheon Lake resident).

Thus, even though a large volume of water flows into Cusheon Lake on an annual basis, the effects of water demand are still important. **Current summer water demand, plus evaporation, causes the lake level to fall by 0.5-0.7 metres, which is enough to have a significant effect on the position of the shoreline. Any increase in licensing of water withdrawals would affect summer lake levels even more.**

2.3 Water quality status

The water quality of Cusheon Lake determines its suitability as a source of drinking-water and as wildlife habitat. It is the basis for every objective and every action proposed in this plan. The quality also reflects overall ecological conditions in the watershed.

Common indicators of water quality are chemical constituents such as nutrients (phosphorus and nitrogen), dissolved oxygen, pH, hardness, etc. Biological indicators are algal biomass or chlorophyll, populations of insects and fish, and bacteria associated with faecal contamination.

An important factor in determining the water quality of lake is its productivity, or how much algal and plant growth occur in the lake. The degree of productivity is also referred to as *trophic state*, and lakes are classified as oligotrophic (low nutrients and hence low productivity), mesotrophic (medium nutrients and productivity) and eutrophic (high nutrients and productivity). The placement of lakes into these three categories is primarily based on phosphorus concentrations, since this is usually the limiting nutrient that determines how much plant and algal growth can occur.

While it might seem that increased productivity is a positive thing, this is generally not true for lakes. As lakes become more productive, they tend to have water quality problems such as lack of oxygen in bottom waters, leading to loss of species that live at least part of their life in deep water, and algal blooms, including cyanobacterial species that may produce toxins. Also, as lakes become more eutrophic, the water is less clear, and decomposing algae can cause odour problems. All of these changes make the lake less desirable to live near, as well as making the water more difficult and expensive to treat for drinking.

Metal contamination, such as mercury in fish tissue is usually related to water quality conditions. Mercury from both natural and anthroprogenic sources, is usually bound to sediments under normal conditions and is non-toxic. Changes in lake water quality through excessive nutrient input and surface run-off can produce an anoxic lake bottom during summer and fall. These locally driven changes in overall lake water quality can release the mercury from the sediments back into the water column where it becomes biologically available. This results in the bioaccumulation of mercury in top-end predators (small mouth bass) and ultimately could affect human health through excessive consumption.

In this document, chemical concentrations are stated as parts per million (ppm) or parts per billion (ppb) for ease of comprehension, although the technically correct units would be milligrams per litre (mg/L) and micrograms per litre (µg/L).

2.3.1 Upstream lakes

Roberts Lake is a small lake, furthest upstream in the Cusheon watershed. It supports a population of trout and is moderately enriched. The land around the lake has been selectively logged in 2003-2004 and there is appreciable small-scale erosion of some of the vehicle trails.

There are only a couple of reliable historic measurements of total phosphorus, but some sampling was done during 2004-2005. The average is 16.5 ppb for all surface samples to date when the lake is mixed (Sprague 2006a). This places the lake in the mesotrophic category. (The designation of mesotrophic is assigned since phosphorus was higher than 10 ppb, the commonly used upper limit for oligotrophy, but was less than 20 ppb, which is a standard criterion for eutrophic lakes (OMOE 1984).

The total hardness of water was about 10 ppm, placing it in the *very soft* category (less than 30 ppm). **The stewardship committee reports that some decades ago, a water wheel at Roberts Lake operated all year to produce power, so there must have been outflow all year long. Today there are no flows in and out of the lake during the dry season. This might be the result of removing forest cover, which can reduce storage in the soils around the lake, or can alter the groundwater flows that feed the lake**.

Blackburn Lake has extensive growths of marsh vegetation around the shores, starting with lilies, blending into cattails and other emergent plants, and finally bushes (*Spirea*, *Salix,* and *Alnus*, among others). This is the classic picture of a lake in the natural process of filling. The emergent plants prevent erosion of the shores, and indeed act as a trap for any silt. The plants also act in a small way to reduce free nutrient levels in the water.

However, Blackburn Lake has occasional algal blooms. There are only seven reliable measurements of phosphorus in the lake. They indicate that the lake was *mesotrophic* in 1981, and continues to be mesotrophic with the latest sample in 2006.

The most meaningful average of total phosphorus concentrations is 16.3 ppb, based on seven values from 1981 to 2005, taken at times of the year (January to March) when the lake can be expected to be mixed (Sprague, 2006e). This places the lake a little above the middle of the mesotrophic zone. Total nitrogen averaged 490 ppb in 1981 (McPherson, 2004), 28 times the phosphorus concentration. This indicates that phosphorus was the limiting nutrient (any nitrogen-to-phosphorus ratio higher than 16 indicates that phosphorus is limiting).

2.3.2 Cusheon Lake

Cusheon Lake has had a great deal of chemical monitoring (phosphorus, nitrogen, dissolved oxygen, etc.) over the years, and some biological monitoring for faecal coliforms, algal species, and fish populations, largely by the environmental ministry of the province (Goddard 1976, Holms 1999, MWLAP 2003), or under the ministry's sponsorship (Reimer 2003), and by researchers at the University of Victoria.

The bathymetry of Cusheon Lake has been determined by provincial government survey, and is shown in Figure 13. Bathymetric measurements are useful for calculating the volume of water in the lake, and together with concentration data, they can be used to calculate the total mass of a chemical constituent such as phosphorus. The total mass of water and chemicals in each layer of water during stratification can also be calculated.

The lake normally stratifies during the warmer months, between May and October, with the warmer surface water staying in the upper 4 metres, and cooler water below. During this time the deep water (the hypolimnion) remains divorced from the surface. It loses oxygen, with the extreme depths becoming completely devoid of oxygen (McPherson 2004, Sprague 2006a).

From mid-October through the colder months, the whole water column is the same temperature, and mixes, so that all chemical constituents have similar concentrations at all depths. The mixed condition usually persists during the winter, until the surface waters start to warm up in the spring.

The hardness of the water has averaged 30 to 45 ppm, depending on season, which classifies it as *soft* (less than 60 ppm). The acid/base reaction has been slightly alkaline, typically ranging from 7 to 8.4 and averaging about 7.4 (McPherson 2004). These qualities are typical of area lakes and satisfactory.

2.3.3 Algal blooms

An ongoing problem in lakes that are mesotrophic to eutrophic is the occurrence of algal and cyanobacterial blooms. One of the main reasons that these blooms are detrimental to lakes is that when the blooms end, the cells fall to the bottom of the lake and decompose. This leads to depletion of oxygen in the lower depths, which is detrimental to deep-swimming fish and some other aquatic species. Oxygen depletion also leads to greatly enhanced release of phosphorus from the deep-water sediments. Later, when the lake mixes, some of this will become available to algae in the surface water. Thus, algal blooms help to increase the phosphorus available to support more algal blooms.

In addition to causing oxygen depletion, cyanobacterial blooms can sometimes be hazardous to human and animal health because of toxins produced by some species. The list below (Table 5) is a compilation of cyanobacteria, categorized according to their genus, and the toxins they produce (Source: www.cyanosite.bio.purdue.edu, Purdue University). The scientific name for each cyanobacterium is made up of the genus and species. For example, in the name *Anabaena flos-aquae*, *Anabaena* is the genus, and *flos-aquae* is the species name. There can be more than one species in a genus, e.g., another species within the genus is *Anabaena cylindrica*.

One of the most hazardous aspects of cyanobacterial **blooms is that they can occur very suddenly. Routine monitoring does not occur frequently enough to pick them up**. **Thus, it often falls to residents or water treatment facility operators to be alert and notice there is a need for testing. This uncertainty and difficulty with testing is another reason why blooms must be prevented.**

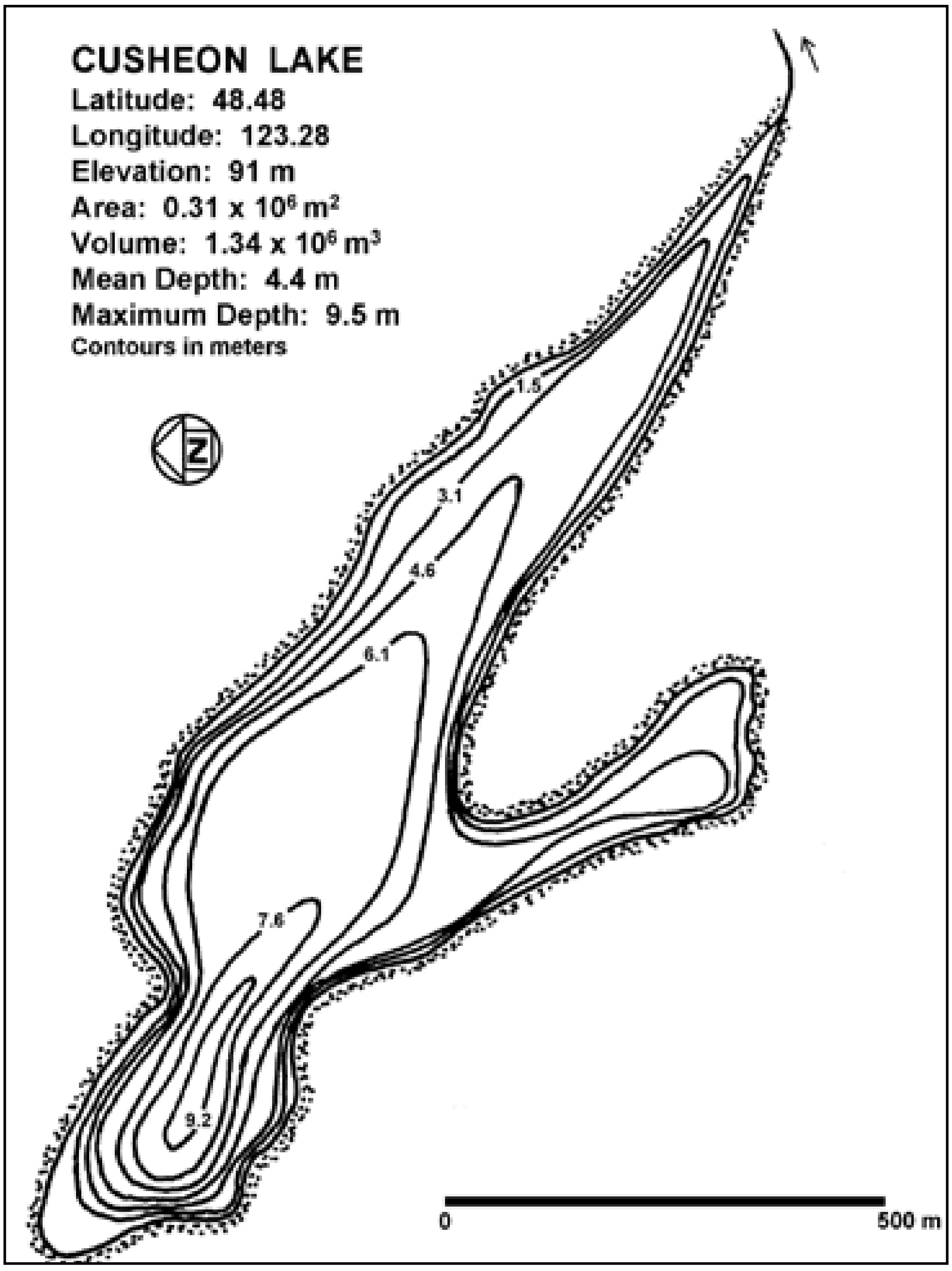


Figure 13. Bathymetry of Cusheon Lake. From Spafard et al. 2002. The dimensions differ from the values of the original survey, which are recommended and shown on Table 3.

Table 5. Examples of species of cyanobacteria and their toxins. This shows the types of toxins that the species within each genus can produce, for these "blue-green algae". *

Genus	Toxins produced by species in that genus
Anabaena	Anatoxins, Microcystins, Saxitoxins, Lipopolysaccharides (LPSs)
Anabaenopsis	Microcystins, (LPSs)
Anacystis	LPSs
Aphanizomenon	Saxitoxins, Cylindrospermopsins, LPSs
Cylindrospermopsis	Cylindrospermopsins, Saxitoxins, LPSs
Hapalosiphon	Microcystins, LPSs
Lyngbia	Aplysiatoxins, Lyngbiatoxin-a, LPSs
Microcystis	Microcystins, LPSs
Nodularia	Nodularin, LPSs
Nostoc	Microcystins, LPSs
Phormidium (Oscillatoria)	Anatoxin, LPSs
Planktothrix (Oscillatoria)	Anatoxins, Aplysiatoxins, Microcystins, Saxitoxins, LPSs
Schizothrix	Aplysiatoxins, LPSs
Trichodesmium	yet to be identified
Umezakia	Cylindrospermopsin, LPSs

* Not all species within a genus produce the same toxins. In addition to these toxins, many other bioactive compounds have been isolated from cyanobacteria. Some are toxic to specific organisms and are potentially toxic to humans.

Even though a cyanobacterium that is capable of producing toxin is present in a lake, it will not necessarily produce that toxin. Thus, **monitoring of drinking-water lakes requires identification of species and measurement of toxin in order to determine if there is a health risk.**

Another challenge is to make the correct measurement of toxin. The most common measurement in drinking-water supplies is for Microcystin LR, produced by *Microcystis* and some other species (Federal-Provincial-Territorial Committee on Drinking-water, October 1999). The other toxins are structurally related, and there is another test, for "total microcystins" which is applicable for a wider variety of species and their toxins.

For further information on cyanobacteria and drinking-water safety, please see Appendix 6, which gives information from Health Canada.

Cusheon Lake suffered its most serious problem of water quality during a bloom of cyanobacteria in late summer of 1999. There was a precautionary ban on human use of water from the lake for two and a half weeks (Appendix 5). Luckily, the species did not turn out to be a great producer of toxin. Still, this bloom of cyanobacteria is an alarming symptom of lake enrichment.

Cyanobacterial blooms are a growing concern in lakes used for drinking-water. Their increased occurrence is most likely related to increasing phosphorus concentrations. However, there are occasional periods in summer when nitrogen is in shorter supply (see next section). Many species of cyanobacteria have the ability to fix elemental nitrogen that is dissolved into the water from the air, and those species are able to grow better than other species during short periods when fixed nitrogen (ammonia, nitrate) is not high enough to meet the needs of growing cells.

2.3.4 The limiting nutrient—phosphorus

For algal growth to occur, the primary nutrients required from the water are phosphorus (P) and nitrogen (N), and they are needed in a ratio of roughly 1 atom of P to 16 atoms of N. A compilation of ratios of P to N in Cusheon Lake water over 30 years (McPherson 2004) shows that brief periods of nitrogen scarcity regularly occur in Cusheon Lake during June through September. Most of the time, however, phosphorus is the nutrient that is limiting for growth of algae. Therefore, it is the total input of phosphorus to the lake that governs the extent of algal blooms.

The following sections show that Cusheon Lake has been in the mid- to upper level of mesotrophy since 1974. As discussed below, estimates of average phosphorus concentrations are variable, depending on the sequence of measurements analyzed, but averages in the most recent decade are 16.7ppb. This is higher than the historic estimates before intensive development, when the lake was in the mid- to lower region of mesotrophy.

2.3.5 Long-term history of phosphorus concentrations

In addition to determining the current status of phosphorus concentrations in Cusheon Lake, it is important to know something about the past trophic history of the lake. The lake cannot be restored to any better condition than it was when the land surrounding it was in pristine condition (prior to logging and human settlement). Thus, it would be helpful to know what this condition was, to see how much improvement might be reasonably expected as sources of human-induced phosphorus are remediated.

Sediment cores were taken in 2002 by Dr. Rick Nordin (currently at the University of Victoria), and have been dated and analyzed for a variety of elements including nitrogen and phosphorus. Analysis of diatoms, which are the most helpful identity in determining the pre-settlement condition of the lake, was done in early 2005 by Dr. Brian Cumming and Dr. Kathleen Laird, Queen's University, with financial support from B.C. MWLAP (Deborah Epps).

The results of the diatom analyses showed that phosphorus concentrations in Cusheon Lake surface waters were fairly constant from 1810 through 1970, with some lower concentrations occurring in the decade between 1937 and 1947. Since 1970, however, the diatom record in the sediments shows more species that grow well at higher phosphorus concentrations, and the resulting estimate of surface water P concentrations is higher than in all previous periods.

