

STATE OF THE
LAKE
ENVIRONMENT
REPORT
2005



RIDEAU VALLEY WATERSHED WATCH PROGRAM



THE ONTARIO TRILLIUM FOUNDATION
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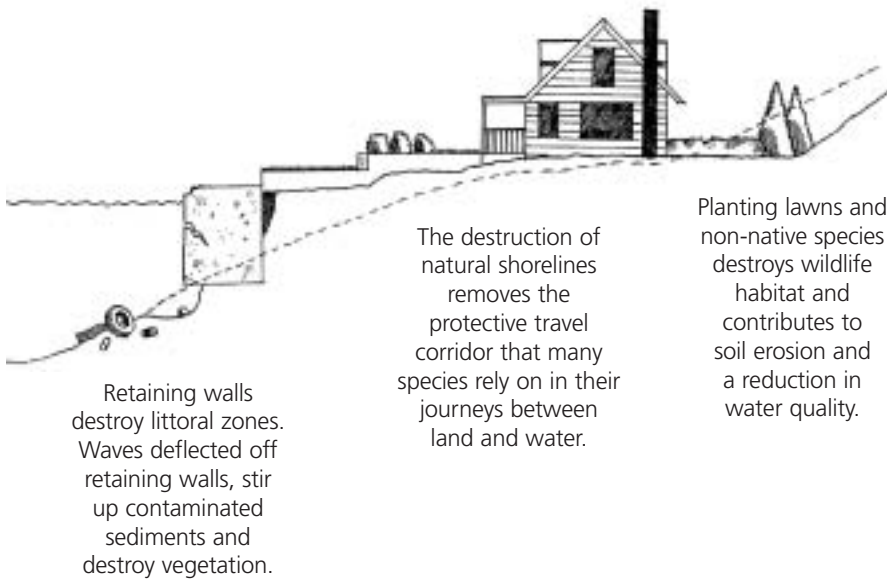
FENDOCK



- ▶ Alliance of Rideau Lakes Associations
 - ▶ Big Rideau Lake Association
 - ▶ Eagle Lake Property Owners Association
 - ▶ Farren Lake Property Owners Association
 - ▶ Rideau Valley Conservation Foundation and its many donors
 - ▶ Township of Bathurst Burgess Sherbrooke
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"The Ribbon of Life" Where the Land Meets the Water

Water quality is affected by many things: natural processes of erosion and runoff accelerated by clearing of shorelines, the use of artificial fertilizers and leachate from sewage disposal systems. All result in too many nutrients reaching the lake.



Retaining walls destroy littoral zones. Waves deflected off retaining walls, stir up contaminated sediments and destroy vegetation.

The destruction of natural shorelines removes the protective travel corridor that many species rely on in their journeys between land and water.

Planting lawns and non-native species destroys wildlife habitat and contributes to soil erosion and a reduction in water quality.

Too many nutrients causes profuse weed and algae growth which affects the aquatic animal species makeup by altering habitat and food sources and by reducing oxygen and light penetration.

The shallow waters and first ten metres of shoreland area form a "Ribbon of Life" around lakes. This ribbon — where the land meets the water — is where much of the lake life is born, raised and fed. Many landowners, unaware of the importance of this area, have cleared the shorelines of native vegetation and replaced it with lawns, non-native ornamental vegetation, retaining walls and boathouses. This has a negative effect on fish and wildlife habitat and water quality. Natural vegetation retained or restored along the shoreline helps prevent erosion and improves water quality by binding nutrients before they can enter the lake.

The Rideau Valley Conservation Authority has long recognized the recreational and aesthetic value of lakes within the watershed and is committed to maintaining and protecting water quality and fish habitat. The Conservation Authority has joined together with volunteer Lake Stewards throughout the watershed to take steps to protect and restore water quality by launching the **Watershed Watch** program. **Watershed Watch** is an environmental monitoring and awareness program. The objectives of the program are to collect reliable environmental data to document current water quality conditions and use the data as an essential educational tool to encourage shoreline residents, both seasonal and permanent, to become personal stewards of their lake and to adopt sound stewardship practices aimed at preserving and protecting water quality. By taking an active role in restoring and enhancing their shoreline, they can help to maintain water quality and a healthy lake environment.

Recreational water quality can be expressed in terms of how clear the water appears. Water clarity is influenced by the amount of soil sediment and phytoplankton, or microscopic algae, present in the water. Clarity is measured by a simple visual test using a **Secchi Disk**, a 20 centimetre black and white disk attached to a measured line that is lowered into the lake until it is no longer visible. Analysis of water samples for **chlorophyll a**, which provides the green pigment in phytoplankton, gives a more specific measure of the abundance of small creatures in the water. Another perspective is gained through analysis of samples for nutrients, particularly **phosphorus** but also **nitrogen**, which tells how much food is available for the algae and aquatic plants. In the late summer when the algae drops to the bottom of the lake, its decomposition uses oxygen so, to find out how much oxygen is available for fish and other aquatic animals, **dissolved oxygen and temperature** profiles are done.

These tests combine to give an indication of the age of a lake and what can be expected. An old or eutrophic lake will have profuse plant growth and relatively few fish species

because of the lack of open water and the competition for oxygen. A middle-aged or **mesotrophic** lake will support the greatest diversity of fish species with a variety of habitats and sufficient oxygen available. Young or **oligotrophic** lakes have very little or no vegetation and are usually well oxygenated but have relatively few fish species.

While lake users are interested in how weedy a lake is and what kind of fishing stories they can experience, they also want to know if the water is safe for drinking and swimming. Eschericia coli (**E.coli.**) are in a family of fecal coliform bacteria common to warm-blooded mammals. A few members of the family are harmful themselves but E.coli. are also a good indicator of the presence of pathogenic or other hazardous bacteria because where there is E.coli., the others will usually be present. Analysis of water samples for E.coli., which is relatively more abundant and easier to count than the other organisms, gives an indication of problems with leaking septic systems or other sources of contamination.

Through **Watershed Watch**, lakes in the watershed will be monitored for these key water quality indicators. Knowing what is in the water will assist the lake stewards when devising a strategy to protect the Ribbon of Life which will reduce the human impact on the aging process and ensure that our lakes will endure for future generations to enjoy.

FIVE EASY STEPS TO IMPROVE WATER QUALITY

1. Build at least 30 metres away from the shoreline.
2. Keep your lot well treed and preserve or replant native vegetation along the shoreline.
3. Pump out your septic tank every three to five years and have the tank and tile field inspected periodically.
4. Reduce water use and use phosphate free soaps and detergents.
5. Keep the size of your lawn to a minimum and do not use fertilizers, herbicides or pesticides.