For the last period shown in Table 6, 1970-2002, there are also actual measurements of phosphorus in surface water, and they are in general agreement with the concentrations predicted from the diatom results, as described in the following sections.

Table 6. Total phosphorus concentrations in Cusheon Lake, estimated from diatoms in sediment cores. Information from Cummings and Laird (2005).

Zone	Years	Midsummer TP (ppb)
A	1810-1910	10 to 17
B	1910-1937	10 to 17
B	1937-1947	10
B	1947-1970	10 to 17
C	1970-2002	14 to 17

Several types of changes in a watershed are related to increasing eutrophication in lakes, as shown in a study of 600 lakes in Minnesota (Brezonik et al. 2000). These factors are:

1. Loss of forest cover
2. Increased agricultural land-uses near the lake edge
3. Increased development
4. Increased impervious surfaces

All of these have taken place In the Cusheon watershed, although the historical record of when changes have occurred is not complete. The best documentation is for the numbers of buildings, available from different maps:

In 1912, there were about 13 households in the watershed, with most of them near Roberts Lake, which was then called Allen's Lake (Kahn, 1998).

In 1969, a B.C. Department of Lands, Forests and Water Resources map shows there were 8-13 buildings around Roberts Lake, 14 around Blackburn Lake, and 37 around Cusheon Lake, with most of them near Cusheon Lake Road, for a total of 59-64 buildings in the entire watershed.

By 1993 this had increased to about 109-114. Most of the increase since 1969 was due to increased density around Blackburn Lake, the trailer court, and more buildings near Cusheon Lake, as shown by a Terrain Resource Information Map (TRIM) produced by the province.

The most up- to-date map from Islands Trust shows 219 to 281 buildings in 2005, depending on whether properties partially within the watershed are included (Figure 4).

In addition to residences and their associated septic fields, forest clearing and agricultural development have been prominent changes in the watershed. As shown in Table 2, 83.3% of watershed lands have been modified over time, but we do not have a record of the timing of land use changes. It would be particularly helpful to know when logging occurred, and where and when farms were actively used for livestock or crops.

There is some information on one property at the lakeshore from *The story of Cusheon Lake Farm*, by Chuck and Natalie Horel (1987). According to this narrative, the first clearing of land around the lake occurred in 1849. The Cusheon Lake Farm property was actively farmed after World War I, and sheep grazing was started around 1928. Howard and Winnie Horel bought the farm in 1945, but were not very interested in farming. They did a lot of logging, but it was small scale and apparently they did this all over the island (Kahn 1998). Land was cleared around Blackburn Lake for a dairy farm in the early 1890's.

In *The Story of an Island*, Charles Kahn (1998) reports there was a sawmill located on Cusheon Cove from around 1906 until 1926, using logs obtained mainly from off-island. Some logs came from "small-scale independent hand loggers working around Cusheon Cove", which presumably would include areas near Cusheon Lake. Kahn also reports that in general, logging activity on Salt Spring Island decreased greatly in the mid-1930's, as most virgin timber had been logged by this time.

While the logging history is sketchy, the timing of early logging activity (mid-1800's to the 1930's) indicates it did not have a major effect on phosphorus in the lake, because the diatom record does not show any periods of increase during the same time-periods (Table 6). Perhaps this is because early logging was "small-scale" and not as disruptive as larger clear-cutting operations today. On the other hand, the expansion of numbers of houses does seem to coincide with increased phosphorus.

The most important message from the diatom history is that recent human development is the likely cause of increased phosphorus levels in the lake, and therefore efforts to decrease the phosphorus inputs associated with this development would be useful for helping to restore the lake to its previous, lower nutrient state.

2.3.6 Recent measurements of phosphorus

Springtime concentrations

A commonly used indicator of trophic state in lakes is the concentration of phosphorus at the time of springtime mixing (Table 7). Experts regard this as the best single measurement for judging the phosphorus content of a lake. Measurements from the different years show that there can be very large differences in the concentrations from one year to another (see further below). Year-to-year differences can be expected, due to differences in amounts and timing of rainfall, weather events, temperatures, and human activities within the watershed, such as land clearing. A major factor in this lake would be the degree of flushing during the heavy inflow from Blackburn Creek in the winter.

Table 7. Average concentrations of total phosphorus in Cusheon Lake during spring circulation. Measurements at several depths on a single day have been averaged, and for more than one day in a year the daily values have been averaged. Values are in parts per billion. Information from McPherson (2004), MWLAP (2003), Reimer (2003), and personal communication from Deb Epps, B.C. Ministry of Environment.

Year	No. of days	Average Total P (parts per billion)	Year	No of Days	Average Total P (parts per billion)
1975	1	11.8	1997	2	19.3
1976	2	13.2	1998	1	16.0
1980	3	16.7	1999	2	19.0
1987	1	9.5	2000	2	22.7
1990	1	13.7	2001	1	18.0
1992	1	14.0	2002	1	11.0
1993	1	18.0	2003	1	13.0
1994	1	3.0	2004	1	15.0
1995	1	6.5	2005	1	14.5
			2006	1	19.0

Spring circulation measurements (Table 7) do not show any consistent increase or decrease since 1976. Measurements in the most recent decade (right side of Table 7) average 16.7 ppb. No water measurements were done before 1974, but sediment measurements can be used to infer concentration trends prior to this time (see discussion in Section 2.3.5). Additional information is considered at the end of this section, under “Yearly values”.

Seasonal changes

In addition to spring circulation, measurements of phosphorus in the surface water have been made at many other times of the year since 1974 (Figure 14). Concentrations tend to be fairly steady most of the year, until autumn when the breakdown of summer stratification and fall circulation brings phosphorus up from deeper anoxic waters.

Also, it has been shown for Blackburn Creek, that freshets (surges of flow) in the first half of the wet season are higher in phosphorus than similar freshets in the last part of the wet season (Sprague 2006b). This pattern of higher concentrations in the first freshets of the high-runoff season is generally recognized in North America. It prevails in other creeks on Salt Spring Island (near Maxwell Lake, personal communication, T. Hutton, North Salt Spring Water District).

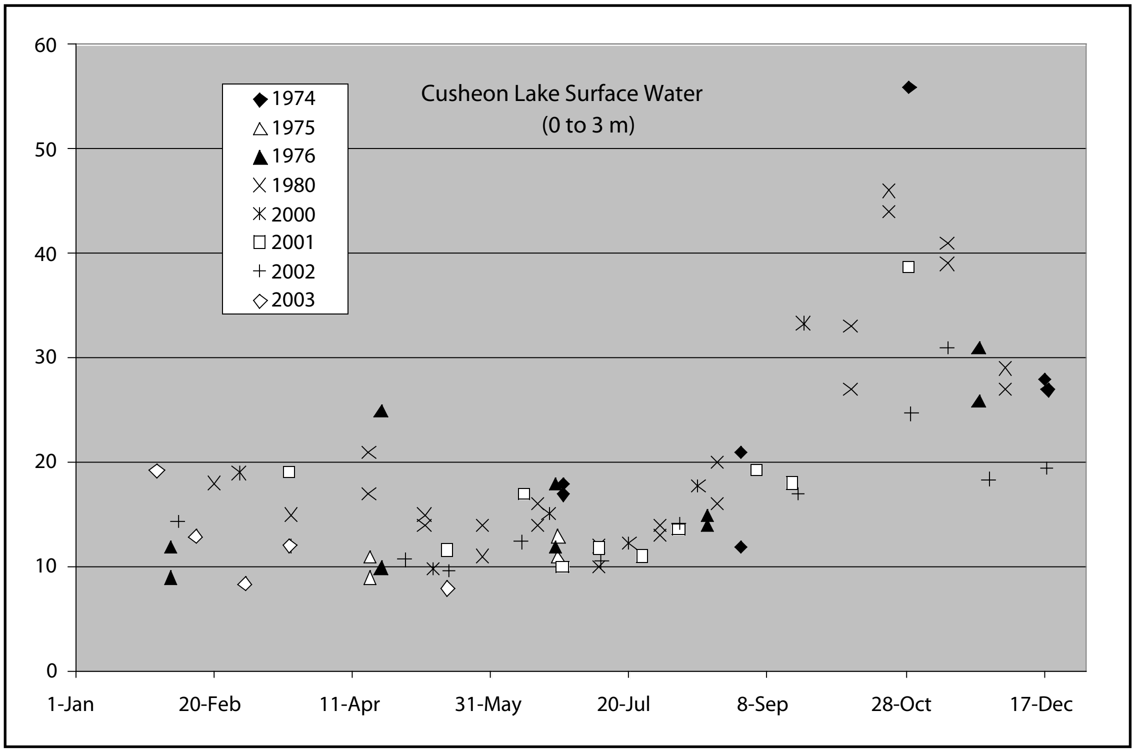


Figure 14. Seasonal pattern of concentrations of total phosphorus in surface water of Cusheon Lake. Data are for samples from zero to one metres depth in eight different years, and are taken from McPherson (2004).

Yearly values

A recent compilation of water quality data over the years from 1974 to 2003, concluded that Cusheon Lake is currently mesotrophic, with some eutrophic characteristics (McPherson 2004). Another recent analysis tabulated the same data (MWLAP 2003), combined with determinations by Reimer (2003), and values to 2006 obtained by the provincial sampling program (personal communication, Deborah Epps, Ministry of the Environment, Nanaimo, B.C.). Results (Figure 15) show major fluctuations from year to year.

Values in Figure 15 can be conveniently separated into three time-periods, 1974-80, 1987-95, and 1996-2006. The early and late periods are fairly similar. Low values in the middle period are thought to represent a period of flushing out of algal populations from the lake, carrying phosphorus with them. During this period, there was at least one late-winter observation that the strong outflow into Cusheon Creek looked very green (personal communication, K. Reimer). The two sets of values (all-season and springtime) are not different statistically, so they would appear to be equally good for interpretation. Statistical analysis showed only a 5% overall difference in the paired data, a difference expected by chance more than 90% of the time.

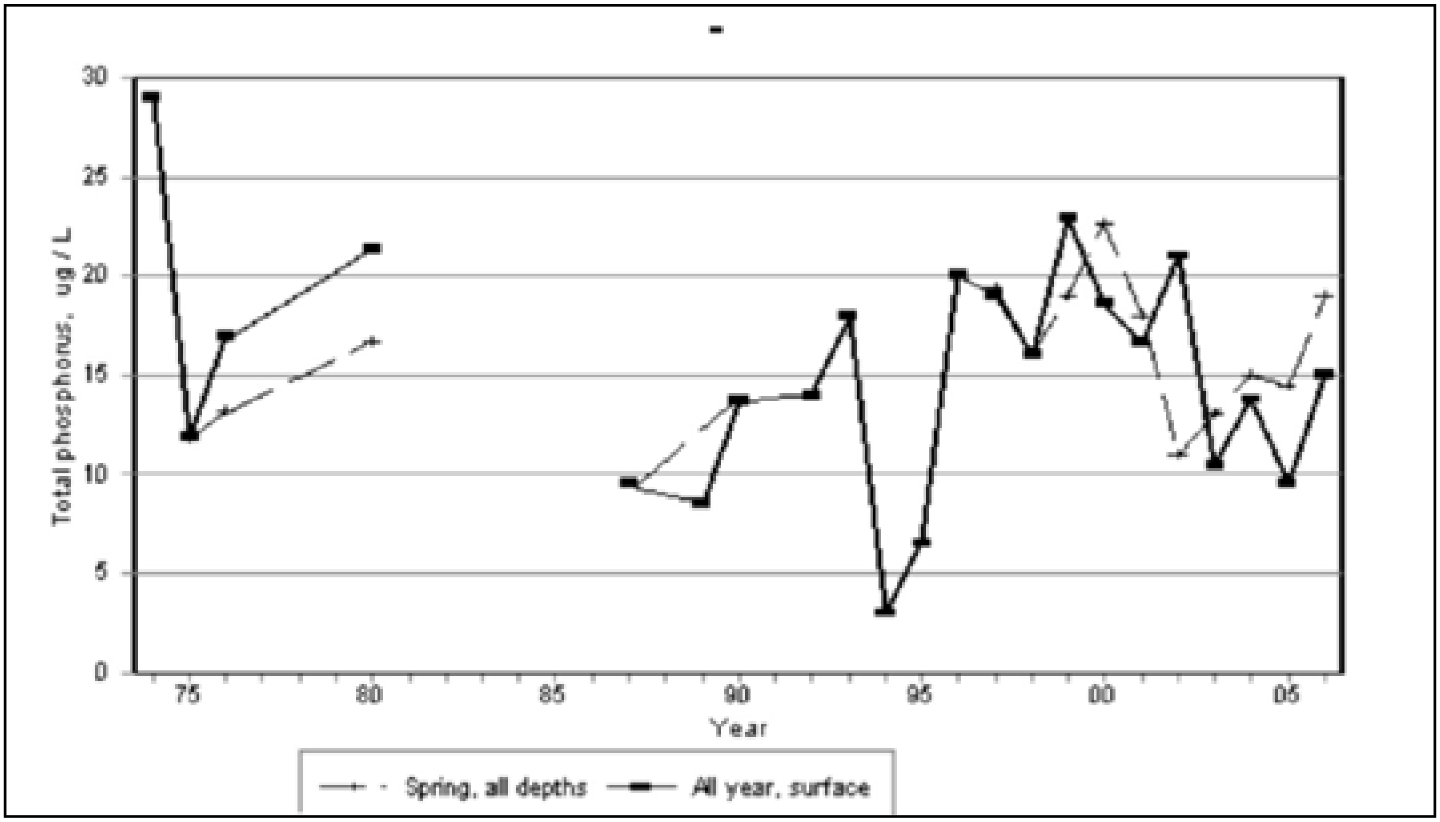


Figure 15. Total phosphorus measurements in Cusheon Lake to 2006. The all-season measurements at the surface and the springtime measurements can be interpreted together. From Sprague (2006a), with data from MWLAP (2003), Reimer (2003), and Deborah Epps, Ministry of Environment.

For the most recent period shown in Figure 15, from 1996 to 2006, the overall average all-season concentration is 16.72 ppb [6]. The spring-time average is 16.75 ppb. These estimates are in general agreement with the prediction from analysis of diatoms in the sediment.

General implications of measurements

The number of phosphorus measurements made for Cusheon Lake is much greater than for the two upstream lakes, so a comparison is not definitive. However, available measurements indicate that phosphorus levels in all three lakes are similar. The values described above are:

Roberts Lake	16.5 ppb
Blackburn Lake	16.3 ppb
Cusheon Lake	16.7 (most recent decade)

Total phosphorus in Cusheon Lake water exceeded the levels specified by the British Columbia Drinking-water and Recreation Criteria in 76% of years between 1974 and 2003 and by the Aquatic Life Criteria (Canadian Council of Ministers of the Environment) in 41% of these same years (McPherson 2004).

Other criteria also indicate enrichment and eutrophication. Holms (1999) reports a monthly average chlorophyll measurement of 12 ppb in 1980, with a maximum of 34 ppb, whereas any value above 20 ppb in the warm season indicates eutrophy (Michalski and Conroy 1972). Visibility as measured by Secchi depth was 1.5 to 2.5 metres in 1976, 1980, and 1994, and anything less than 3 metres indicates eutrophy (Dobson et al. 1974).

6 The value 16.7 ppb is derived as the average of the yearly means, but other methods of calculation gave similar values. The data-base has 59 values, with some of them being themselves, the average for different depths on a single day, in the springtime.

Faecal coliforms exceeded the Drinking-water Criteria for untreated water in two of six samples taken in 1999 to 2003 (McPherson, 2004).

2.3.7 Potential sources of phosphorus for Cusheon Lake

Figure 16 shows a simple diagram of the natural phosphorus cycle, as it pertains to watersheds and lakes. Phosphorus enters the cycle in rainfall and by release from rocks as they weather. The amount of phosphorus in rainfall varies from place to place, being higher in areas with a lot of dust in the air, such as the prairies, and lower on the coast, where much of the rainfall comes from ocean areas.