Low Phosphorus Lifestyle

Human Waste	535 g
No Dishwasher	0 g
No fertilizer	0 g
Uses phosphate-free products	20 g

High Phosphorus Lifestyle

Human Waste	535 g
Dishwasher using powdered detergent once per day	650 g
Lawn fertilized once/year	1,960 g
Uses products with phosphates	180 g

In a Bit More Detail:

The basic characteristics of a lake depend on the physical properties (dimensions and geology) and climate. Six processes or actions further define an individual lake:

- Precipitation directly onto the lake surface deposits phosphorus and other chemicals and runoff from the lake watershed carry bacteria and pathogens, plant debris and soil particles which bear phosphorus and other chemical elements, into the water ;
- Use by aquatic plants of the nutrients (phosphorus, etc.) has two impacts:
 - plant communities develop in the lake, becoming profuse over time, which limits the development and diversity of other plants and aquatic animals, and
 - along with plant debris and sediment from the shoreline, dead phytoplankton and other plants settle to the lake bottom where it decomposes using up oxygen and releasing nutrients;
- Each spring and fall temperature changes in the lake cause a mixing or turnover of the waters which can bring phosphorus from bottom waters to the surface to be available for aquatic plant and microorganism growth;
- A “sink” of phosphorus is created by settling of phosphorus-bearing sediment and the decay process at the bottom of all lakes with the phosphorus either held adsorbed to the lake bed soil particles when dissolved oxygen levels are high or in solution when the dissolved oxygen levels decline.
- After the spring turnover, the lake warms and stratification occurs creating a warmer surface layer (epilimnion), a transition zone (metalimnion) and colder deep waters (hypolimnion). As water warms, the ability to hold dissolved oxygen decreases. While the warm waters of the epilimnion can hold less the air/water contact and wave action ensures that there is a constant supply. As the deep waters of the hypolimnion warm, there is no mechanism to get new oxygen. The demand for oxygen for the decay process can cause the hypolimnion to become anoxic (no dissolved oxygen);
- Lakeshore development affects the shoreline runoff/erosion characteristics which usually leads to increased sediment, bacterial and nutrient loading of lake waters by changes to the vegetation composition, hardening the surface (buildings, roads, retaining walls, etc.) and installation and operation of septic facilities;

There are several methods of measuring the impacts of these processes or actions. The common ones are:

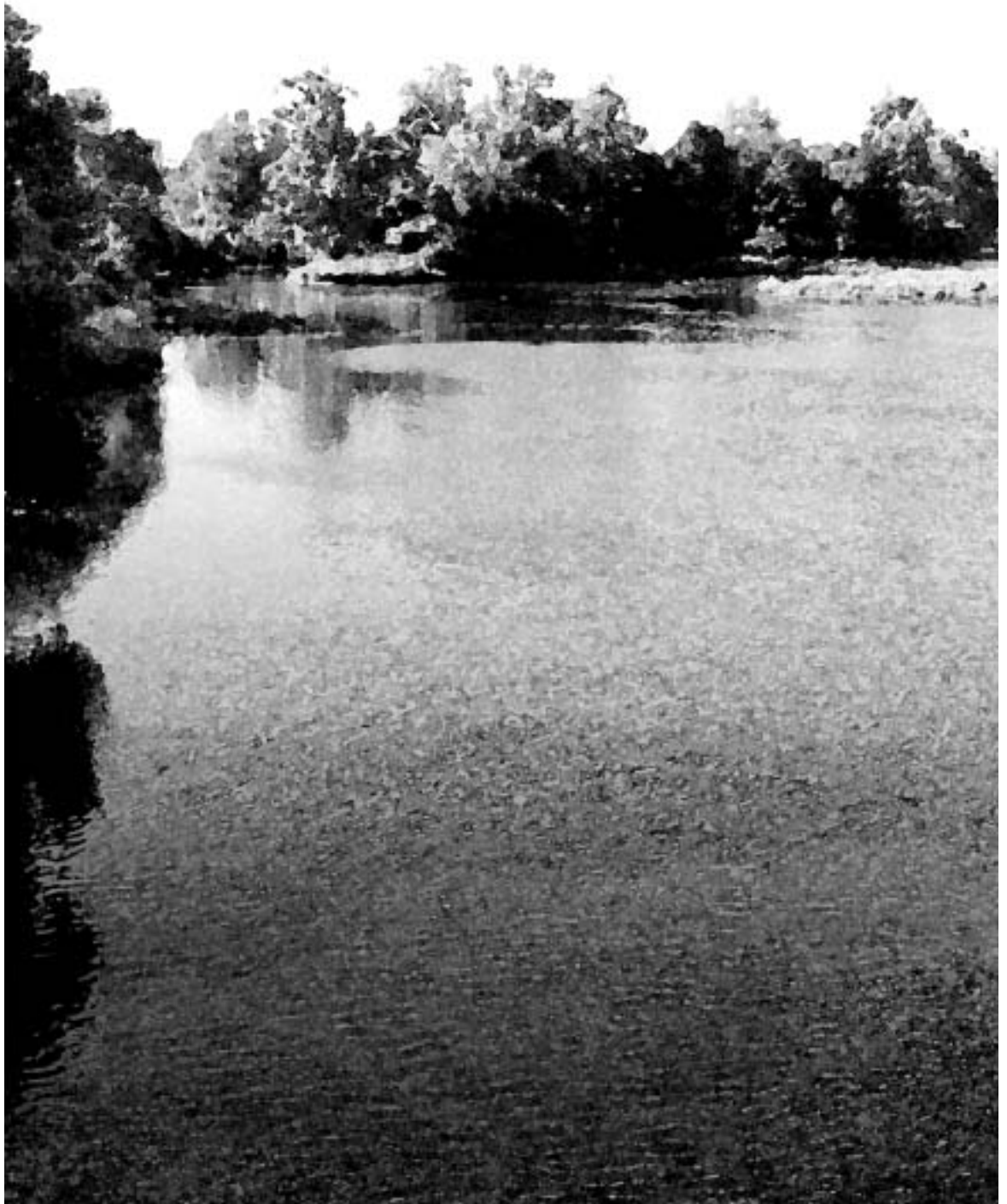
- measurement of **water clarity** or the presence of suspended material using a **Secchi disk**,
- dissolved oxygen (DO)/Temperature profiles to show what the extents of the habitable waters are (most fish species inhabit the warmer, oxygenated surface waters),
- analysis of samples for nutrients: **Total Phosphorus (TP)** - the limiting nutrient for plant and microorganism growth, and/or
- presence or concentration of phytoplankton indicated by the amount of **chlorophyll a**, a pigment in phytoplankton (aquatic plants) – Chlorophyll a was used as the primary indicator of lake trophic state (age or nutrient level) until 1994 when it was replaced by total phosphorus because sampling and analysis for TP was shown to be more reliable and more economical. The relationship between the two is that chlorophyll a is one of the pigments found in phytoplankton giving it a green colour and phosphorus is the primary nutrient for the phytoplankton. In other words, the higher the concentration of TP, the greater the potential for growth of phytoplankton would be which, in turn, would mean that there would be a correspondingly high concentration of chlorophyll present. In such a case, the water clarity could be poor from the abundance of suspended plant material.

Added for the Watershed Watch program were:

- Total Kjeldahl Nitrogen (TKN), a secondary nutrient, to see what is available to work with the phosphorus and to see if the high counts found elsewhere in the watershed occur in the lakes;
- Escherichia Coliform (E.Coli) sampling around the lake nearshore to check for bacterial pollution problems, and
- Dissolved Organic Carbon (DOC) that comes typically from wetlands and can have a limiting effect on the nutrient uptake process.

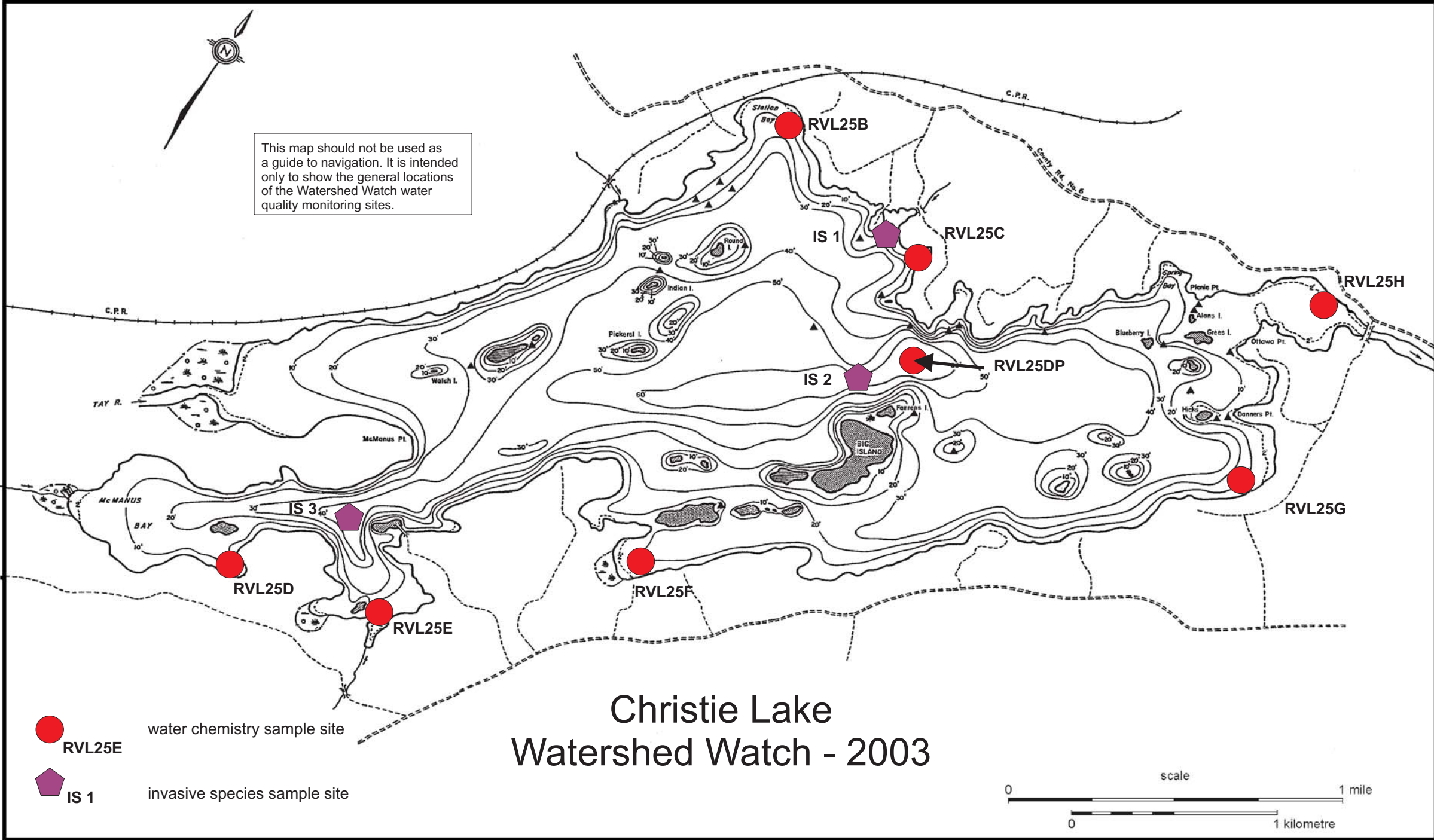
Christie Lake 2003–2005



published December 2005



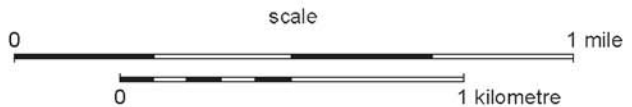


This map should not be used as a guide to navigation. It is intended only to show the general locations of the Watershed Watch water quality monitoring sites.



-  RVL25E water chemistry sample site
-  IS 1 invasive species sample site

Christie Lake Watershed Watch - 2003



CHRISTIE LAKE – 2003 - 2005

LOCATION:	Township of Tay Valley. On the Tay River downstream from Bobs Lake and west of the Town of Perth.
ELEVATION:	lake surface approximately 198 metres above mean sea level
DIMENSIONS:	perimeter: 27.4 kilometres; maximum depth: 18.3 metres.; area: 646 hectares; volume: 55,170,000 m ³
LAKE WATERSHED:	drainage area: 43,270 hectares ; land cover: 75% shield forest, 15% lake, 4.2% wetlands, 3.6% pasture, 1% crops, 0.7% successional lands, 0.4% mesic mixed hardwood
FISHERY:	warm water fishery - largemouth bass, smallmouth bass, pickerel and pike
DEVELOPMENT LEVEL:	233 seasonal cottages, 78 permanent cottages, three farms, five resorts, 2 tourist camps (as of count in 1982)
BACKGROUND DATA:	Ministry of Environment Recreational Lakes, Self-Help and Lake Partner Programs; Ministry of Natural Resources Christie Lake Management Plan (1982).

The sampling component of the Watershed Watch program consisted of the following:

SITES:	one site at deepest point of lake, eight around shoreline adjacent to cottage groupings (see map)
TOTAL PHOSPHORUS (TP):	a composite sample taken in the euphotic zone (layer which light penetrates – twice the secchi disk depth) at the deepest point (where there is least point source input) and one metre above the bottom; at eight shoreline sites at approximately half metre depth in one metre of water
TOTAL KJELDAHL NITROGEN (TKN):	samples from deepest point at the surface and one metre above the bottom; at eight shoreline sites at half metre depth in one metre of water
SECCHI DISK (SD):	at deepest point – measurement is depth where disk can no longer be seen
DISSOLVED OXYGEN/TEMPERATURE (DO):	at deepest point readings taken at intervals from surface to bottom and back to the surface
CHLOROPHYLL <u>a</u> (Chl):	a composite sample taken in the euphotic zone at deep point - <u>not done in 2003 Watershed Watch</u>
ESCHERICHIA COLI (E. Coli):	at eight shoreline sites at approximately half metre depth in one metre of water
INVASIVE SPECIES (IS):	sampling for Zebra Mussel veligers and Spiny Water Flea completed during September sampling
BENTHIC MACRO INVERTEBRATES:	at three shoreline sites. One site in a “pristine” location and two sites in locations representative of development levels on the lake. Three replicates completed at each site.