Release by weathering of rock minerals is a very slow process. In the soil of watersheds, plants take up phosphorus. When the plants die, the dead material decomposes, releasing some of the phosphorus in a soluble form, which is usually rapidly taken up again by living plants. However most of it remains bound in the insoluble humic and mineral materials that make up the soil.

When it rains, some portion of phosphorus dissolved in the rain, or released from the soil, can move downhill into streams and the lake. If water movement is very fast, as in a very heavy rain event, some soil particles will also move. The phosphorus contained in these particles will be carried with them into streams and lakes. Thus, under natural, undisturbed conditions, some small amount of phosphorus always enters streams and lakes from soils and from rainfall

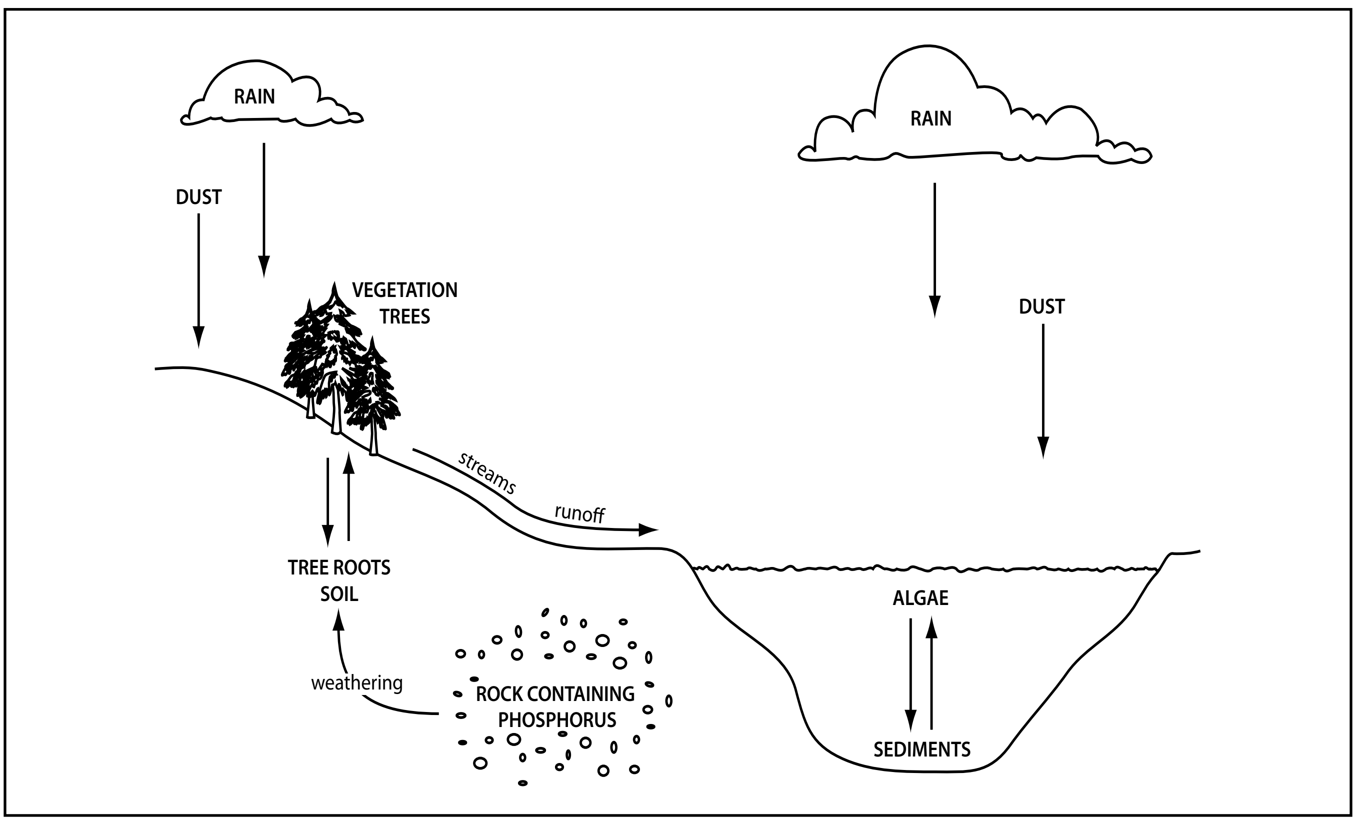


Figure 16. Diagram of the phosphorus cycle in a watershed.

The fact that natural inputs of phosphorus are small means it is easy for human activities to cause significant increases in inputs to lakes. Major sources of human-related phosphorus in Canadian lakes are usually :

- *Soil erosion*, especially from stream-bank erosion and ploughed fields. As stated above, phosphorus tends to cling to soil particles, so sheet erosion of fields and disintegration of stream banks can be enormous sources. Almost invariably, the input comes at times of heavy rainfall and runoff. That is true for the runoff in Blackburn Creek. (Sprague, 2006b) The movement of soil particles is greater in straight ditches, where water moves faster, than in meandering streams.

- *Livestock waste*, especially runoff from feedlots. This can be a major item where it exists, but is not an appreciable factor in the Cusheon basin at present.

- *Regeneration from bottom sediments*. When bottom waters of lakes become devoid of oxygen, phosphorus that was deposited in sediments during previous years can become dissolved, and return to the water column. Some of this will become available to algae in the surface water.

Other common sources, often of moderate intensity, include:

- *Agricultural fertilizers,* which can be a major contributor of nutrients to the runoff from fields. Any type of fertilizer, whether “chemical” or “organic”, could contribute, although a bulky organic fertilizer might be less prone to running off. At the Blackburn golf course, fertilization does not appear to be a big problem under current practices. The animal-meal fertilizer is used sparingly and judiciously. There is a potential for greater input if future operators changed to a less benign set of procedures.

- *Septic tank beds* that are functioning poorly. Leakage of liquid can run into creeks and lakes. In a properly functioning septic field, phosphorus will be “filtered out” and will adhere to soil particles. Modern research suggests that in favourable soils, an average of 74% of phosphorus might stay in the soil (Hutchinson 2002). This is only an average, and individual performance will vary according to the situation.

Other possible sources:

- *Shoreline erosion*. This aspect of soil erosion deserves explicit consideration. Shoreline erosion might not be a major factor on Cusheon Lake, because there is not the opportunity for large waves to build up in a small lake. It would not be a factor on the shallow parts of shoreline that are weedy or marshy; they would act as sediment traps. Similarly, Blackburn Lake with its vegetated shoreline would not be an upstream source of nutrient from shoreline erosion. However, any change of the natural shoreline such as infilling would promote erosion.

- *Detergents* in wash water that reaches surface drainage. This has not been a big problem in Canada for 25 years. Most detergents are now relatively low in phosphates (except for dishwasher products). If wastewater goes through a proper septic system, phosphorus is largely removed.

- *Lawn fertilizer* could be important if it was washed off directly into surface watercourses.

- *Organic waste* such as grass clippings and leaves. These could be a minor contributor if dumped in water bodies, where they would decompose and contribute nutrients.

2.3.8 Current phosphorus loads, water quality objectives, and remedial actions

A separate report on phosphorus inputs to Cusheon Lake is meant to go hand-in-hand with this management plan. The phosphorus inputs report gives the technical background behind the estimated sources of phosphorus for Cusheon Lake (Sprague, 2006a). The technical report is referred to here as "the loading study" and gives detailed support for the general statements made in this Plan.

The purpose of the loading study was to estimate the importance of the different sources of phosphorus reaching Cusheon Lake. Some sources, particularly seepage from septic fields, are very difficult to measure, although they can be estimated on the basis of research in other places. The loading study used mathematical modelling of the watershed and its lakes, based on a well-known scientific model that was developed in Canada (Dillon et al 1986; Hutchinson et al 1991, Hutchinson 2002). Details are given in the loading study (Sprague, 2006a).

Table 8 shows the most probable scenario from the loading study. Land runoff and the upstream lakes were estimated to contribute 63 kilograms of phosphorus per year to Cusheon Lake (first line of the table). Rainfall contains some phosphorus, but was estimated to provide only 2.6 kilograms per year (second line). These inputs are determined by the size of the watershed, the condition of the land and its vegetation, and the surface area of the lake receiving rain. The land runoff contributes about 53.5% of the total phosphorus loading to the lake.

The next two lines show the estimated inputs from septic fields around the lake, and at the modular home court nearby which is on the inflowing creek. The soil around the septic fields was assumed to be 74% effective in stopping phosphorus, on the basis of recent studies (Hutchinson 2002). There were additional reductions allowed for greater distance of a septic field from the lake. Shoreline clearing also contributes some phosphorus due to erosion, estimated at 1.4 kilograms per year. Altogether, the septic fields and shoreline clearing were estimated to contribute 26.9 kilograms of phosphorus per year, about 23% of the total.

The last input was phosphorus regeneration from the sediments at the bottom of the lake, estimated by the increase that was measured in bottom waters during the summer season, when the water is isolated and without oxygen. At an estimated 22% of total input, this is an important source. This "old" phosphorus comes back into the water each autumn when the lake mixes. If the lake water contained oxygen all the way to the bottom, the phosphorus at the bottom would disappear into the mud and would stay buried.

Table 8. **Estimated yearly loadings of phosphorus to Cusheon Lake**. This is for the most likely scenario of land use and direct human input. (Data from Sprague 2006a)

Source of Phosphorus	Estimated input	
	kg P	%
Land runoff and upstream lakes input	62.7	53.5%
Rainfall to surface of lake	2.6	2.3%
65 residences near lake	17.7	15.1%
26 units in trailer court	7.8	6.6%
Shoreline clearing at 40 residences	1.4	1.1%
Regeneration from deep sediments of lake	25	21.3%
Total loading to lake (kg P/yr)	117.3	100%

The scenario of Table 8, with an annual phosphorus load of about 117 kg, is considered the most probable estimate of existing conditions in Cusheon Lake. That loading predicts a lake concentration of 16.7 ppb of phosphorus, identical to the average of 16.7 ppb measured during 1996 - 2006 (Figure 15, Table 7).

Critique of the estimates
The exact agreement of the predicted concentration with the observed average is most unusual in modelling of this kind, with all its approximations. It might be largely coincidence, but lends some credence to the general validity of the scenario.

The general technique in the modelling was to use Roberts and Blackburn Lake to estimate the phosphorus runoff from the land. Since there are no human residences on their shores, most of the phosphorus input to those lakes comes from the land. Various values were tried for land runoff into each lake, until the predicted concentration of P in the lake matched the real observed concentration. The separate estimates of those two values for P runoff were averaged to create a runoff value which was applied to Cusheon Lake.

From that modelling exercise, a land runoff value of 0.089 kg of phosphorus per hectare of land was estimated. That corresponds reasonably well with an estimate of 0.11 kilograms/hectare, which was obtained in a year-long study of phosphorus runoff to Blackburn Creek (Sprague 2006b). The difference is 20% which is reasonable since the runoff study was done in a wet year. Both values are close to the standard value of 0.10 kilograms/hectare for "forested land" (Dillon et al.1986). This agreement tends to give further general validation to the estimates of the sources of phosphorus which are shown in Table 8.

Remedial actions and water quality objectives
Algal blooms could be reduced by lowering the inputs of phosphorus. If the total input of phosphorus were reduced by 10 kilograms, the average spring-time phosphorus concentration in the lake would become 15 ppb (Sprague 2006a). This would be a mid-mesotrophic status, algal blooms would be reduced, and might be tolerable. **The water quality objective would be 15 ppb.**

If the total phosphorus load of 117.3 kg were reduced by 17.7 kg (e.g., by eliminating septic input from lake-side homes), the predicted spring-time phosphorus would be **13.5 ppb (the water quality objective)**. The lake would improve to low mesotrophic status. That would not be a crystal-clear lake, but would equal the probable natural condition (see Section 2.3.5, Table 6).

If a water quality objective were adopted, it would not matter how the phosphorus reduction was achieved. It could be all from one source, or small amounts from several sources. It might be difficult to achieve a desired reduction by focusing on any single input listed in Table 8. For example, eliminating 100% of septic inputs would presumably require a collection of all septic waste or a sewer around the lake with a centralized sewage treatment plant. However, improvement of any faulty septic systems might lead to a beneficial reduction of a few kilograms. With similar small improvements in most of the sources, a 10-kilogram reduction might be achieved.

The runoff of phosphorus from the land to successive lakes in the system represents about half of the input to Cusheon Lake. This large fraction is difficult to reduce because easily remedied activities such as fertilizer use and pasturing of farm animals are not prominent in the drainage basin. However, progress could be made by re-vegetating creek-banks, roadsides and clear-cut areas, and by improved ditching practices, to slow the passage of water from land to the lakes.

Regrettably, land use in the watershed seems to have been going in the opposite direction in recent years. There have been massive road-building operations and clear-cutting of hillsides, exposing bare soil to erosion. As such operations continue, they make it more and more difficult to achieve any desired goal for reduction of phosphorus inputs.

The other large input to Cusheon Lake is internal regeneration of phosphorus from the bottom sediments (21% of total), due to oxygen depletion in the deeper waters of the lake. The best way to reduce this contribution is to reduce the other inputs to the surface water. That will lead to decreased levels of blooms, fewer algae falling to the lake bottom, and less oxygen depletion as they decompose. Thus, if there were a reduction in external inputs such as septic fields, then the internal regeneration would likely also decline.

There are various mechanical methods for reducing or eliminating such phosphorus regeneration from bottom sediments. Artificial aeration of the bottom waters can be done by several means. This was successfully done for a number of years in St. Mary Lake, but might not be possible in Cusheon Lake because it is shallower. Withdrawal of water from the hypolimnion during summer stratification is another method. Water is taken from the hypolimnion and released downstream. Ideally, water is taken from as close to the bottom as possible, because the deepest water contains the highest concentrations of phosphorus.

This method is very simple, but would be very undesirable for Cusheon Lake since it would lower the lake level during the summer, when there is no inflow. Evaporation and withdrawal of drinking-water already lower the lake by about 0.8 metres in the summer (see section 2.2.1). It might be feasible to have the intake for Beddis water system in the deep water. The potential benefit of that approach could be examined using current knowledge of water volumes and phosphorus concentrations. It might remove 2 or 3 kilograms of phosphorus every year.

2.3.9 Drinking-water treatment

Most of the drinking-water taken from Cusheon Lake undergoes treatment by the Beddis Water Works Treatment Plant. Until recently, treatment involved filtration. Cleaning the filters was accomplished by backwashing the filters and sending the removed solids (mainly algal cells) back into the lake. This was undesirable as nutrients in the cells were returned to the lake.

In the new facility, expected to operate in 2007, the method of separating organic colloids and algal cells from the water will be “dissolved air flotation”. In this method, water is drawn into a large stainless steel tank, and air is forced through small apertures at the bottom of the tank, producing tiny bubbles.

These bubbles cause organic molecules to aggregate (as can be commonly observed in the brown colour of foam in waves breaking on shorelines). The aggregates and solids float to the surface where they are removed with a paddle that scrapes across the surface. The solids are taken away and composted. This will result in less phosphorus being returned to the lake, although the amounts are likely small compared to other inputs.

Flotation will be followed by ultraviolet treatment to kill pathogenic bacteria, and activated charcoal which removes a wide variety of organic substances.

2.3.10 Current water quality monitoring

There are two types of water quality monitoring for drinking-water lakes:
- Monitoring lake water itself
- Monitoring water quality after treatment and delivery to homes

Water exiting the drinking-water treatment facility is tested for total coliform bacteria every two weeks by the Environmental Health Officer of the Vancouver Island Health Authority (VIHA). Once a month, samples are also taken from the faucets of two households located at the ends of the distribution system

Treated water is tested for trihalomethanes, which are by-products of chlorination of some organic substances which may be present in natural waters. The level of these is regulated in drinking-water because they are potential carcinogens. In the past, the level in treated Cusheon Lake water has been close to the allowed limit (0.1 ppm). This should improve with the new treatment system. No other variables are regularly tested in the treated water. If an algal bloom appears to be present, samples are taken for identification of the species, to see if it is one that produces toxin. If so, testing is done for microcystins.

Lake water is tested for coliform bacteria only in the summer months, at the beach area near the dock.

In recent years, chemical and biological sampling for Cusheon Lake has been done on a quarterly basis by the Ministry of the Environment at the deep station site (February, May, August, and October). Samples are taken at the surface and at one metre above the bottom.