Looking a little deeper:

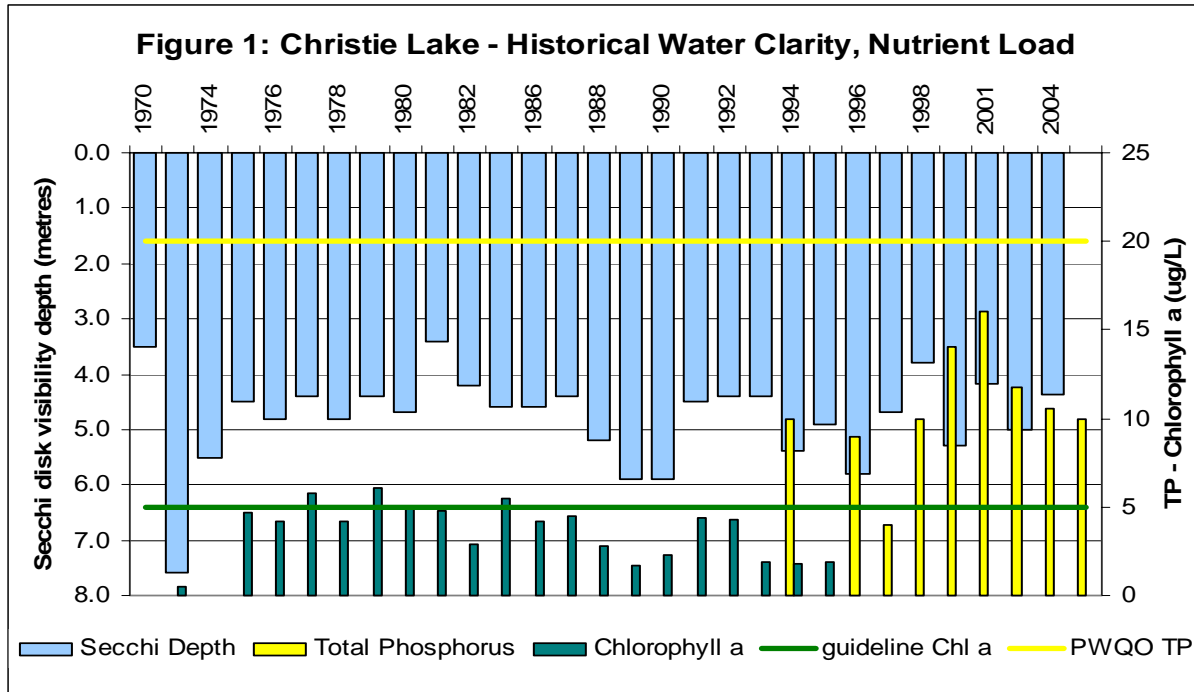
An obstacle to assessing the condition of lakes is the length of the historical data record. There is a relatively long dataset for Christie Lake (Table 1, below). Some of the numbers are averages of several measurements or sample results in a year and others are from a single sample or measurement in a year which makes statistical analysis unreliable. However, observations about the data can be made that can lead to a reasonable assessment of the lake condition.

Table 1: Christie Lake, Historical Data - 1970-2005

Sample Year	Secchi Disk (metres)	Total Phosphorus ($\mu\text{g/L}$)	Total Kjeldahl Nitrogen ($\mu\text{g/L}$)	Chlorophyll <u>a</u> ($\mu\text{g/L}$)
1970	3.5			
1971	7.6			0.5
1974	5.5			
1975	4.5		355	4.7
1976	4.8			4.2
1977	4.4			5.8
1978	4.8			4.2
1979	4.4			6.1
1980	4.7			5.0
1981	3.4			4.8
1982	4.2			2.9
1983	4.6			5.5
1986	4.6			4.2
1987	4.4			4.5
1988	5.2			2.8
1989	5.9			1.7
1990	5.9			2.3
1991	4.5			4.4
1992	4.4			4.3
1993	4.4			1.9
1994	5.4	10	377	1.8
1995	4.9			1.9
1996	5.8	9	400	
1997	4.7	4		
1998	3.8	10		
2000	5.3	14		
2001	4.2	16		
2003	5.0	13	401	
2004	4.4	11	386	
2005		10	368	
Number	27	9	6	19
Minimum	3.4	4	355	0.5
Maximum	7.6	16	401	6.1
Mean	4.8	10.6	381	3.7

Table 1 and Figure 1 show that, except for one high measurement and three measurements less than 4 metres, there has been relatively little variation in water clarity, as measured with a **Secchi disk**, over the 27 years of record for Christie Lake. The simple model is a lake that is clear with minimal suspended material. That was the case in 1971 when the Secchi disk measurement was 7.6 metres and the **chlorophyll a** (CHL A) concentration

(the measure of green pigment in suspended phytoplankton and algae) was 0.5 milligrams/litre (mg/L), or virtually non-existent. However, Christie Lake, like all lakes, is not a simple system and the simple relationship does not hold up. When CHL A concentrations were relatively high through to the mid-eighties, clarity was not significantly less than for the subsequent period to the present suggesting that, while there may have been significant growing material in the water and there were likely to have been regular algae blooms to various extents, it was not enough to impair the water clarity. CHL A concentrations declined in the lake through the eighties and **Total Phosphorus (TP)** concentrations, which replaced CHL A as the measure of nutrient loading in 1994, have continued to be relatively low.



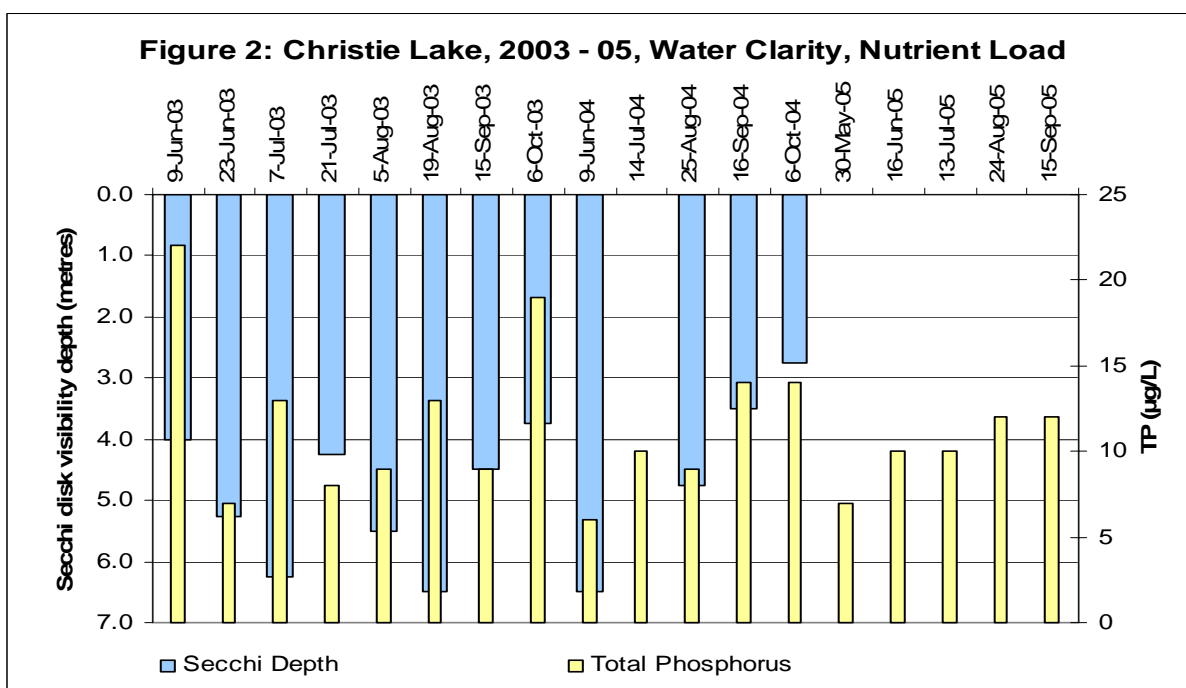
TP concentrations over the last three years (Table 2, below) have been similarly low except for the occasionally elevated result. It is difficult to state precisely what causes the specific sample concentrations. All are related to the weather and water conditions (level, temperatures, wind) at the time. The two high concentrations in 2003 would likely have been related to seasonal stratification as the lake warmed and cooled in the spring and fall with vertical movement occurring that distributed TP throughout the water column. With relatively high concentrations, generally, in the bottom waters, there was a ready cache available. Water levels were particularly low in January and February that year which may have had some impact on both the phosphorus and nitrogen concentrations.

Nitrogen, measured here as **total Kjeldahl nitrogen (TKN)**, has been found to be generally in concentrations in the range of 450 to 500 micrograms per litre of sample (µg/L) in the Tay River system. Christie Lake has had lower concentrations in surface waters. In other lakes, TKN has been more randomly distributed with much less difference between surface and bottom concentrations than TP. In Christie Lake it appears that nitrogen settles along with phosphorus in similar proportions and is re-introduced to the surface waters in the fall during thermal de-stratification. This could mean that some more nutrients were available for growth through the winter and in the spring than is typical in other lakes.

Water clarity in 2003 and 2004 was similar to the historical record although it declined at the end of 2004 which may indicate there was algae bloom activity.

Table 2: Christie Lake, 2003 - 2005 – Deep Point

Date	TP surface (µg/L)	TP bottom (µg/L)	TKN surface (µg/L)	TKN bottom (µg/L)	Secchi disk (metres)
9-Jun-03	22	11	460	350	4.0
23-Jun-03	7	110	390	880	5.3
7-Jul-03	13	113	420	560	6.3
21-Jul-03	8	55	370	400	4.3
5-Aug-03	9	210	380	640	5.5
19-Aug-03	13	60	400	800	6.5
15-Sep-03	9	410	380	860	4.5
6-Oct-03	19	380	410	870	3.8
AVERAGE:	13	169	401	670	5.0
9-Jun-04	6		360		6.5
14-Jul-04	10		400		
25-Aug-04	9		410		4.8
16-Sep-04	14		380		3.5
6-Oct-04	14		380		2.8
AVERAGE:	11		386		4.4
30-May-05	7		300		
16-Jun-05	10		330		
13-Jul-05	10		370		
24-Aug-05	12		420		
15-Sep-05	12		420		
AVERAGE:	10		368		



Dissolved oxygen and temperature profiling is important for lakes because both parameters affect all aquatic organisms and the chemistry of the lake environment. The primary source of oxygen in aquatic systems is the atmosphere with wind action constantly recharging the surface waters with oxygen. Lake waters also gain oxygen as a byproduct of photosynthesis by algae and macrophytes. However, as these die, they settle to the bottom of the lake where bacteria convert the organic material into carbon dioxide, consuming oxygen in the process. Because the lake becomes thermally stratified early in the summer, oxygen cannot be replenished in the water in the hypolimnion, the lower part of the lake, so that, as oxygen levels are lowered, phosphorus in the bottom sediments becomes more readily soluble adding to the loading available for plant growth.

Profiles were done at the lake deep point site through the 2003 sampling period by Ministry of Environment and RVCA. The profile results are shown in tabular and graphical form in Appendix 2, The MOE mid-June profile shows that the lake was still in the process of stratifying which relates to the higher concentration of TP discussed above. By the July 21st RVCA profile, stratification was complete and the lower 6 metres were nearly anoxic (without oxygen). The August 18th profile shows the worst case measured that year when the oxygen depletion was at its greatest in the bottom 10 metres. The MOE August, 2001 data show similar conditions despite that being a much drier and hotter summer. It appears that approximately 7 metres depth at the surface is the minimum habitable for fish (grey area on the profile tables). This is suitable for a warm water fishery which requires no less than 4 mg/L concentration of oxygen at a maximum of 25 degrees Celsius (fish can survive at lower oxygen concentrations and higher temperatures but only for brief periods without suffering severe stress).

Near the shore:

In addition to sampling at the deep point in the lake, the Watershed Watch program included sampling at a number of sites near the shore. The objectives were:

- a) To look at the phosphorus and nitrogen distribution around the lake.
- b) To do general sampling for bacterial pollution (*E.Coli*) in proximity to the developed areas to see if there was a problem with septic and grey water entering the lake.

The complete datasets for the three years of sampling are in tables in Appendix 1. Table 3, below is a summary of the data in terms of exceedances in which "exceeds 1" is an initial reference threshold and "exceeds 2" is the **Provincial Water Quality Objective (PWQO)** for TP and *E.Coli* and, for TKN and **dissolved organic carbon (DOC)**, "exceeds 1" is a guideline used in the Watershed Watch program as a reference.

Over the last three years, 161 TP samples have been collected from Christie Lake. Of those, only 5 results exceeded the PWQO (20 µg/L) and those were all in 2003 in no particular pattern that would indicate specific pollution problems. "Exceeds 1", in the case of TP, refers to the boundary of 10 µg/L between the trophic, or "lake age", levels oligotrophic ("young" or clear water with little aquatic plant growth) and mesotrophic ("middle-aged" with lower water clarity and some plant growth). The majority of samples had results greater than 10 µg/L. Of note may be that the proportion of results above the boundary was lowest in 2003, despite the exceedances of the PWQO that occurred that year.