Variables sampled include:

- pH
- True colour
- Specific conductance
- Total residue
- Turbidity
- Silica
- Alkalinity
- Total organic carbon
- Total inorganic carbon
- Total nitrogen
- Ammonia
- Nitrate
- +nitrite
- Nitrite
- Total phosphorus
- Total dissolved phosphorus
- Chlorophyll *a*

A Secchi disk reading is taken to measure the general clarity of the water. Profiles of selected measurements are also done. These include:

- Temperature
- Dissolved oxygen
- pH
- Reactive phosphorus
- Conductivity

Zooplankton and phytoplankton samples are also collected quarterly.

Biweekly field measurements are to be collected by the local residents from May to October. These include dissolved oxygen and temperature readings at one-metre intervals, and a Secchi disk reading. Samples for phosphorus in surface water have been taken monthly.

PART B. Objectives

The Action Planning Process

The planning and management process is divided into four phases:

- Assessment
- Planning
- Implementation
- Evaluation

The general flow is shown in Figure 17.

Various manuals, guidebooks, and pamphlets give advice on the planning process and techniques for protecting waterbodies. Some useful ones, listed in the References, are Chilibeck et al. (1993); Canada/B.C. (1994, *Stream stewardship*); Nowlan and Jeffries (1996, on wetlands); *Fraser River Action Plan* (1996); EC and FOC (2001), and *Millstream Watershed Management Forum* (1999). The B.C. Ministry of Water, Land and Air Protection (WLAP) has a number of relevant pamphlets.

The purpose of the Cusheon Watershed Management Plan

The purpose of this plan is to provide goals, objectives, strategies, and proposed actions to protect and restore the quality of surface waters within the Cusheon Lake drainage basin.

The Implementation and Priorities section lays out critical activities, involvement of local government and other organizations and time lines.

A watershed approach

Sections 2.3.6 and 2.3.7 indicated that the deterioration of water quality in Cusheon Lake was related to human activities throughout the Cusheon basin. **A remedial approach for Cusheon Lake must encompass the whole drainage basin, and it must include all the people living in the basin. Without participation of the local government and residents, a remedial plan cannot succeed.**

Accordingly, all stakeholders should have opportunities, at all stages of the plan, to express their views and have them considered. This is indicated on the left side of Figure 17, which shows the process for development of a Cusheon Watershed Management Plan by stakeholder input .The first public meetings were held in 1999, with more recent meetings in the fall of 2004 (Appendix 1).

The development of a Cusheon Watershed Management Plan is a relatively new process, and therefore must necessarily be iterative in nature, as indicated by the arrows in Figure 17.

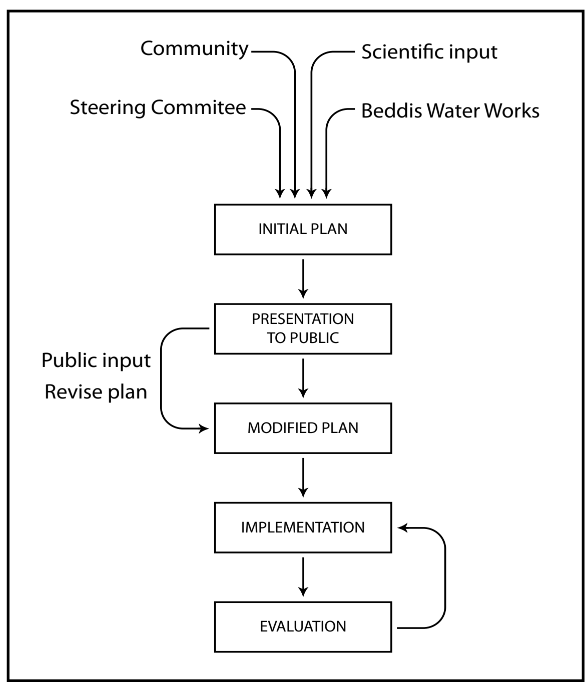


Figure 17. Diagram of recommended planning and implementation processes

OBJECTIVES AND RECOMMENDED ACTIONS

The primary goal of the Cusheon Watershed Management Plan is to **protect and restore the quality of surface waters in the Cusheon Watershed**

Cusheon Lake is a source of drinking water. The main difficulty with the water in Cusheon Lake is excessive algal growth and related toxins caused by nutrient enrichment. The key limiting nutrient is phosphorus. Accordingly, the most important strategy to achieve the primary goal of the watershed plan is to **reduce the loading of phosphorus into Cusheon Lake.** The steering committe recommends an objective of 13.5 parts per billion (ppb) of phosphorus in the springtime lake. To achieve that, a reduction of 17 kg or yearly loading from 117 to 100 kg is required. This is a reduction of 15 percent.

Evidence that this goal is being accomplished would be:

1. Decreased phosphorus concentrations at spring overturn;
2. Increased water clarity, as measured by Secchi disk readings;
3. Reduction and eventual elimination of potentially toxic algal blooms.

Improved fish and wildlife habitat will be an automatic benefit when the above goal is achieved. With reduced nutrients and algae, fish and other aquatic organisms will face fewer problems resulting from oxygen reduction, the release of metal contaminates from the lake bottom, and less danger of kills from cyanobacteria, as occurred in Fraser Lake (Personal communication, Dr. Rick Nordin, U. of Victoria, and Gary Gibson and Michel Riefman, Vancouver Island Health Authority).

Financial and other benefits are associated with improved water quality. Residents can avoid expensive special treatment of drinking water or the need to buy imported water. Better water quality and improved lake aesthetics protect property values. There are also tangible benefits from improved fishing and other recreational uses favourable to tourism.

This management plan provides a set of objectives and actions for achieving the major goal.

The five main objectives that must be accomplished to achieve the plan's goal are:

1. Define and map Cusheon's watershed, its land uses, creeks, wetlands and the status of riparian vegetation.
2. Undertake a scientific analysis of the phosphorus sources in the watershed.
3. Reduce inputs of phosphorus from land management activities.
4. Reduce inputs of phosphorus from water management activites.
5. Monitor springtime levels of phosphorus. (See section 2.3.8) When monitoring indicates consistent springtime concentrations of 13.5 ppb of phosphorus, the major goal of the plan will have been achieved.

OBJECTIVE 1: DEFINE AND MAP DRINKING WATERSHED.

Recommended strategy: Inventory and map the land use and key environmental features, particularly riparian zones, within the boundary of the drinking watershed. Translate this mapping into Official Community Plan (OCP), Zoning & Land Use Bylaw (LUB) designations. This Plan adopts a physical definition of the drinking watershed as the upper watershed (i.e., above the Cusheon Lake outlet). The lower Cusheon watershed is crucial for salmon, especially Coho, but is not a source of drinking water. In support of the watershed planning process, Islands Trust has mapped the outlines of the upper and lower Cusheon watershed.

1(a) Action: CRD and Islands Trust should develop a set of maps of the Cusheon drinking watershed showing current land uses, zoning and development permit areas, covenants, ecosystem types, and locations of streams, wetlands and other riparian areas within the watershed boundary. All maps need to be compatible, so they can be overlaid.

Mapping and related databases should also include air photos of current status of riparian zones (e.g. state of vegetation and evidence of erosion.) These need to be deciphered and explained by an expert in interpreting aerial photos. In particular, the following items need to be identified.

- Location and type of any dams, barriers, or diversions in watercourses
- Location of buried, abandoned fuel tanks
- Location of man-made ditches
- Information on any existing covenants on riparian lands

The CRD Natural Areas Atlas shows the location of lakes and major streams, the topography within Cusheon Watershed and marks the boundary of the watershed. Islands Trust plotted the boundaries (see Figure 3). Note that Islands Trust maps fail to show many of the creeks.

1(b) Action: The CRD Atlas must be examined with a focus on pointing out difficult to map areas in the watershed. Afterwards, these areas must be "ground-truthed" within the physical boundary of the watershed.

Riparian area mapping is still incomplete for Salt Spring and there is no mapping at all of seasonal streams, even though these streams that flow into fish-bearing waters are now to be protected through the adoption of the new Provincial Riparian Areas Regulation. Much of the above information is not available at present, and obtaining it is a large undertaking, requiring a good deal of time by people examining maps, atlases, creeks and other sites. Identifying places where streams come into the three lakes in the Cusheon watershed, and following these creeks upstream during winter months when flows are occurring, could start the process of mapping within the watershed boundaries. Such maps are essential as database for planning and for protecting the drinking watershed.

1(c) Action: Islands Trust should use the watershed mapping described above as a basis for redefining watershed zoning within the OCP and land use bylaw designations. To ensure equity and consistency, it is important that these changes should apply to all properties within the drinking watershed at the same time, rather than on an individual or piecemeal basis.

1(d) Action: Determine desireable lake level objective and install new staff gauge.

OBJECTIVE 2: SURVEY PHOSPHORUS SOURCES IN THE CUSHEON BASIN.

2(a) Determine sources of phosphorus entering lake.

An analysis of phosphorus sources (i.e. phosphorus budget") has been developed from studies that took place while this management plan was being developed (Sprague 2006 a,b,c). These studies made use of a modelling approach based on direct measurements in tributary creeks and lakes during one year. These studies estimate the amounts and sources of phosphorus inputs to the lake. The information is adequate as a basis for pursuing watershed planning objectives and strategies that will help to reduce phosphorus in Cusheon Lake.

2(b) Determine phosphorus objective. The goal is to return the lake to a level of phosphorus measured at 13.5 parts per billion. A number of actions are recommended to reduce sources of phosphorus. The committee recommends that those actions should be pursued until the lake attains an average springtime concentration of 13.5 parts per billion of phosphorus. As described in section 2.3.5 and 2.3.8 of this plan, that measurement would represent approximately the historic level of nutrient in the lake.

To achieve that concentration, the total yearly input of phosphorus should be reduced by 15%. That would be a reduction of approximately 17 kg, from the existing load of about 117 kg to a recommended load of just under 100 kg. This could be achieved by a reduction in any one of the sources of phosphorus, or a combination of reductions in several of the sources.

OBJECTIVE 3: REDUCE INPUTS OF PHOSPHORUS FROM LAND MANAGEMENT ACTIVITIES

The phosphorus budget indicates that over fifty percent of phosphorus enters Cusheon Lake with runoff from the land. This can be reduced by protecting and increasing vegetated riparian and nonriparian areas, including forested land in the watershed. The benefits are:

- Vegetated riparian areas reduce runoff and promote infiltration into the ground;
- Soils are held in place and sediment is kept out of the watercourse;
- Any pollutants in the surface or sub-surface water tend to be stabilized and "filtered out;"
- In summer, leaves shade the water, thereby reducing heating, evaporation, light entering the water, and algal growth.

While riparian protection is the first priority in land use management for a watershed, the protection and restoration of vegetation cover elsewhere, especially in the so-called uplands, the type of vegetation cover has a profound effect on trophic status of local lakes. A basin that remains in its natural forested state usually contributes about half as much phosphorus to a watercourse, as does a mixed agricultural system of fields, pastures, and woods (Dillon et al. 1986; Hutchinson 2001).

3(a) Action: Islands Trust to establish or strengthen/extend Development Permit Areas (DPAs) for riparian areas in all land use designations.

Salt Spring Island's Land Use bylaws regulate location of buildings, septic systems and farm animal waste but in themselves do not ensure preservation of natural vegetation or prevent farm animals from contacting potable water sources. This need has been partly addressed by the designation of Development Permit Area 4 (see Figure 8), which prohibits clearing of any area larger than 9 square metres within 10 metres of identified watercourses in the Cusheon watershed (Blackburn Creek, Cusheon Creek, and the lake edges). However, the width of the DPA 4 on agricultural lands is only 3 metres.

The B.C. Ministry of the Environment (MOE) has developed new guidelines for Riparian Areas Regulation that require protective measures within 30 metres of fish-bearing lakes and streams. Local governments are expected to bring their bylaws up to the provincial standard. Local government may also decide to exceed provincial guidelines. All three lakes in the Cusheon system have fish and are covered by this new legislation. However, these guidelines do NOT apply to ALR land and current DPA on ALR should be strengthened.

Adopting the 30-metre "buffer area" would strengthen current riparian protection provided by Development Permit Area 4. The new guidelines would also apply to all watercourses, not just the ones currently covered by DPA 4.

3(b) Action: It should also be noted that there appears to be a flaw in DPA 4, which appears to allow in-filling/dumping of fill or diking in riparian areas. This obvious gap should be rectified immediately and wording clarified.

3(c) Action: Islands Trust should seek ways to improve the enforcement of, and education about, DPAs.

Development Permit Areas are not subject to ticketing. In addition to seeking ticketing authority from the province, Islands Trust should find other ways to make DPA offences have more serious consequences for offenders, for example:

- All DPA offences should result in environmental restoration guided by a specialist in the field of riparian restoration, expenses to be paid by landowner.
- Penalties for DP offences should also require covenanting the DPA in perpetuity. Covenants should include significant rent charges and these penalties should be indexed to inflation.
- Tree cutting bylaws that are ticketable should be applied within DPAs.

3(d) Action: Islands Trust, as the lead agency, should limit the number, kind, and size of docks allowed on shoreline properties by working on an agreement with Ministry of the Environment and Ministry of Agriculture and Lands, (MAL) Integrated Land Management Branch, to avoid soil disturbance and harm to riparian zones.

3(e) Action: Islands Trust and CRD should seek ways to improve the education of landowners about their responsibilities regarding DPAs.

Examples of such actions could include:

- All property owners within a DPA should immediately be provided with information about the importance and legal responsibilities regarding maintaining riparian vegetation.
- Any sale of a lot in a DP area should trigger a letter informing the new owner of the responsibilities related to the DPA.

3(f) Action: Protect and preserve the shoreline parcel of Crown land in its current undeveloped state.

The Crown land parcel D on the south side of Cusheon Lake, towards the westerly end, should be fully protected. It occupies 880 metres of shoreline and has been left undisturbed since the early 1950's when the Powell River Logging Company logged it. At present, it contributes less phosphorus to the lake than if the shoreline were opened up for use by people. However, even now there is a raised trail going through the woods that should be eliminated and allowed to grow over. In times of heavy rain, surface water is "dammed up" by the trail, and flows to the lake as a muddy liquid carrying a load of nutrient.

CRD Parks has agreed to seek transfer of the Cusheon Lake Crown parcel from the province and has compiled the necessary background information. The Islands Trust Fund has agreed to hold a conservation covenant to ensure that the management priority for the land is watershed management. Currently, CRD is waiting for resolution of the Hul'qumi'num treaty process before initiating the application process.

3(g) Action: Local government could designate the entire drinking watershed a Watershed Development Permit Area with a hierarchy of strictness so that activities potentially harmful to water can be regulated in a way that is less strict than in a DPA 4 but more strict than on land outside the drinking watershed.

This would require landowners to obtain a permit to carry out any extensive land use change. This would not prohibit such activities, but rather provide a process in which watershed management expertise could be used in helping the landowner choose how he or she will go about activities such as logging, ditch digging, altering stream flow, avoiding impermeable surfaces, etc.

3(h) Action: Islands Trust should work with Trust Council to develop an agreement with B.C. Hydro to regulate roadside tree cutting in the drinking watershed. B.C. Hydro prunes roadside trees carefully in Vancouver and Victoria but on Salt Spring applies "rural standards" and employs a damaging technique called "slashing."

3(i)Action: Islands Trust should create a tree-cutting bylaw effective inside DPA 4 (Lakes, streams and wetlands), DPA 6 (Unstable slope and soil erosion hazards) elsewhere in the drinking watershed.

3(j) Action: Island Trust should seek to create treed buffers between lots such as buffer zones regulated by bylaws on other Trust islands. Treed buffer zones would help slow and filter runoff within the drinking watershed. They will also connect groups of trees to each other and so will help to decrease blow-down and other problems associated with narrow strips of trees or lone trees. Tree cutting bylaws should be implemented within treed buffer zones.

3(k) Action: Local government should work to develop a Gulf Islands FireSmart manual that will fulfil the needs of fire safety while preserving riparian and uplands vegetation within the drinking watershed.

3(l) Action: Islands Trust should restrict soil disturbance by creating a soil removal and deposit bylaw that will regulate and reduce the disturbance of earth in the drinking watershed.

3(m) Action: Islands Trust, in the OCP and LUB, should outline best management practices for development that will reduce exposed earth and silt-laden runoff.

3(n) Action: Islands Trust should change the OCP and LUB, to prevent "up-zoning" within the drinking watershed even as part of an amenity zoning or density transfer proposal.

3(o) Action: Islands Trust, in the OCP and LUB, should institute a way of ending the right to subdivide land for a relative within the drinking watershed.

3(p) Action: Islands Trust should, in the OCP and LUB, uphold and strengthen Islands Trust Policy Statement 4.4.2 that states:

"Local Trust committees and Island Municipalities, shall, in their official community plans and regulatory bylaws, address measures that ensure:

- neither the density nor intensity of land use is increased in areas which are known to have a problem with the quality or quantity of the supply of freshwater,
- water quality is maintained, and
- existing, anticipated and seasonal demands for water are considered and allowed for."

3(q) Action: Islands Trust should disallow those types of home-based businesses that have the potential to pollute water, use large amounts of water or increase sewage effluent unless special measures are undertaken to conserve water, reduce runoff and entirely eliminate pollution. As well, septic tanks must be of sufficient size to meet maximum use. Business parking areas should be regulated and should not add impervious surfaces or reduce vegetation.

3(r) Action: Islands Trust, in the OCP and LUB, should reduce "site coverage" on lots. This means that site coverage (defined as roofed structures and paved areas) should be more strictly limited in the drinking watershed than presently permitted and Islands Trust should consider limiting maximum house size permitted.

3(s) Action: Islands Trust, within the agreement between MOT and Islands Trust, and by negotiation and agreement with the subdivision approval branch of the provincial government, should limit road width to reduce impervious surfaces in the drinking watershed.

3(t) Action: In cooperation with local farm groups, Islands Trust and CRD should promote awareness among farm owners of the importance of riparian areas and waste management regulations, and encourage farmers to follow the voluntary practices recommended by Agricultural Stewardship.

Special regulations are already included in the Salt Spring Island Land Use Bylaw No. 355 to address issues of water quality and some types of agricultural activity. These regulations require large confined livestock areas, manure-based mushroom cultivation and agricultural waste storage to maintain a minimum setback of 60 metres (200 ft.) from Blackburn Lake, Roberts Lake and Cusheon Lake, and 30 metres (100 ft.) from any other waterbody that drains into one of these lakes. Any collection sites should have a roof or tarpaulin to keep off rain, and should be surrounded by some sort of wall or barrier to prevent runoff of liquids.

If livestock are ranging across fields, they should be kept out of the riparian buffer zone of vegetation. The required distance for maintenance of undisturbed riparian area in agriculturally zoned lands is 3 metres, but this offers little protection and a greater distance would definitely be desirable.

3(u) Action: Document the incidence of commercial fertilization. A periodic recheck should be part of future activities. Understanding the side effects of using fertilizer should be part of stewardship education.

3(v) Action: Local government should work with local farmers' groups to cooperatively protect the drinking watershed by promoting watershed stewardship awareness.

The following activities should be supported:

- Distribute information on best farm practices,
- Complete farm management plans,
- Raise awareness of the Environmental Farm Planning program from Agriculture Canada, which helps landowners to look at their farm operations to see if they are environmentally sound. (It also provides a source of funds for improving the operations if necessary. Local contacts for this program are Sheri Neilson and Dave Tattum of the Farmer's Institute.)

OBJECTIVE 4. REDUCE INPUTS OF PHOSPHORUS FROM WATER MANAGEMENT ACTIVITIES (SEPTIC, STORMWATER.)

4(a) Action: Identify and repair faulty septic systems, particularly those within the drinking watershed and consider establishing a sewage collection and central treatment system.

It is not easy for homeowners to assess poorly functioning septic fields, particularly the nutrient escape. Unless there is surface pooling of liquid above the field, septic field owners will likely be unaware of any problem. The provincial Ministry of Health and Capital Health Region share jurisdiction, but their interest is in bacteria. There needs to be recognition that nutrient escape into lakes is also a health concern, since these nutrients contribute to the development of toxic cyanobacterial blooms. For nutrient input control, the most important fields to check are those within 100 metres of the shoreline or streams. There is no regular inspection program of existing systems. Rather, Vancouver Island Health Authority (VIHA) will respond to complaints. The CRD has committed to the implementation of a septic monitoring program. It is recommended that this program include the following elements:

- Strict inspection of new disposal facilities to ensure that they meet or exceed all aspects of the building code,
- Public information campaign on proper design, functioning, and use of septic systems,
- Regular pumping of septic tanks ,
- Investigate the feasibility of a septic effluent collection system and common treatment facility for residences around Cusheon Lake, particularly those between Cusheon Road and the lake,
- Establish protocol agreement between CRD Building Inspection, Islands Trust and VIHA, to ensure a 60-metre setback of septic fields from water courses,
- Consider establishment of incentives to assist property owners to upgrade their septic systems.

4(b) Action: Islands Trust and CRD should request an investigation by Ministry of Environment of potential leachate contamination of water sources associated with the former Blackburn garbage dump.

4(c) Action: Map and prevent removal of aquatic plants

Removal of aquatic plants, or macrophytes, and spreading them on gardens or farms would transfer nutrients, including phosphorus, from the lake to the land. Beds of submerged water plants do develop in Cusheon Lake; however harvesting is not recommended. The plants do not actually contain as much phosphorus as might be thought, and a large tonnage would have to be harvested to cause any appreciable lowering of phosphorus in the lake.

There is also a major question about the effects of stirring up sediments during the harvesting, with consequent dissolving of phosphorus from the sediment to the water. Even special boat-mounted harvesters would cause appreciable disruption of the shallow bottom of Cusheon Lake. Operating on foot would be very disruptive, creating suspended sediment and also destroying fish spawning habitat and the natural habitat of insects and other small creatures around the edges of the lake.

4(d) Action: Initiate a stormwater management program to minimize deleterious aspects of direct water runoff. Paved roads and other impervious areas (roof, patio, etc.) have an immediate and complete runoff. Any such area contributes towards “flashy” local creeks, i.e., they tend to flood, carry off runoff quickly, and then drop off to low flows. This is inherently bad for the plants and animals living in the waterways, but it also increases scouring, erosion, and the carriage of nutrients.

If there are pollutants such as oily substances on roads, household chemicals, or spills accumulated in ditches, the flashy runoff can carry them towards the nearest watercourse. There is a particular concern along Cusheon Lake Road which is very close to the lake. Spills and road runoff can accumulate in ditches. Cleaning out ditches during or just before the wet season will result in direct runoff of contaminated or muddy water.

Highways maintenance officials must recognize that if natural vegetation is retained in ditches, it is a good trap for silt. If natural vegetation must be removed, artificial “silt fences” can partially reduce transfer of sediment.

A stormwater management program should have several elements, listed below.

- The Islands Trust-MOT protocol agreement should be revised to define best management practices for amelioration of direct runoff from roads, including ditching practices, especially those related to roads in drinking watersheds.
- For existing roads that are close to watercourses (e.g., Cusheon Lake Road), there should be long-term planning of alternative routes for through traffic. These should be recorded in local and provincial government planning departments for automatic consideration when there is any thought of upgrading local road facilities.
- Local government agencies should encourage, in any new developments, drainage techniques that use infiltration, such as pits or ponds for groundwater recharge.
- Storm water drainage ditches should not have a “straight tube” construction, but rather have small pools and steps built in, to slow water flow. Allowing vegetation to grow in ditches also slows water and absorbs nutrients. These measures help to prevent the carrying of silt into receiving waters, and slower flow encourages ground water recharge.
- Storm water drainage ditches should not cross agricultural lands, where they might pick up nutrients from fertilizer or livestock waste. The culvert located near the junction of Lord Mikes Road and Cusheon Lake Road should be blocked by MOT to prevent the current discharge onto the ALR, A2 land. This stormwater should be allowed to continue its course in the ditch located on the north side of Cusheon Lake Road.

  The old broken concrete culvert east of Beddis Waterworks should be removed and the stormwater should be drained downstream through the new 20” culvert.

  The culvert at the junction of Stewart and Horel Road drains into the end of Cusheon Lake before the lakewater enters Cusheon Creek. This storm water carries large amounts of silt which can flow into the lake. The discharge of this culvert may be redirected directly into Cusheon Creek.
- Narrow roads should be constructed rather than wide ones to limit impervious surfaces.
- Roadside hedgerows should be preserved or restored.
- Install oil/sediment water separators in all culverts that discharge toward the lake.

4(e) Action: Islands Trust and CRD should seek registration of The Cusheon Watershed Management Plan with the Province. The B.C. Drinking Water Protection Act is designed to help protect drinking-water supplies. Under this Act, communities can seek to register Watershed Management Plans, if it can be shown that the Plan is needed to protect local drinking water supplies. If a plan is approved for registration, then the provisions of the plan essentially become legal requirements that supersede current bylaws. Registration would also add a layer of protection that would prevent loosening of local bylaws.

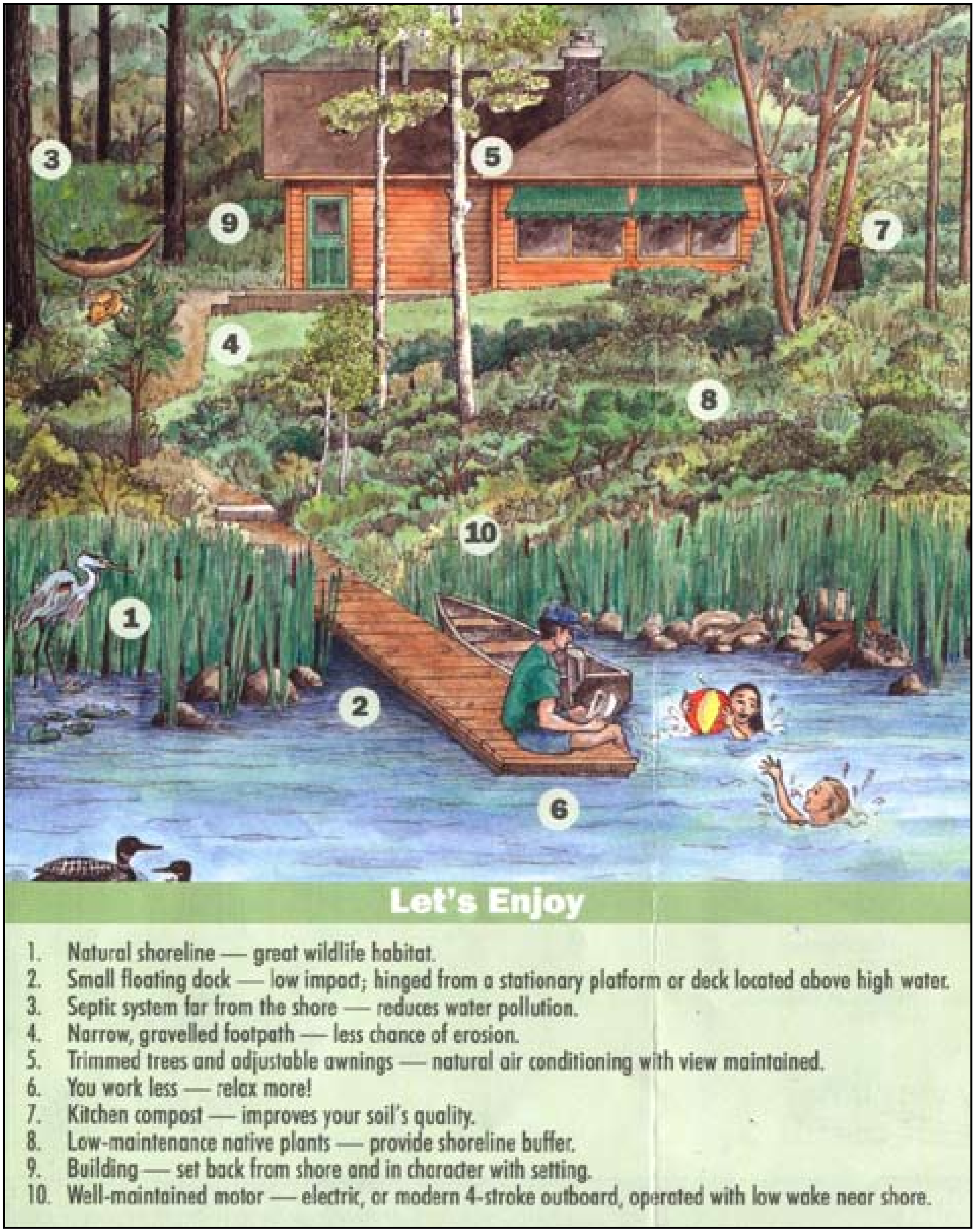
4(f) Action: Local government should initiate an ongoing “Awareness” program. The education program should include the following elements.

- Prepare and distribute an easily understandable brochure that summarizes the highlights of the Cusheon Watershed Management Plan to the community.
- Support Watershed Stewardship groups.

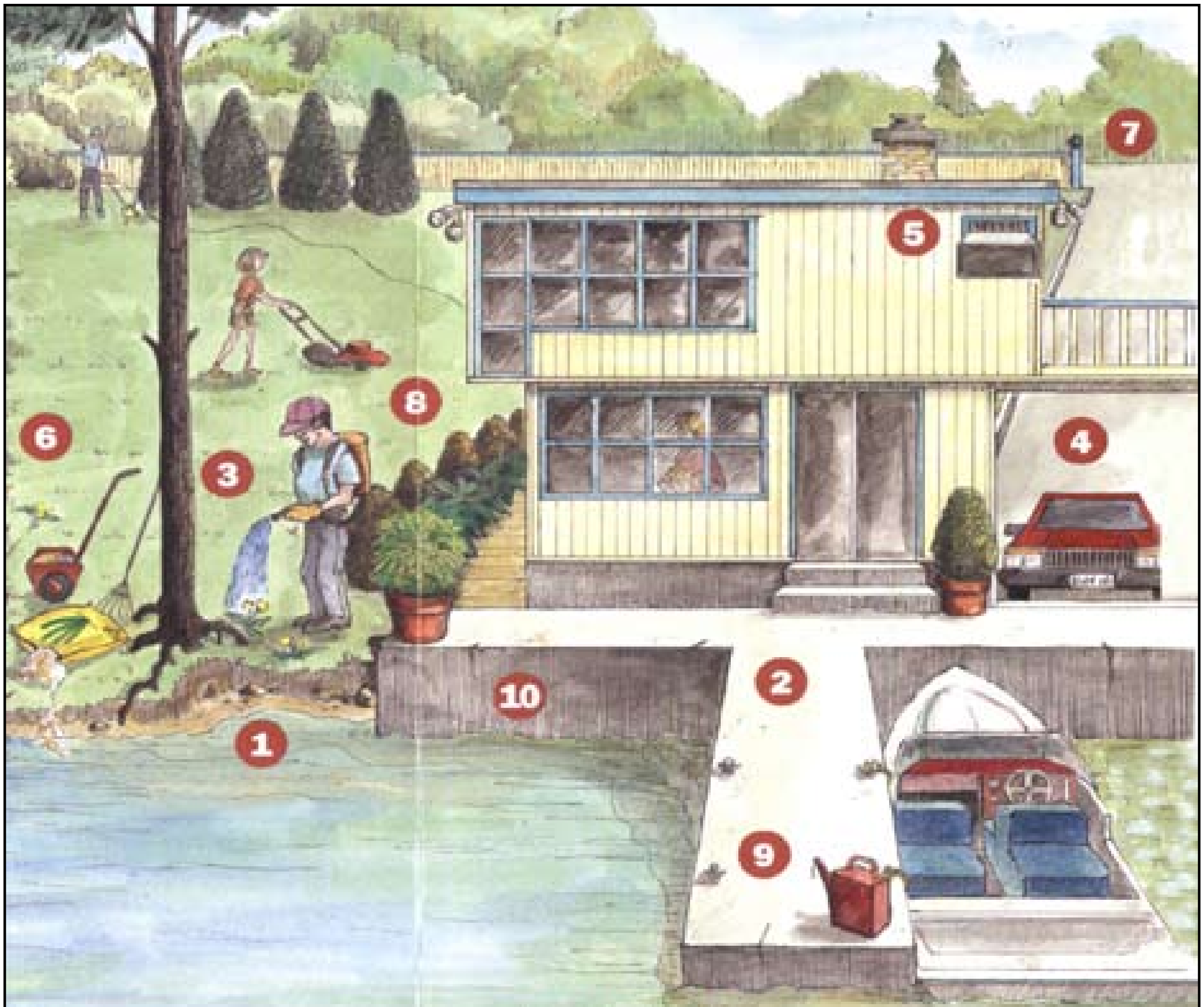
- Educate Islands Trustees and CRD planning and enforcement staff on water quality protection measures.
- Provide workshops and lectures co-sponsored by stewardship groups.
- Purchase and donate books on watershed protection to the library for community use.
- Provide Septic Savvy information on management of septic systems to all watershed residents.
- Create a “best practices” guide for builders and developers who will be carrying out their projects on lands within watersheds.
- Distribute watershed stewardship literature to new residents.
- Make watershed residents aware of the uses of protective covenants, including the Natural Areas Protection Tax Exemption Program (NAPTEP). This program provides up to a 65% reduction in total property taxes for owners who covenant natural areas on their land.