TKN concentrations exceeded the reference guideline of 500 µg/L in all of 3 samples of the total of 161. One of those coincided with an exceedance of the PWQO for TP although TKN concentrations were slightly higher than in previous samples for the other exceedances of the TP objective.

"Exceeds 1" for *E.Coli* is a reference RVCA uses of 10 counts/100 millilitres of sample. When results consistently are above 10 µg/L at a sample site, it could mean that there is a source of bacterial pollution nearby that ought to be further investigated. While 19% of the 140 sample counts were in the "exceeds 1" category, none were consistently so. The PWQO ("exceeds 2") was not exceeded at any of the sample sites in the three years of sampling. While all parts of the lake were not sampled, the *E.Coli* results indicate that the waters of Christie Lake did not pose a health concern for cottagers and residents for swimming and other water contact recreational use.

(Note: Not all bacteria are harmful. Some can be a food source for macroscopic aquatic invertebrates. Also, what is commonly referred to as blue-green algae, are bacteria which share many characteristics with algae and can be toxic to aquatic species as well as cause reactions in humans when in high concentrations).

Table 3: Sample Exceedances

		TP	TKN	EC	DOC
ALL	# samples	161	161	140	27
	exceeds 1	94		26	
	%age	58%		19%	
	exceeds 2	5	3	0	25
	%age	4%	2%	0%	93%
2003	# samples	72	72	64	24
	exceeds 1	39	2	6	24
	%age	54%	3%	9%	100%
	exceeds 2	5		0	
	%age	7%		0%	
2004	# samples	45	45	40	0
	exceeds 1	30	1	9	0
	%age	67%	2%	23%	
	exceeds 2	0		0	
	%age	0%		0%	
2005	# samples	44	44	36	3
	exceeds 1	25	0	11	1
	%age	57%	0%	31%	33%
	exceeds 2	0		0	
	%age	0%		0%	

Dissolved Organic Carbon (DOC) has been receiving greater research attention in recent years. It appears that it can interfere with the nutrient uptake process by aquatic plants in Canadian Shield lakes if it is in sufficient concentration and from the “right” source (incoming rather than “resident” in the lake). Elevated DOC can impede the decay process so that, for example, branches falling in the water will accumulate on the bottom in much the same condition as when they fell. Lakes with such conditions are being referred to as dystrophic, rather than eutrophic. Because research is ongoing into the effects of DOC, our main purpose in measuring DOC concentrations at this time is to build a dataset that can be compared to research results. No firm conclusion can be drawn at this time except that it appears that DOC concentrations in Christie Lake are relatively high but are resident. This data is available for those who are interested by contacting the RVCA.

Benthic invertebrates:

In addition to chemical testing, the Watershed Watch program included sampling for **benthic invertebrates** (the bugs that live on the bottom). The analysis of what actually lives in the lake is an excellent complement to chemical analysis of the shore waters because it gives a longer term look at what creatures the lake can support. The more varied and numerous the invertebrates, the better the water quality.

The samples are collected using a D-Net with the “kick and sweep” method. The sampler starts in waist deep water facing away from the shore. The person moves backwards toward the shore while kicking up the bottom. The net, on a loop of wire in a D shape attached to a broom handle, is dragged along the bottom to “sweep” up the substrate that is disturbed including any invertebrates living there. Three sites were sampled on Christie

Lake with three replicates collected at each site. The analysis of the samples includes identification and counting of the bugs after which the counts of each are compared to a set of indices. Below is a summary of the results.

Taxa Richness

Taxa Richness (TR) indicates the health of the community. This is determined through its diversity and will increase with increasing habitat diversity, suitability, and water quality. TR equates the total number of taxa found within the sample. The healthier the community is, the greater the number of taxa found within the community. Generally, a taxa count above 10 can be considered to have excellent family diversity and communities are very stable. Anything below 5 indicates that families have low diversity and communities are unstable. Samples collected from Christie Lake (below) showed healthy and stable communities.

Table 6: Taxa Richness- Christie Lake (RVL-25)

	SITE	REPLICATE 1	REPLICATE 2	REPLICATE 3
Fall, 2003	CL-1	10	10	11
Fall, 2003	CL-2*	9	11	11
Fall, 2003	CL-3	8	10	10
Spring, 2004	CL-1	20	17	19
Spring, 2004	CL-2*	26	19	22
Spring, 2004	CL-3	17	20	17
Fall, 2004	CL-1	12	17	14
Fall, 2004	CL-2*	10	10	16
Fall, 2004	CL-3	18	16	19

*Site CL-2 was sampled in an area minimally impacted by development

Tolerance Index

The chart below categorizes the taxa into various pollution tolerances those being sensitive, somewhat sensitive, and tolerant.

SENSITIVE	SOMEWHAT SENSITIVE	TOLERANT
Pollution sensitive organisms found in good water quality	Somewhat pollution tolerant organisms that can be found in good or fair water quality	Pollution tolerant organisms can be found in any quality of water
Caddisfly larvae Hellgrammite Mayfly nymphs Gilled snails Riffle beetle adult Stonefly nymphs Water penny larvae	Beetle larvae Clams Crane fly larvae Crayfish Damselfly/dragonfly nymphs Scuds Sowbugs Fishfly/alderfly larvae	Aquatic worms Blackfly larvae (simuliidae) Leeches (hirudinae) Midge larvae Pouch (and other) snails

As with the chemical testing, the tolerance index indicated good water quality for Christie Lake with the sensitive organisms dominating. Further information on benthic macro invertebrate testing, including complete data sets, graphs and site photos are available at <http://www.rideauvalley.on.ca>, within the surface water quality section or by contacting Jennifer Lamoureux at the RVCA.

Invasive Species:

The Watershed Watch program has included sampling for zebra mussel veligers and spiny water flea. Three locations were sampled: site "DP1", site "C" and site "H". No spiny water fleas have been found in any of the samples since 2003. It was thought that zebra mussel veligers were detected in the samples taken at both the deep point (DP1) and near the marina, at site "C" in 2003. However, there were issues about the identification method which has since been changed and no veligers were found in samples taken in 2004 and 2005. While

these results do not conclusively show that zebra mussels are not present in Christie Lake, it does give a good indication, at least, that they have not become established in the lake. Therefore, precautions should continue to be taken to prevent both the mussels and fleas as well as any other non-native species from inadvertently entering the lake.

The Ontario Federation of Anglers and Hunters, in co-operation with the Ministry of Natural Resources have published "ZEBRA MUSSELS: A Guide for Boaters and Cottagers". This publication along with fact sheets, brochures, watchcards, signs and stickers are available free of charge. OFAH also have videos and slide presentations available for purchase or loan, perfect for lake association meetings and information sessions. Visit <http://www.invadingspecies.com> or call the Invading Species Hotline (1-800-563-7711) for more information.

In conclusion:

Variable	Conditions for trophic status	Christie Lake
Total phosphorus concentration	Oligotrophic: < 10 µg/L Mesotrophic: 10 – 20 µg/L Eutrophic: >20 µg/L	Period of record (since 1994): 11 µg/L; 2003: 12 µg/L; 2004: 11; 2005: 10
Chlorophyll <u>a</u> concentration	Oligotrophic: < 2 µg/L Mesotrophic: 2.0 to 4.9 µg/L Eutrophic: > 4.9 µg/L	Period of record: 3.7 µg/L
Secchi disk measurement	Oligotrophic: > 5 metres Mesotrophic: 2 to 5 m Eutrophic: < 2 m	Period of record: 4.8 m; since 1996: 4.8 m; 2003: 5 m; 2004; 4.4 m; 2005: N/A

The historical data and the results of Watershed Watch sampling through the summer of 2003 and volunteer sampling through the summers of 2004 and 2005 indicate that Christie Lake is in an early mesotrophic stage. The surface of the lake has a moderate quantity of nutrients with only a few exceedances of the Provincial Water Quality Objective. Dissolved oxygen/temperature profiles done in 2003 indicate that the lake appears to have a good proportion of the volume available for warm water fish species. The lake bottom waters did become anoxic relatively early in the summer which would have caused phosphorus to be put back in solution from lake sediments. Samples from the bottom of the lake indicated that there appeared to be a "high stock" of phosphorus which could be circulated to surface waters during spring turnover, as may have happened in 2003 (site DP! June 9th: 22 µg/L). Benthic populations show a good diversity including species sensitive to pollution, indicating good habitat conditions and longer term water quality.

On average, nutrient concentrations are relatively low in Christie Lake. However, there is sufficient for weed growth in bays and shallow areas and algae blooms have occurred and will continue to occur. The amount of growth and species makeup of each will vary from year to year depending mainly on the weather and monitoring of both has merit.

It does not appear that Zebra mussels have become established in the lake so precautions should be taken by all residents, land owners and recreational users of the lake to control the spread from other lakes in the region.

Of the six things in the list of processes and actions at the beginning of this section that affect the character of a lake, the first point has to be addressed by society as a whole. The amount of phosphorus reaching lakes by airborne deposition can be reduced by controlling the amount that gets into the air from industrial and agricultural emissions. It is the last point in that list regarding lakeshore development that is largely the responsibility of those who own property around the lake to act on. It is not possible to restore any lake to a

“youthful”, nutrient free condition nor should that be the objective because it would mean that the present degree of biodiversity would be lost. However, the process of lake aging can be slowed by all users taking a stewardship approach and making sure that they minimize their impact on the lake environment.

Finally, thanks go to Stan Seymour and the other members of “Team Christie” for their assistance with on-water transportation for RVCA monitoring staff in 2003 and sample collection in 2004 and 2005.

For more information regarding *Watershed Watch* or for free advice on how you can help protect or enhance your lake environment, contact the LandOwner Resource Centre at (613) 692-2390 or info@lrconline.com.

APPENDIX 1:**Total Phosphorus ($\mu\text{g/L}$) – 2003 - 2005**

site	A	B	C	D	E	F	G	H	DP1	average
9-Jun-03	13	5	8	10	6	12	5	6	22	10
23-Jun-03	11	7	8	22	14	12	10	9	7	11
7-Jul-03	17	7	7	11	24	12	12	10	13	13
21-Jul-03	11	9	12	10	12	15	9	9	8	11
5-Aug-03	12	7	11	9	16	14	8	8	9	10
19-Aug-03	12	8	7	14	9	8	9	13	13	10
15-Sep-03	14	10	10	12	12	13	13	9	9	11
6-Oct-03	15	18	19	18	24	15	21	16	19	18
9-Jun-04	8	9	9	5	7	6	9	7	6	7
14-Jul-04	16	12	11	12	15	18	11	12	10	13
25-Aug-04	13	11	9	10	12	12	9	8	9	10
16-Sep-04	13	12	12	12	11	13	11	12	14	12
6-Oct-04	13	12	14	13	14	12	13	13	14	13
30-May-05	10	7	7		10	12	10	20	7	10
16-Jun-05	17	9	9	9	11	10	12	18	10	12
13-Jul-05	13	10	13	14	14	16	11	11	10	12
24-Aug-05	14	10	8	12	13	12	10	9	12	11
15-Sep-05	12	9	9	13	14	15	11	11	12	12
average	13	10	10	12	13	13	11	11	11	
								average 2003		12
								average 2004		11
								average 2005		12
								3 year average		12

TKN ($\mu\text{g/L}$) – 2003 - 2005

site	A	B	C	D	E	F	G	H	DP1	average
9-Jun-03	330	330	400	420	360	490	360	350	460	389
23-Jun-03	410	350	380	480	430	400	390	370	390	400
7-Jul-03	470	360	400	440	520	440	430	410	420	432
21-Jul-03	390	360	400	380	380	420	370	400	370	386
5-Aug-03	410	390	410	420	530	420	350	410	380	413
19-Aug-03	420	390	380	430	390	380	360	440	400	399
15-Sep-03	440	400	410	400	410	440	390	390	380	407
6-Oct-03	400	390	420	400	440	400	450	430	410	416
9-Jun-04	410	410	420	380	440	370	420	390	360	400
14-Jul-04	500	430	410	440	470	460	410	420	400	438
25-Aug-04	460	440	420	410	420	430	410	420	410	424
16-Sep-04	380	390	370	380	370	390	370	390	380	380
6-Oct-04	390	400	420	390	400	400	400	400	380	398
30-May-05	320	270	280		310	320	290	360	300	306
16-Jun-05	420	340	350	350	370	360	450	430	330	378
13-Jul-05	420	400	420	420	440	460	390	450	370	419
24-Aug-05	410	380	340	390	400	410	360	390	420	389
15-Sep-05	420	400	380	430	440	450	400	430	420	419
average	411	379	389	409	418	413	389	404	388	
								average 2003		405
								average 2004		408
								average 2005		384
								3 year average		400

E.Coli (counts/100 mL), 2003 - 2005

site	A	B	C	D	E	F	G	H	average
9-Jun-03	86	2	22	6	2	2	6	16	18
23-Jun-03	6	2	12	2	4	2	2	8	5
7-Jul-03	8	2	2	10	2	2	2	2	4
21-Jul-03	4	2	2	2	8	2	4	2	3
5-Aug-03	4	2	4	2	2	2	2	2	3
19-Aug-03	8	2	2	2	2	2	2	2	3
15-Sep-03	4	4	2	8	4	6	2	22	7
6-Oct-03	2	4	2	2	2	2	2	2	2
9-Jun-04	8	30	7	1	6	90	1	7	19
14-Jul-04	18	4	2	18	22	2	2	26	12
25-Aug-04	2	2	2	2	4	2	2	2	2
16-Sep-04	6	2	4	2	2	2	2	8	4
6-Oct-04	10	4	10	2	2	4	2	10	6
30-May-05	2	2	2		2	2	2	8	3
16-Jun-05	40	10	8	10	6	38	6	22	18
13-Jul-05				2	18	18	68	4	22
24-Aug-05	2	2	2	2	2	2	2	2	2
15-Sep-05	6	16	2	6	2	28	2	16	10
average	13	5	5	5	5	12	6	9	
								average 2003	5
								average 2004	8
								average 2005	10
								3 year average	7

Appendix 2: Dissolved Oxygen Temperature Profiles

Warm Water Fisheries Habitat (e.g. bass, walleye, pike) defined as Dissolved Oxygen concentrations greater than 4mg/L at temperatures less than 25 degrees Celsius.