OBJECTIVE 5: MONITOR SPRINGTIME LEVELS OF PHOSPHORUS

5 Action: Monitoring springtime levels of phosphorus. The goal that should be reached to reduce or eliminate blooms of cyanobacteria and their toxins is a reduction of 15 percent from the present yearly load of phosphorus to the lake. The phosphorus objective is 13.5 ppb.



Figures 18A Illustration of how to protect a waterbody. Taken from EC and FOC (2001).



Let's Talk

1. Bare shoreline — subject to erosion which can be serious and affect your property value.
2. Solid dock — destroys wildlife habitat, alters currents, causes erosion elsewhere.
3. Fertilizer spills, chemical run-off and pet droppings — damage water quality.
4. Paved lane — pollution-laden runoff, including oil and antifreeze leaks from your car, flows to water.
5. No shade trees — overworked air conditioner adds to electric bill.
6. Removal of natural vegetation — more work for you and more runoff.
7. Collecting lawn clippings — deprives soil of nutrients; try mulching.
8. Ornamental shrubs — require chemicals and extra work.
9. Poor fuel management — gas and oil spills from cans, tanks and leaky boat motors are deadly.
10. Hardened shoreline — eliminates "natural filter", degrades water quality and blocks wildlife access

Figure 18B Illustration of how NOT to protect a water body. Taken from EC and FOC (2001).

Table 9. Summary Table: Priorities for the various activities proposed under this management plan.

Action to be carried out	Lead group / Funding	Timing
1 (a) Develop maps of Cusheon Lake watershed with current land use & other key features.	CRD & Islands Trust	2007
1 (b) Ground truth watershed mapping.	CRD & Islands Trust	Ongoing
1 (c) These maps should be used to redefine the drinking watershed in terms of OCP, LUB & zoning designations	Islands Trust	2007 **OCP Review**
1 (d) Determine lake level objective and install new staff gauge.	CRD, MOE, Islands Trust, DFO/Salmon Enhancement	2007
2 (a) Determine sources of phosphorus entering Cusheon Lake.	CWMP Steering Ctte.	Completed: Sprague 2006, a, b, c.*
2 (b) Determine phosphorus objective	Steering Ctte.	Completed: 2007
3 (a,l) Strengthen development permit areas, & soil removal bylaws on all lands within drinking watershed	Islands Trust	2007-2008 Soil Bylaw process & **OCP Review***
3 (b) Eliminate any flaw in Development Permit Area 4 related to infill/dumping of soils in streams & lakes.	Islands Trust	2007 **OCP Review**
3 (c, i) Improve enforcement & education about DPAs.	Islands Trust	2008 **OCP Review***
3 (d) Limit docks on shoreline properties	Islands Trust, MOE, MAL	2008 **OCP Review**
3 (e) Educate landowners and contractors about DPA responsibilities.	Islands Trust & CRD	2008 Ongoing
3 (f) Transfer treed shoreline Crown parcel D to CRD Parks.	CRD Parks & Islands Trust Fund	2007-08 (Awaiting FN treaty resolution)
3 (g) Designate entire Cusheon watershed as a DPA.	Islands Trust	2008 **OCP Review**
3 (h) Develop regulations & protocol agreement for roadside tree cutting in watershed areas.	Islands Trust, BC Hydro & MOT	2008
3 (i,j) Create treed buffer zones & tree cutting bylaw.	Islands Trust	2008 **OCP Review**
3 (k) Develop Gulf Islands Fire Smart manual featuring watershed protection as well as fire safety.	CRD, Islands Trust & SSI Fire District	2008
3 (m) Outline best management practices for development in watershed. See BMP.	Islands Trust, CRD	2008 **OCP Review**
3 (n) Change OCP, LUB & Trust Policy to ensure no "up-zoning" in drinking watersheds.	Islands Trust	2008 **OCP Review**
3 (o) Implement policy to disallow subdivision of land for relatives within the watershed.	Islands Trust	2008 **OCP Review**

3 (p) Strengthen Trust Policy Statement 4.4.2	Islands Trust	2008
3 (q) Within watershed, disallow home-based businesses with significant water pollution potential.	Islands Trust	2008 **OCP Review**
3 (r) Reduce lot site coverage in watersheds.	Islands Trust	2008 **OCP Review**
3 (s) Investigate route alternatives & limit road width (impervious surfaces) in watershed.	Islands Trust, CRD & MOT	2007
3 (t,v) Encourage farm owners to follow Agricultural stewardship practices & promote awareness of watershed protection.	Islands Trust, CRD Farm Stewardship Groups	Ongoing
3 (u) Document use of fertilizers & educate landowners regarding need to reduce or eliminate.	Islands Trust, CRD	Ongoing
4 (a) Inspect, monitor & remedy faulty septic systems in watershed, particularly those near riparian areas.	CRD, VIHA	2007 *
4 (b) Investigate potential water source contamination from former Blackburn garbage dump leachate.	Islands Trust, CRD & Ministry of Environment	2007
4 (c) Map aquatic plants and prevent their removal.	MOE	2007
4 (d) Ensure best management practices for storm water management on public roads in watershed as part of Islands Trust / MOT protocol agreement & maintenance contract .	Islands Trust, CRD & MOT	2007
4 (e) Seek registration of the Plan under BC Drinking Water Protection Act legislation.	Islands Trust, CRD, VIHA, MOE	2008
4 (f) Watershed Awareness Program for entire community.	Islands Trust, CRD, Stewardship Groups.	Ongoing
5 Monitoring springtime levels of phosphorus	MOE	Ongoing

NOTE: ALL ACTIONS ARE HIGH PRIORITY. THE 4 MOST URGENT ONES HAVE BEEN STARRED.

The numbering of the actions above is related to the five objectives:
1. Define and map Cusheon's watershed
2. Undertake a scientific analysis of phosophorus sources.
3. Reduce inputs of phosphorus from land management activities.
4. Reduce inputs of phosphorus from water management activities.
5. Monitor springtime levels of phosphorus.

MEASUREMENT OF SUCCESS: If the recommended actions are followed, the measurement of success would be a lower concentration of phosphorus in Cusheon Lake. This should be measured yearly. To reduce or eliminate cyanobacterial blooms and their toxins, the target level of springtime phosphorus that must be reached is 13.5 parts per billion (ppb). This requires a 15% reduction in the phosphorus load, from 117 kg to 100 kg.

PART C. IMPLEMENTATION

3. Priorities for Implementation

Diverse actions were identified in Part B.. Now they need to be implemented. Priorities and timing need to be assigned by local government.

3.1 Priorities of actions

A summary of the priorities perceived by the committee is shown in Table 9. During discussions, top priorities generally agreed on are:

1) Implementation of the most effective reductions of phosphorus inputs now that the study of inputs has identified them.

2) Strenghten development permit areas (DPAs) & community understanding of regulations plus enforcement.

3) Evaluation and improvement of septic systems within 100 metres of the shoreline and major streams. All areas identified in the plan are important if the drinking-water supply is to be truly protected.

PART D. EVALUATION

Assessing Activities and Results

Local government, along with stewardship groups, should ensure continuing consultation and evaluation, with checks on progress and beneficial effects. Local government and the Cusheon Lake Stewardship Committee should issue a report on “Health of the Watershed” every three to five years. This should be given to all participants in the planning process, and should coincide with public consultation.

Progress of groups

Local government must take the initiative to check on progress. Quarterly meetings should include all participating groups. Some formal record of progress should be kept. A simple synoptic report sheet might be used, with columns for activity, the lead group, and status of the task (an example is in the Millstream plan (Saanich Planning Department, 2001).

Monitoring water quality

Some monitoring of aquatic conditions must be made to assess whether improvements are taking place, possibly over decades. The most meaningful variable would be total phosphorus concentration at spring overturn. Ideally, this would be done at several locations and depths to check on uniformity. (See Actions 2(b) and 5(a).)

The spring overturn samples have been carried out in recent years by the Stewardship Program, and Ministry of the Environment, Nanaimo. Continuing that program is important, and would meet the needs of annual monitoring of phosphorus. The Cusheon Lake Stewardship Committee has been monitoring Secchi depth, dissolved oxygen, temperature profile and lake level and in the warm season it is highly desirable for that testing to continue.

The Cusheon Lake Stewardship Committee should resist “busy-work” schedules for a list of other measurements. A variable should only be measured if it would answer a particular important question. Haphazard programs to “collect data” on a lake are usually fruitless and a waste of effort. Interest in the remedial program will dwindle if efforts are diverted to activities of questionable value.

Achievement of objective

Monitoring will show that the actions taken in the watershed have been successful when the average springtime phosphorus concentration is lowered from its current average of 16.7 parts per billion to the recommended concentration of 13.5 ppb (the estimated average historic level, see section 2.3.8). This lower concentration would have to be evident over a number of years, because the lake is quite variable from year to year (see Figure 15).

PART E. CONCLUSION

The Cusheon Watershed Management Plan is the result of over three years of work by the Cusheon Watershed Management Plan Steering Committee, consisting of volunteer scientists, local residents and other volunteers. It is the first such management plan on Salt Spring Island. This work was prompted by urgent community concern about the ongoing problem of cyanobacterial “blooms” in a lake that is the source of drinking-water for over 200 households. Some cyanobacteria produce toxins harmful to the brain and liver and these toxins have been found in Cusheon Lake. There is evidence that such toxins may be stored in body tissues, so levels increase with exposure. High levels in water can be instantly fatal. One sign of cyanobacteria in a lake is dead animals around the shoreline.

The governing factor for algal blooms is the supply of phosphorus. If the supply is reduced, blooms decrease. That is why a phosphorus budget was prepared that estimated the sources of phosphorus entering Cusheon Lake. Background reports on the budget have been written that detail the testing and results of the scientific research.

This Plan is a final document that must stand as written. In future, if additional aspects of water protection are explored by other individuals or groups, separate documents should be produced.

After the scientific findings were clear, the Steering Committee made specific recommendations that, if implemented, would reduce the amount of phosphorus polluting Cusheon Lake. The Committee recommends as a goal, that the average springtime concentration of phosphorus in the lake should be lowered to 13.5 parts per billion, which approximates the historic natural level. To achieve that requires a 15% reduction in the annual phosphorus load, from 117 kg to 100 kg. It should be noted that ideally, a watershed surrounding a lake or reservoir should be kept in a natural state to protect the surface water by filtering runoff.

Cities do not generally have people living in the watersheds of their drinking water reservoirs; however, rural areas only have surface water protection supplied by zoning and bylaws. This is one reason why Canadian studies have found that water quality in rural areas is inferior to that in cities. For the Cusheon watershed, it’s crucial that local government implement protection for surface water in order to mitigate the effects of development.

It is also important that our community education process should enhance local knowledge about ways to protect surface water on Salt Spring so that the depth of community spirit here will be activated to protect our drinking-water. Without implementation, community education and cooperation this plan will remain a mere document. The next step is up to government and Salt Spring Islanders.

Glossary

Definitions in the glossary are for the purposes of this management plan, and might not be suitable for other situations. Definitions have been expanded to include some explanations.

(An) Action is the means by which an *objective* is met. Something is to be done, to carry out the action. An action should be accompanied by a timeline, a designated person or organization, and an estimate of resources required for implementation.

ALR is Agricultural Land Reserve, signifying land that is officially designated for farming by the government of British Columbia and subject to specific regulations.

Biodiversity concerns the variety, distribution, and relative abundance of different plants, animals, and microorganisms. It also embraces the ecological processes and functions that they carry out.

Blue-green algae see cyanobacteria.

(A) community, in a biological sense, is a fairly uniform assemblage of organisms in a particular place. It would usually be most recognizable by the type of vegetation, e.g. a grassland community, or a Douglas-fir forest. A community could be quite small, such as an assembly of mosses and ferns on a damp rocky wall, but would often be hectares in size or many square kilometres. “Community” is the technical term that should be substituted for “ecosystem” in most popular writing.

Cyanobacteria is the name of a group of bacteria that has the ability to carry out photosynthesis, which is why they are often incorrectly called *blue-green algae.* They appear similar to algae, having photosynthetic pigments. Unlike algae, many species have the ability to fix nitrogen, and so they become the most common species when nitrogen is relatively scarce, compared to phosphorus..

Ecosystem describes the living organisms of a particular area, plus the non-living components of substrate, medium, and source of energy (usually the sun). The term implies that this ecological system is, to some extent, defined by boundaries which separate it from adjacent ecological systems. It is difficult to specify any particular size for an ecosystem, but the word loses its meaning when it is applied to every puddle or every patch of bushes. Salt Spring Island including its shorelines would be a good example of an ecosystem since it has a variety of interacting communities and a defined boundary. The most common misuse of the word ecosystem is to apply it when the proper term would be *community* (q.v.).

Eutrophication is a process by which a lake becomes enriched. It is caused by a large input of nutrients; a *eutrophic* lake is enriched. It will have algal blooms, either light or heavy depending on the degree of enrichment. The opposite situation is an *oligotrophic* lake, meaning one that has low levels of nutrient in the water. A classic oligotrophic lake would be cold, deep, with clear water and usually with an undisturbed watershed with poor soils. A *mesotrophic* lake is in a condition between the other two.

Goal is a general idea or thing that one wishes to accomplish. It deals with a major topic of concern. It might be somewhat philosophical in nature, rather than a particular thing that can be measured. A goal might have several subsidiary *objectives*.

Hectare (ha) is a standard unit of area, 100 metres by 100 metres, or about the size of two football fields. There are 100 hectares in one square kilometre. A hectare equals 2.47 acres.

Limnology is the scientific study of fresh waters, the functioning of waterbodies, and their flora and fauna.

Mesotrophic, see *eutrophication*.

Monitoring is a measurement or set of measurements, repeated over time, to see if an *action* was successful in accomplishing the *objective*. A monitoring procedure should be built into the implementation section of a management plan.

Nutrients, for purposes of this plan, are the inorganic chemicals that are used by plants to build their tissues. Examples are phosphorus, nitrogen, calcium, and iron.

Objective is a particular thing that one desires to accomplish. It is more specific than a *goal*, which could encompass several specific objectives. Each objective contributes towards achieving the goal. Objectives can be met by *actions*. There should be clear methods to decide whether the objective has been accomplished.

Oligotrophic, see *eutrophication*.

Phosphorus is a chemical element, a nutrient required by all of the usual living organisms. It is usually in short supply, and available phosphorus is taken up quickly by organisms. In lakes, it is almost always the nutrient that is in shortest supply; growth of algae is usually limited by the amount of phosphorus, no matter how much of the other nutrients are available. "Phosphorus" is used as a general term to include all chemical forms of the element. It is likely to be present in the form of salts such as phosphates, or bound to silt or organic matter. Elemental phosphorus will not be found in water because it is violently reactive.

Photosynthesis is the process by which green plants (including algae) manufacture their food. During the process, the plants take up carbon dioxide and produce an excess of oxygen. The process is powered by sunlight, and shuts down at night. The plants respire continually, and at night they switch to being net consumers of oxygen and producers of carbon dioxide. If the plants are growing, the overall balance is net storage of carbon and net production of oxygen.