June 17, 2003

*MOE

Depth (metres)	Average Temperature (°C)	Average D.O. (mg/L)	Percent Saturation	Lake Stratification
0	21.3	9.1	103.9	in progress
1	20.9	9.2	104.8	
2	19.7	9.1	101.3	
3	19.3	8.6	95.0	
4	18.6	8.2	89.2	
5	18.0	7.4	79.1	
6	17.2	7.2	76.1	
7	16.2	6.9	71.8	
8	14.6	6.2	62.5	
8.5	13.2	6.0	57.8	
9	12.1	5.6	53.1	
9.5	11.8	5.5	52.0	
10	10.8	5.3	49.1	
11	9.8	4.9	44.1	
12	9.1	4.7	41.3	
13	8.8	4.6	40.3	
14	8.4	4.5	38.9	
15	8.2	4.3	37.4	
16	8.1	4.2	36.2	
17	7.8	2.4	20.3	

July 21, 2003

RVCA

Depth (metres)	Average Temperature (°C)	Average D.O. (mg/L)	Percent Saturation	Lake Stratification
0.1	21.9	6.6	75.9	Epilimnion
1	21.9	6.5	74.7	
2	21.9	6.5	74.7	
3	21.8	6.5	74.6	
4	21.8	6.5	74.6	
5	21.8	6.4	74.0	
6	21.7	6.4	73.3	
7	21.6	6.3	72.6	
8	16.8	4.9	50.8	Metalimnion
9	13.3	3.2	30.7	
10	11.6	2.1	19.2	
11	10.5	1.8	16.0	
12	10.1	1.4	12.2	Hypolimnion
13	9.6	1.0	9.0	
14	9.4	0.8	7.1	
15	9.3	0.6	4.9	
16	8.9	0.3	2.6	
17	8.8	0.3	2.2	
18	8.8	0.2	1.8	
19	8.8	0.2	1.3	
20	8.8	0.1	0.9	

August 18, 2003

RVCA

Depth (metres)	Average Temperature (°C)	Average D.O. (mg/L)	Percent Saturation	Lake Stratification
0.1	24.9	6.5	79.4	Epilimnion
1	24.7	6.5	78.5	
2	24.6	6.5	79.0	
3	24.6	6.5	78.9	
4	24.5	6.5	78.8	
5	24.1	6.5	77.7	Metalimnion
6	22.7	6.0	70.5	
7	20.1	4.8	53.8	
8	17.6	3.0	32.0	
9	14.4	0.4	3.5	
10	12.3	0.1	1.2	Hypolimnion
11	10.8	0.1	0.6	
12	10.0	0.1	0.7	
13	9.7	0.1	0.5	
14	9.4	0.1	0.5	
15	9.2	0.0	0.4	
16	9.0	0.1	0.4	
17	8.8	0.1	0.4	
18	8.7	0.1	0.4	
19	8.6	0.0	0.4	
20	8.5	0.0	0.3	

September 15, 2003

RVCA

Depth (metres)	Average Temperature (°C)	Average D.O. (mg/L)	Percent Saturation	Lake Stratification
0.1	21.7	8.3	95.8	Epilimnion
1	21.7	8.3	95.9	
2	21.7	8.3	95.9	
3	21.7	8.3	95.2	
4	21.6	8.3	95.1	
5	21.3	8.2	93.5	
6	20.8	8.0	90.3	
7	19.9	7.1	79.2	
8	19.8	6.9	76.2	
9	19.4	6.1	66.8	Metalimnion
10	15.3	0.2	2.0	
11	11.7	0.1	0.5	
12	10.3	0.1	0.5	Hypolimnion
13	9.9	0.0	0.0	
14	9.3	0.0	0.0	
15	9.0	0.0	0.0	
16	9.0	0.0	0.0	
17	8.8	0.0	0.0	
18	8.8	0.0	0.0	
19	8.8	0.0	0.0	
20	8.8	0.0	0.0	

October 6, 2003

RVCA

Depth (metres)	Average Temperature (°C)	Average D.O. (mg/L)	Percent Saturation	Lake Stratification
0.1	14.2	8.0	78.9	Epilimnion
1	14.3	7.8	77.5	
2	14.3	7.8	77.0	
3	14.2	7.7	76.4	
4	14.2	7.7	76.4	
5	14.2	7.7	75.9	
6	14.1	7.6	74.8	
7	14.1	7.6	74.8	
8	14.1	7.5	73.8	
9	14.1	7.4	73.2	
10	14.1	7.3	72.3	
11	14.1	7.3	71.8	
12	14.1	7.2	71.3	
13	13.0	4.3	41.1	Metalimnion
14	10.5	0.2	1.8	
15	10.1	0.2	1.4	Hypolimnion
16	9.9	0.2	1.4	
17	9.5	0.1	0.9	
18	9.4	0.1	0.4	
19	9.3	0.1	0.4	
20	9.3	0.0	0.0	
21	9.3	0.0	0.0	
22	9.2	0.0	0.0	

August 20, 2001

MOE

Depth (metres)	Average Temperature (°C)	Average D.O. (mg/L)	Percent Saturation	Lake Stratification
0	23.6	7.5	89.1	Epilimnion
1	23.5	7.6	90.2	
2	23.4	7.3	86.5	
3	23.4	7.3	86.5	
4	23.4	7.2	85.3	
5	23.4	7.2	85.3	
6	23.4	7.2	85.3	
7	23.2	6.7	79.1	
8	20.5	3.6	40.5	
9	15.8	0.5	5.1	Metalimnion
10	12.9	0.2	1.9	
11	11.5	0.2	1.9	
12	10.9	0.2	1.8	Hypolimnion
13	10.4	0.2	1.8	
14	10.1	0.1	0.9	
15	9.8	0.1	0.9	
16	9.6	0.1	0.9	
17	9.6	0.1	0.9	
18	9.5	0.1	0.9	