Riparian zone (or area) is, simply speaking, the extended bank of a river or creek. It includes the land immediately adjacent to a stream or other body of water, which has direct influences on the creek because the land slopes towards it. The riparian zone often has vegetation that shades the creek, contributes leaf litter, governs the speed of runoff, and otherwise influences the nature of the creek or the quality of the water in it. No fixed width can be assigned the riparian zone because it is governed by the particular topography at the site. A width of the riparian zone is protected by local and provincial governments (see DPA4 and Riparian Areas Regulation (RAR).

Secchi disc is a flat circle of metal painted black and white in quarters. It is lowered into a lake until it just disappears. That depth is the reading, and indicates (mainly) the amount of suspended matter in the water, including algal cells.

Sensitive habitat is often used to signify a small area of natural land/water and vegetation that is thought to be particularly productive and important for certain species, especially rare or endangered species. The term is generally avoided in this plan since all natural habitats are sensitive to human activity in one way or another, and the interlocking nature of ecological functions make entire wide communities important for organisms.

Toxin is a poison manufactured by an organism. Usually the poison is an organic compound, sometimes extremely potent. Some cyanobacteria produce toxins. The word should not be applied to toxicants which are not produced by organisms, but it is frequently used that way in the popular media, to the point that its technical meaning has been almost destroyed.

Trophic refers to nutritional status (from the Greek word for nourishment or food). In lakes, trophic state refers to the level of nutrients present in the water.

Watercourse is (a) a river, stream, creek, waterway, lagoon, lake, spring, swamp, marsh or other natural body of fresh water, or (b) a canal, ditch, reservoir or similar surface feature created by humans, (c) in which water flows constantly, intermittently, or at any time. [Modified from Saanich bylaw no. 7502]

Watershed has two meanings. One meaning is the height of land which divides the flow of surface water so that it splits towards two separate drainage basins. The other common usage, as in this document, is synonymous with drainage basin and signifies all the area of land which drains water into a particular stream or lake. All land areas are part of one watershed or other. In the local Islands Trust zoning categories, "Watershed" has a particular meaning. It refers to a restricted area specially designated for protection, normally for protection of drinking-water supplies. Only part of Cusheon watershed would be designated as "Watershed" by Islands Trust.

Wetlands are low-lying areas of standing shallow water or very wet soil. They usually grow a profuse cover of distinctive plants such as water lilies, rushes, cattails, tall grasses, or other plants which have their roots below water or in wet soil, and their upper portions emergent into the air. The dense vegetation provides habitats for a diversity of specialized insect, mammal, and bird life.

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Appendices

Appendix 1. History of events including public participation

The problem of algal blooms

Mild blooms have probably occurred for decades, but there is no documentation of how long they have been occurring. In 1999 there was a bloom of cyanobacteria in Cusheon Lake, which caused a drinking-water crisis (see Appendix 3).

Cusheon Lake Stewardship Committee

A group of concerned citizens who live around Cusheon Lake, plus representatives from Beddis Water Works and Salmon Enhancement Society, started the management plan process. They had support from Dr. Rick Nordin and Deb Epps of the Ministry of Water, Land and Air Protection, and from Michael Riefman, Regional Environmental Health Officer, Environmental Health Office, Vancouver Island Health Authority.

In 2001, the Stewardship Committee asked Dr. Nordin to apply for a "map reserve" for a section of crown land on the shore of Cusheon Lake (Parcel D, southwest quarter of district lot 86). A map reserve means that a provincial ministry witholds crown land from disposition, and this is formally recorded by the goverment (Section 12 of the Land Act). However, a map reserve had already existed, but had been changed to a Notation of Interest (No. 901028 of file #0327064). A Notation of Interest means that a reference map of one provincial ministry records an interest in Crown land by another provincial agency. In 2003, Deb Epps of MOE obtained a much later expiry date: Dec. 31, 9999. The rationale was protection of water quality. Notation of Interest- Extended Term means a recording on Ministry reference maps of an interest in Crown land by another provincial ministry or agency, which requires long term or continuous consideration. The maximum term for a notation of this kind is 5 years.

Goals of the Cusheon Lake Stewardship Committee

1. To develop a public awareness of how each individual's actions can affect the watershed and to explain how each has a role in caring for and protecting the watershed and to facilitate an on-going flow of information to residents.
2. To improve the quality of water for drinking and recreational use.
3. To have the Capital Health Region take actions to ensure that all sewage disposal systems in Cusheon watershed are adequate to prevent both the discharges of sewage and/or nutrient rich leachate into Cusheon Lake.
4. To encourage preparation of a Lake Management Plan for Cusheon Lake.
5. To facilitate communication between agencies and all stakeholders about steps to be taken in protecting the watershed and their part in developing and implementing a Water Management Plan.

Public input

The first Public Information Meeting was on Thursday, October 14, 1999, 7:00 pm, at the Canadian Legion, Meaden Hall. A discussion panel was present, consisting of:

- Linda Adams – Chief Administrative Officer, Islands Trust
- Christine Bender -- Health Impact Consultant, Capital Health Region
- Norm Bennett -- Ministry of Transportation and Highways, Area Manager, Gulf Islands
- John Bodnarchuck -- Ministry of Transportation and Highways, District Highways Manager
- Robert Bradbury -- Chief Environmental Health Officer, Capital Health Region
- Wayne Hewitt -- Cusheon Lake Stewardship Committee, Chairman
- Dr. Rick Nordin -- Ministry of Environment, Water Management Division, Senior Limnologist
- Michael Riefman -- Regional Environmental Health Officer, Capital Health Region
- Dr. John Sprague -- Consulting Biologist

The bloomers

This ad hoc group worked towards a management plan in March to May of 2001 and then merged with the Cusheon Lake Stewardship Committee.

Process Meeting
The Cusheon Lake Stewardship Committee recognized that any management plan could not be successful without full support of those who live in the watershed. The first process meeting for the management plan was held in June, 2001 to obtain endorsement from local and provincial government representatives.

Cusheon Watershed Management Plan Steering Committee
An organizational meeting was held on Jan 23, 2003, at the request of Wayne Hewitt of the Cusheon Lake Stewardship Committee, with the support of the provincial government through Deborah Epps, representing the Ministry of Water, Land and Air Protection. The adopted goal was to develop management directions and actions for protection and restoration of the lake and watershed. The committee intended to promote partnerships of governments, community groups, landowners and other interested parties.

In March of 2003, it formed three sub-committees: membership, fund-raising, technical. The initial task of the technical group was to produce a working draft of this management plan.

After the plan had undergone considerable development in committee, it was presented at public meetings in August and November, 2004. The Cusheon Watershed Management Plan recommendations were presented in December, 2006 to the Local Islands Trust Committee.

Studies by provincial and university scientists
There have been samples taken for chemical analysis, and significant scientific studies of conditions in Cusheon Lake as early as 1974 (Goddard 1976, MWLAP 2003). Further monitoring of chemical conditions occurred sporadically since then with results summarized up to 1999 (Holms 1999), as a data-record (MWLAP 2003) and summarized to 2003 by McPherson (2004). A companion to the present report summarized phosphorus results to 2006 and estimated the sources of nutrient loading to the lake (Sprague 2006a). Useful information from these studies formed part of this management plan

Appendix 2. Measurement units and conversion factors

Metric	Imperial
One metre (m)	3.28 feet
One square metre (m^2)	10.8 square feet
One hectare (ha)	2.47 acres (One hectare is 100 metres by 100 metres, or the size of two football fields. 100 hectares = one square kilometre.)
One cubic metre (m^3)	35.3 cubic feet or 1.3 cubic yards
One thousand m^3	1.23 acre-feet
One litre (L)	0.220 Imperial gallons (One cubic metre = 1000 litres)
One kilogram (kg)	2.205 pounds (One tonne = 1000 kg)
Concentrations	• One part per million (ppm), in the context of lakes and streams, usually means one part of chemical by weight, dissolved into a million parts of water by weight or volume. The standard scientific term (in a liquid) would be milligrams per litre, but ppm is used for convenience. • One part per billion (ppb) has a similar meaning, except it is a thousand times more dilute, that is, one part of chemical dissolved in a billion parts of water, or one milligram in a thousand litres. The scientific term would be one microgram per litre.

One kilogram per hectare (kg/ha) is used in this report to describe the amount of phosphorus coming off the land in a year. One kg/ha would equal 0.1 grams per square metre (gm/m^2), a unit used for the same purpose in scientific reports.

Appendix 3. B.C. Ministry of Environment Riparian Areas Regulation, 2005

http://www.env.gov.bc.ca/habitat/fish_protection_act/riparian/riparian_areas.html

Protecting riparian fish habitat, while facilitating urban development that exhibits high standards of environmental stewardship, is a priority for the Government of British Columbia. Good quality urban streamside habitat is essential for ensuring healthy fish populations.

An alternate model for urban riparian management has been developed that satisfies the statutory obligations of the federal Fisheries Act, provides certainty and flexibility to urban land owners and developers, and is not dependent on local, provincial and federal government resources.

Many local governments have shown strong leadership in managing riparian areas. To reinforce this work, the Province is providing a consistent approach to addressing the potential impact of residential, commercial, and industrial activities on riparian fish habitat.

In developing this new regulation, the Ministry of Environment has worked in collaboration with the Union of British Columbia Municipalities and the Department of Fisheries and Oceans.

The Riparian Areas Regulation (RAR), enacted under Section 12 of the Fish Protection Act in July 2004, calls on local governments by March 31, 2005 to protect Riparian Areas during residential, commercial, and industrial development by ensuring that proposed activities are subject to a science based assessment conducted by a Qualified Environmental Professional.

Some local governments are ready to use the RAR, some are not. A further extension order has been issued for those local governments needing extra time, to ensure the orderly and efficient implementation of the regulation.

The purpose of the Regulation is to provide protection for the features, functions and conditions that are vital in the natural maintenance of stream health and productivity. These vital features, functions and streamside area conditions are numerous and varied and include such things as sources of large organic debris (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 runoff pollution.

The Riparian Areas Regulation model uses Qualified Environmental Professionals, hired by land developers, to assess habitat and the potential impacts, develop mitigation measures and avoid impacts of development to fish and fish habitat, particularly riparian habitat. This shifts the cost of assessing developments to the land developer, allowing governments to focus on monitoring and enforcement within their respective jurisdictions. By conscientiously following the assessment procedure set out in the Regulation, the Qualified Environmental Professional and the land developer will have applied due diligence in avoiding a harmful alteration, disruption or destruction (HADD) of riparian fish habitat. In the event that a HADD cannot be avoided, an application for an authorization, including compensation, must be submitted to Fisheries and Oceans Canada.

The assessment methods attached as a schedule to the regulation are a key component of a regulatory regime for riparian protection that is clear and measurable, but does not rely exclusively on default set backs. The assessment is based on the best available science with respect to riparian habitats.

The assessment methodology provides clear direction to Qualified Environmental Professionals on how to assess impacts, how to determine setbacks based on site conditions, and what measures need to be employed to maintain the integrity of the setbacks. Qualified Environmental Professionals, for the purpose of this regulation, will have to certify they have the qualifications, experience and skills necessary to conduct the assessment. The assessment will form the content of notifications by development proponents to regulatory agencies. The Ministry of Environment will provide local governments confirmation of notifications, enabling them to move forward in approving urban developments without taking on liability for reviewing and approving riparian setbacks.

To increase the accountability of the Qualified Environmental Professional and to permit compliance monitoring, the assessment methodology will yield outcomes that are measurable, repeatable, and independent of observer. The assessment methodology will also enable effectiveness in monitoring to be undertaken to determine whether impacts from urban development on riparian habitats are being fully avoided when the assessment methodology is used correctly.

The Riparian Areas Regulation will apply only to local governments located on the east side of Vancouver Island, the Lower Mainland and the Southern Interior, as these are the parts of the province that are experiencing the most rapid urban growth. This includes the following regional districts and all municipalities within them: Capital, Central Okanagan, Columbia-Shuswap, Comox-Strathcona, Cowichan Valley, Fraser Valley, Greater Vancouver (except the City of Vancouver), Nanaimo, North Okanagan, Okanagan-Similkameen, Powell River, Squamish-Lillooet, Sunshine Coast, Thompson-Nicola and the trust area under the *Islands Trust Act*.

The regulation does not apply to agriculture, mining or forestry-related land uses. Riparian protection for these activities are provided by other initiatives.

Appendix 4. Bird species found near Cusheon Lake

Compiled by Dr. Bob Weeden, biologist.

"Almost certain"

Pied-billed grebe
Great blue heron
Canada goose
Wood duck
Mallard duck
American wigeon
Barrows goldeneye
Bufflehead
Hooded merganser
Bald eagle
Sharp-shinned hawk
Cooper's hawk
Red-tailed hawk
Merlin
Ruffed grouse
California quail
Killdeer
Rufous hummingbird
Belted kingfisher
Red-breasted sapsucker
Downy woodpecker
Hairy woodpecker
Northern flicker
Pacific-slope flycatcher
Violet-green swallow
Barn swallow
Steller's jay
Common raven
Chestnut-backed chickadee

"Likely"

Green-winged teal
Ring-necked duck
Lesser scaup
Common goldeneye
Common merganser
Peregrine falcon
Osprey
Virginia rail
American coot
Common snipe
Mew gull
Glaucous-winged gull
Band-tailed pigeon
Great-horned owl
Barred owl
Screech owl
Common nighthawk
Olive-sided flycatcher
Tree swallow
Rough-winged swallow
Northwestern crow
House wren
McGillivray's warbler
Chipping sparrow
Savannah sparrow
Brewer's blackbird
Brown-headed cowbird
Evening grosbeak

Appendix 5. Announcements of 1999 cyanobacteria bloom

- The official announcement is reproduced below.
- The second page is an additional communiqué distributed to residents, giving details about the dangers of cyanobacteria.
- The third page shows test results for Microcystin-LR , one of many toxins that may be produced by cyanobacteria in Cusheon Lake.

Capital Health Region
Building Partnerships for Better Health

NEWS RELEASE

FOR IMMEDIATE RELEASE – SEPTEMBER 10, 1999

Cusheon Lake Precautionary Health Notice

Victoria – Dr. Richard Stanwick, Medical Health Officer of the Capital Health Region has issued a precautionary health notice as a result of an overgrowth of algae in Cusheon Lake. An algae overgrowth can make the water unpalatable and, depending on the algae present, can present a health hazard to people and animals who consume it.

As a precaution, until the algae can be identified, individuals who rely on Cusheon Lake water as their source of drinking water and for personal purposes are advised to use alternative sources of water. Pending completion of the testing of the water samples, the Medical Health Officer recommends alternate sources of water be used for drinking, brushing teeth, washing dishes, washing clothes and bathing. Pet owners are advised to take similar precautions when caring for their animals. Boiling the water is not recommended at this time as it may not be an effective control measure.

The Capital Health Region collected samples of lake water on September 9, 1999 in order to identify the algae involved. The results of that identification should be complete by early next week. Additional samples will be taken by the Ministry of Environment staff with assistance from the Lake Stewardship citizen's group on Monday, September 13, 1999.

The attached information bulletin from Health Canada describes blue-green algae, the species which is of greatest health concern and for which testing is being performed.

CUSHEON LAKE WATER HEALTH NOTICES 1999

Sept 10, 1999 CRD Health Region Precautionary Health Notice

Due to an overgrowth of algae, Dr. Richard Stanwick, issued an order that water must not be used for drinking, brushing teeth, washing dishes, washing clothes or bathing.

An attached information bulletin from the B.C. Ministry of Health described the risks of blue-green algae, the "species which is of greatest health concern."
The attachment states, **"blue-green algae are not true algae, they are really bacteria, called *cyanobacteria*.** They usually occur only in small numbers and are so small they are invisible to the casual observer."
When numbers increase (a "bloom") they became visible.

Strains of blue-green algae produce two types of toxins: 1. neurotoxins (affecting the nervous and respiratory systems---after ingestion death may occur in 30 minutes) --**2.hepato-toxins** (affecting the liver –after ingestion, death may occur slowly, in approx 36 hours.) The attachment goes on to state, "Some blue-green algae blooms are more toxic than others, so **all** blooms should be treated with caution."

Sept 14, 1999 CRD Health Region Precautionary Notice continues—Blue-green algae species identified.

Due to the need for further testing, the ban on water use was continued and people were warned that **"toxins produced by blue-green algae are NOT eliminated by boiling the water."**

Sept 27, 1999-Cusheon Lake Precautionary Notice lifted.

Samples were negative for toxicity although the algae bloom may cause taste and odour problems.

Test results for Microcystin-LR

The data below are the results of testing for Microcystin-LR in Cusheon Lake, by the Vancouver Island Health Authority. The results are in micrograms per litre. The standard for Microcystin-LR in the Guidelines for Canadian Drinking-water Quality is 1.5 micrograms per litre.

Date	Result
Sept 14/99	<0.3
Sept 21/99	<0.3
Nov 02/99	<0.3
Nov 30/99	<0.3
Feb 03/00	<0.3
Apr 13/00	<0.3
June 12/00	<0.2
June 27/00	<0.2
July 13/00	<0.2
July 25/00	<0.2
Aug 15/00	<0.2
Aug 29/00	<0.2
Sept 5/00	<0.2
Sept 21/00	<0.2
Oct 5/00	<0.2
July 12/01	<.0.3
Aug 02/01	<0.3
Aug 30/02	0.045
Sept 11/02	ND[7]
Sept 25/02	ND
Sept 04/03	ND
Sept 24/03	0.96
Sept 30/03	ND
Oct 07/03	ND

Michael Riefman, Regional Environmental Health Officer
Environmental Health Office
Vancouver Island Health Authority
B (250)544-2426
F (250)544-2425

7 ND- None Detected

Appendix 6. Health Canada information on cyanobacteria

(Note: this information is updated periodically at Health Canada's website: **www.hc-sc.gc.ca/waterquality**)

What are cyanobacteria?

Cyanobacteria is the scientific name for blue-green algae, or "pond scum." The first recognized species were blue-green in colour, which is how the algae got their name. Species identified since range in colour from olive-green to red.

Cyanobacteria form in shallow, warm, slow-moving or still water. They are made up of *cells*, which can house poisons called *cyanobacterial toxins*. A mass of cyanobacteria in a body of water is called a bloom. When this mass rises to the surface of the water, it is known as *surface scum* or a *surface water bloom*. Although we don't know the extent to which cyanobacterial blooms occur across Canada, we do know they mostly appear in the hot summer months and are quite prevalent in the prairies.

What are cyanobacterial toxins?

Cyanobacterial toxins are the naturally produced poisons stored in the cells of certain species of cyanobacteria. These toxins fall into various categories. Some are known to attack the liver (hepatotoxins) or the nervous system (neurotoxins); others simply irritate the skin. These toxins are usually released into water when the cells rupture or die. Health Canada scientists are more concerned about hepatotoxins than neurotoxins, because neurotoxins are not considered to be as widespread as hepatotoxins in water supplies. Very few cyanobacterial toxins have actually been isolated and characterized to date. Better methods of detection are being developed to help us learn more about them, especially to find out which toxins are a problem in Canada and what conditions encourage their production.

What are microcystins?

One group of toxins produced and released by cyanobacteria are called *microcystins* because they were isolated from a cyanobacterium called *Microcystis aeruginosa*. Microcystins are the most common of the cyanobacterial toxins found in water, as well as being the ones most often responsible for poisoning animals and humans who come into contact with toxic blooms. Microcystins are extremely stable in water because of their chemical structure, which means they can survive in both warm and cold water and can tolerate radical changes in water chemistry, including pH. So far, scientists have found about 50 different kinds of microcystins. One of them, microcystin-LR, appears to be one of the microcystins most commonly found in water supplies around the world. For this reason, most research in this area has focused on this particular toxin.

Does the presence of a cyanobacterial bloom always mean the water is contaminated?

No. Researchers generally agree that between 30 and 50 per cent of cyanobacterial blooms are harmless because they contain only non-toxic species of freshwater cyanobacteria. Blooms containing even one species of toxic cyanobacteria will be poisonous and potentially dangerous. Because there's no obvious way to tell if a particular bloom is toxic, samples have to be analyzed in a laboratory before a body of water can be declared safe.

Why do blooms sometimes appear overnight?

Even if you can't see a cyanobacterial bloom floating on the surface of the water, that doesn't mean one isn't present in the water - the bloom could be suspended at various depths in the water where you can't see it.

The depth at which cyanobacterial blooms float depends on a number of factors. The most important of these are light, phosphorus and nitrogen, which cyanobacteria need in order to survive. As the availability of these elements can change quickly with the time of day and the weather, most cyanobacteria have evolved to be able to control their buoyancy. By being able to sink and rise at will, they are able to move to where nutrient and light levels are at their highest.

In order to activate the mechanism that allows them to move, cyanobacteria need light. At night, when there is no light, cells are unable to adjust their buoyancy and often float to the surface, forming a surface scum. This scum literally appears overnight and lingers until the wind and waves scatter the cells throughout the water.

Are cyanobacterial blooms a new problem?

No. The earliest reliable account of a cyanobacterial bloom dates back to the 12th century; the toxic effects of cyanobacteria on livestock have been recognized for more than 100 years. Since cyanobacterial bloom formation seems to be linked to nutrient-rich waterbodies (for example, water that contains a lot of phosphates from detergents and phosphate fertilizers), the problem is not likely to go away in the near future.

Effects on Humans and Animals

Can cyanobacterial toxins kill me?

Although many people have become ill from exposure to freshwater cyanobacterial toxins, death from algal-contaminated drinking-water is unlikely to occur given that water resources are usually effectively managed to control taste, odour and other algae-related problems. It's possible that extended exposure to low levels of cyanobacterial hepatotoxins could have long-term or chronic effects in humans.

How will I know if I've accidentally come into contact with cyanobacterial toxins?

If you ingest water, fish or blue-green algal products containing elevated levels of toxins, you may experience headaches, fever, diarrhoea, abdominal pain, nausea and vomiting. If you swim in contaminated water, you may get itchy and irritated eyes and skin, as well as other hay fever-like allergic reactions. If you suspect you might have come into contact with cyanobacterial toxins and are experiencing any of these symptoms, rinse any scum off your body and consult your physician immediately.

Are children more vulnerable than adults?

Yes. Children are at greater risk than adults of developing serious liver damage should they ingest high levels of microcystins, because of their comparatively lower body weight.

Should I let my pets or my livestock drink water containing cyanobacterial blooms?

No. The animals could become extremely ill and even die. The first recorded episode of animal poisoning attributable to cyanobacteria occurred in Australia in 1878. Since then, there have been many widespread incidents of poisoning, affecting a variety of both wild and domestic animals. Animals are not more sensitive than people to the effects of the toxins; they are simply not as concerned with the way water looks or smells before they drink it.

Death is usually caused by damage to the liver or to the nervous system, depending on which toxins were predominant in the water. Treatments to counteract the effects of cyanobacterial toxins in animals have not been extensively investigated to date.

Issue: Drinking-water And Water Used For Dialysis Treatment

How likely am I to drink water contaminated with cyanobacteria and/or its toxins?

Not very likely. Relatively few incidents of human poisoning have been reported. People don't usually drink water contaminated with cyanobacteria because of the scum and the accompanying smell (fresh blooms smell like newly mown grass; older blooms smell like rotting garbage). However, people could unknowingly drink water containing cyanobacterial toxins released from blooms that have died naturally.

If your water comes from a source that is prone to blue-green algal contamination (dugouts, for example), you should monitor the water for bloom formation. If you detect a bloom in your water supply, contact your local health authorities for advice.

Can I cook using water with blue-green algae in it?

No! Boiling water does not remove toxins from the water. As it is impossible to detect the presence of toxins in the water by taste, odour or appearance, you must assume that they are present until testing is completed.

What about using contaminated water for washing?

If there is a safe source of water available, don't use contaminated water for washing clothes or dishes. If no alternative supply is available, use rubber gloves to avoid direct contact with the water. Bathing or showering in contaminated water should be avoided, as skin contact with the algae can lead to skin irritation and rashes.

Are cyanobacteria a year-round problem in water supplies?

No. Canadian water supplies are unlikely to contain cyanobacteria during the winter, although some hepatotoxins may linger.

How do water treatment plants deal with cyanobacteria?

Most municipal water treatment plants do not regularly look for cyanobacterial toxins in the water supply. However, because cyanobacteria have strong smells and tastes and interfere with certain water treatment processes, most municipalities with a history of blooms monitor their surface water supplies for cyanobacteria.

Once cyanobacteria are detected in the water supply, treatment plants can remove them in a number of ways. Conventional water treatment facilities can remove the cells by adding chemicals that bind them together. As the cells clump together, they become heavier and fall to the bottom of the reservoir or tank, where they can be easily filtered out.

While this method will remove cells, it will not remove potentially harmful cyanobacterial toxins. These can be removed using certain oxidation procedures or activated charcoal. Further research in this area is required.

Generally speaking, chemicals (such as copper sulphate) or any other treatment method that causes the cells to break down and release their toxins should not be used.

The best way to avoid the problems associated with cyanobacterial blooms is to prevent blooms from forming. This can be done by reducing the input of nutrients, such as phosphates, into the water source or by mixing the water in a reservoir.

Can I treat my water at home to remove blue-green algae and their toxins?

Although results vary, treatment options are available for the homeowner. However, devices for household treatment can be very expensive. As well, it is difficult to assess the performance and ensure the quality of these household devices. More research in this area is needed and is under way.

What is Health Canada doing to make sure our drinking-water is safe?

Health Canada works with the provinces and territories to establish drinking-water quality guidelines. The guidelines often take the form of maximum acceptable concentrations for substances found in drinking-water supplies. A consultation document on microcystins prepared by the Secretariat of the Federal-Provincial-Territorial Subcommittee on Drinking-water recommends a maximum acceptable concentration of 0.0015 mg/L for total microcystins in drinking-water, based on the toxicity of microcystin-LR. This proposed guideline is believed to be conservative, as it is based on a lifetime of daily exposure via the oral route, even though toxins will probably not be present in Canadian water supplies more than four or five months each year because of climatic conditions.

The Subcommittee has decided that it will not adopt this guideline until a practical analytical method for microcystins is available to all jurisdictions. Health Canada is currently developing such a method, and it should soon be available. Once the guideline is approved, some municipal water treatment plants may be required to monitor for the presence of microcystin-LR in their water supplies, especially if the source is prone to cyanobacterial blooms. Monitoring strategies will vary between provinces.

To obtain a copy of the consultation document on microcystin-LR or to learn more about Health Canada's drinking-water program, please refer to either our English web site at http://www.hc-sc.gc.ca/waterquality or our French web site at http://www.hc-sc.gc.ca/eauqualite.

I am undergoing renal dialysis treatment. Am I more at risk than others?

While the proposed level of microcystins allowed for drinking purposes will not adversely affect the health of most people, patients undergoing renal dialysis treatment may be more susceptible to the associated health risks. Because dialysis patients receive dialysis two or three times per week (exposure to more than 300L of water per week), there is potential for dialysis patients to be exposed to elevated levels of these toxins.

Conventional surface water treatment processes are usually effective in removing the algal cells, but are not very effective at removing or destroying dissolved toxins, particularly from supplies that contain high levels of organic material. Specialized surface water treatment processes can reduce the toxin levels to below the drinking-water guideline, but these levels (0.1-0.5 μg/L) are still of concern for dialysis patients.

As a dialysis patient, what can I do to reduce my risk of exposure?

If you think your water supply comes from surface water, you or your dialysis treatment provider, should ask your local treatment plant if this source water is prone to blue-green algae blooms. If, after contacting your source water supplier, you discover there may be microcystins in your water, sampling should be done to determine whether the toxins are in the dialysate (hospitals and treatment centres may already have additional treatment capacity in place to eliminate all toxins of this nature). Additional treatment of the water may be necessary. These treatments can range from granular activated carbon filtration followed by reverse osmosis to much more complex membrane filtration systems (e.g., ultrafiltration). The extent of additional treatment will depend entirely on the quality of the municipal water supply.

▲Issue: Recreational Water

Can water containing cyanobacterial blooms be used for recreational activities?

Unlike controls available with a drinking-water source contaminated with cyanobacteria, there are very few options available once these algae accumulate in water used for recreational activities, such as swimming, boating, wind surfing and fishing. Blooms in recreational bodies of water are usually associated with unpleasant odours and offensive appearance on shorelines as the scum accumulates and decays. Although cyanobacterial toxins are probably not absorbed through the skin, they can cause skin irritation. The toxins, if present, can be absorbed from the water via ingestion or can become airborne and be absorbed via inhalation. Individuals should avoid swimming and other water-related activities in areas with dense blooms.

What should I do if I suspect water has been contaminated by toxic cyanobacteria?

Because all cyanobacterial blooms are potentially toxic, it's always best to stay away from contaminated water until it has been tested and declared safe. Even after the bloom is gone, it's a good idea to wait until health authorities declare the water safe before swimming in it. For example, in one study in which a bloom was treated with algicide, the toxins released by the dead cells took more than three weeks to disappear.

What is Health Canada doing to ensure the quality of recreational water?

The drinking-water guideline for microcystins will not apply to recreational water. To ensure public safety, Health Canada is developing a separate guideline for microcystin-LR in recreational water.

Issue: Fish Consumption

Can I eat fish from contaminated water?

Microcystins can accumulate in the tissues of fish, particularly in the viscera (liver, kidney, etc.), and in shellfish. Levels in the tissues depend upon the severity of the bloom in the area where the fish or shellfish are caught or collected. In general, caution should be taken when considering the consumption of fish caught in areas of a waterbody where major blue-green algal blooms occur; in particular, the viscera of the fish should not be eaten.

Appendix 7.

BEST MANAGEMENT PRACTICES AND INFORMATION FOR WORKING IN A WATERSHED

Water Rights and Legislation can be found at www.env.gov.bc.ca/wsd/water_rights/index.

The Riparian Areas Regulation can be found at www.env.gov.bc.ca/habitat/fish_protection_act/riparian/riparian_areas

Changes In and About a Stream can be found under Popular Topics on the following website www.env.gov.bc.ca/wsd/

Planning, Protection and Sustainability can be found at www.env.gov.bc.ca/wsd/plan_protect_sustain/index.

The site of the **Environmental Stewardship Division of B.C. Ministry of Environment** is found at www.env.gov.bc.ca/esd/

Develop with Care: Environmental Guidelines for Urban and Rural Land Development in British Columbia can be found at www.env.gov.bc.ca/wld/documents/bmp/devwithcare2006/develop_with_care_intro

Guidelines and Best Management Practices (BMPs) can be found at www.env.gov.bc.ca/wld/BMP/bmpintro.

A Users' Guide to Working in and Around Water: Understanding the Regulation under British Columbia's Water Act May 18, 2005 can be downloaded as a PDF from www.env.gov.bc.ca/wsd/water_rights/cabinet/working_around_water.pdf

Standards and Best Management Practices for Instream Works from the B.C. Ministry of Environment can be found at www.env.gov.bc.ca/wld/documents/bmp/iswstdsbpsmarch2004.pdf

Fish-stream Crossing Guidebook from the Forest Practices Code of British Columbia can be found at /www.for.gov.bc.ca/tasb/legsregs/fpc/FPCGUIDE/Guidetoc.htm

Best Management Practices for Highway Maintenance Activities July 2004 can be downloaded as a PDF from www.th.gov.bc.ca/Publications/eng_publications/environment/MoT_Hwy_Maint_BMP.pdf

Canada's Fish Habitat Law can be found at www-heb.pac.dfo-mpo.gc.ca/water_quality/fish_and_pollution/fish_act_e.htm

Policy for the Management of Fish Habitat from the Canadian Waters Info Centre of Fisheries and Oceans Canada can be found at www.dfo-mpo.gc.ca/canwaters-eauxcan/infocentre/legislation-lois/policies/fhm-policy/index_e.asp

Working In and Around Water from the Canadian Waters Info Centre of Fisheries and Oceans Canada can be found at www.dfo-mpo.gc.ca/canwaters-eauxcan/water-eau/process_e.asp