Environmental Studies of the Halfway River System Impoundments Nova Scotia

Prepared for

Minas Basin Pulp and Power Ltd.

By

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Executive Summary

As part of the renewal process for approval of storage and use of water in the Halfway River system by Minas Basin Pulp and Power Limited, a number of environmental studies were carried out at two impoundments located on the Halfway River. These studies included a database survey, carried out by the Atlantic Canada Conservation Data Centre, on the presence of significant wildlife habitats, rare, endangered or species at risk known to exist within the study area, and field and laboratory water quality surveys and assessments of fish species presence and abundance.

Results of the water quality surveys indicate both impoundments to have very low biological productivity as a result of both low nutrient availability and low light availability. Nitrogen and phosphorus concentrations are very low. The low light availability within the water column of the impoundments is a result of highly coloured water due to the presence of dissolved humic and fluvic acids originating from terrestrial leachates of coniferous vegetation. Both impoundments can be characterized as being dystrophic systems. Despite their low biological productivity, both impoundments have a relatively high pH and alkalinity and do not appear to be impacted by acidic precipitation.

Gill net and minnow trap collections within the impoundments yielded five fish species. These included white sucker (*Catostomus commersoni*), American eel (*Anguilla rostrata*), banded killifish (*Fundulus diaphanous*), golden shiner (*Notemigonus cryoleucas*) and creek chub (*Semotilus atrmaculatus*). The most common species caught was white sucker. No brook trout (*Salvelinus fontinalis*) were collected from either impoundment. Neither of the impoundments appears to have suitable summer habitat for cold-water fish species such as book trout.

Results of the Atlantic Canada Conservation Data Centre survey indicate no records for significant wildlife habitats, rare, endangered or species at risk exist within the areas influenced by management of water levels in the impoundments.

Comparisons of the results obtained from this survey with a more a more intensive survey carried out in 2001 suggest that little change has occurred in environmental conditions within the impoundments which, although low in biological productivity, appear to be relatively pristine.

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Environmental Studies of the Halfway River System Impoundments

1. Introduction

During the period between 4 August and 18 September 2012, the Acadia Centre for Estuarine Research (ACER) carried out environmental studies of two impoundments located within the Halfway River system as part of the renewal process for approval of storage and use of water by Minas Basin Pulp and Power Limited in the Halfway River system. The environmental studies focused on items specified in the Terms of Reference, dated June 2012, prepared by Nova Scotia Environment (NSE). These included the following major components:

A desktop study, carried out using data available from the Atlantic Canada Conservation Data Centre (ACCDC), on database records of presence of significant wildlife habitats, rare or endangered species and species at risk which occur within the area affected by water storage and use,

A survey of water quality within each impoundment,

A survey of the species present, age/size class distribution and mercury levels of fish species within each impoundment and,

A comparison of the findings with those obtained from previous studies carried out in 2001.

2. Personnel

Overall project supervision and budget control was coordinated by Dr. Anna Redden, Director of the Acadia Centre for Estuarine Research (ACER). The following persons comprised the research team:

Dr. Michael Brylinsky – Research Associate, ACER

Mr. Jeremy Broome – Research Operations Manager, ACER

Ms. Freya Keyser –B.Sc.H. – Biology, Acadia University

Mr. Mathew Baker – MSc. Candidate - Biology, Acadia University

3. Methodologies

3.1 Identification of Significant Wildlife Habitats and Rare, Endangered or Species at Risk

The Atlantic Canada Conservation Data Centre (ACCDC) was contracted to provide information contained within their databases on the presence of significant wildlife habitats, rare, endangered or species at risk known to exist within the study area that may be affected by water storage and use. The specific request made was that this be carried out for a spatial coverage that included the entire area within a radius of 10 km around a centroid located approximately at a point equidistant from the centre of each impoundment.

3.2 Water Quality

The water quality sampling methodologies and protocols used in this survey were the same as those used in surveys carried out in 2001 (Daborn et.al. 2001). The water quality surveys were carried out on the 8th and 9th of August 2012. The location chosen for each water quality sampling station was the same as that used in the 2001 impoundment surveys. The general approach used in collecting water quality data was to measure depth profiles of water temperature, dissolved oxygen and percent dissolved oxygen saturation using a Yellow Springs Instrument YSI 6920 Sonde or a YSI Model 95 Dissolved Oxygen Meter. Water quality samples were then collected at a depth of 0.5 m below the surface and 1.0 m above the bottom. In addition, a Secchi Disk depth measurement was made at each station.

Once collected the water quality samples were kept cool and in the dark until couriered within 24 hours of collection to the Environmental Services Laboratory of the QE II Health Science Centre in Halifax for analyses. In addition to the concentration of 18 metals, a total of 18 water quality parameters were measured at each site. These are listed in Appendix I.

3.3 Fish Surveys

Fish surveys within the lower and upper impoundment were carried out on the 13th and 17th of September 2012, respectively, using experimental gill nets and minnow traps. The experimental gill nets consisted of four eight metre long by two metre deep panels having stretched mesh sizes of 2.5, 5.0, 6.5 and 8.0 cm. The minnow traps were standard sized traps baited with dry dog food.

Two gill nets and two minnow traps were set during each survey. At each set site, a net and minnow trap were set in close proximity to each other. The sets were made at dusk and retrieved at dawn the following morning. The total time of each set typically ranged between 10-12 hours.

The numbers and species of all fish collected in the nets and minnow traps were recorded and, with the exception of white suckers, which were often the most numerous species collected in the gill nets, gill net collections of fish species having recreational or commercial importance were retained for length/weight determinations and tissue mercury analysis.

Fish specimens retained for tissue mercury analysis were frozen within three hours of collection. Samples were prepared for analysis by removal and homogenization of approximately 30 gram samples of epaxial muscle tissue which were kept frozen until sent for analysis by Maxxam Analytics at their Bedford, Nova Scotia laboratory.

4. Results

4.1 ACCDC Survey

The report produced by ACCDC is contained in Appendix II. Fig. 4.1 is a map showing the location of each set of records.[1]

The 10 km buffer area around the study area contains 376 records of 83 taxa from 27 sources for rare and/or protected flora and fauna, which is stated in the report to be a relatively low density of records. Of the 373 records, 106 were for flora and 267 were for fauna. The records for flora consist entirely of nonvascular as opposed to vascular species. The records for fauna consist of 50 vertebrate species and three invertebrate species as well as records for wood turtles and peregrine falcons.

The 10 km buffer area includes an area much larger than the two impoundments. There were no records in close proximity to either of the impoundments and there appears to be very few records located within the entire Halfway River watershed.

In an extensive survey of riparian and sublittoral vegetation within the Halfway River system, carried out in 2001 by personnel of the E.C. Smith Herbarium at Acadia University, no species of concern, rare or endangered or of special interest were recorded.

[1] Appendix II contains a more detailed map showing the taxa reported at each location.

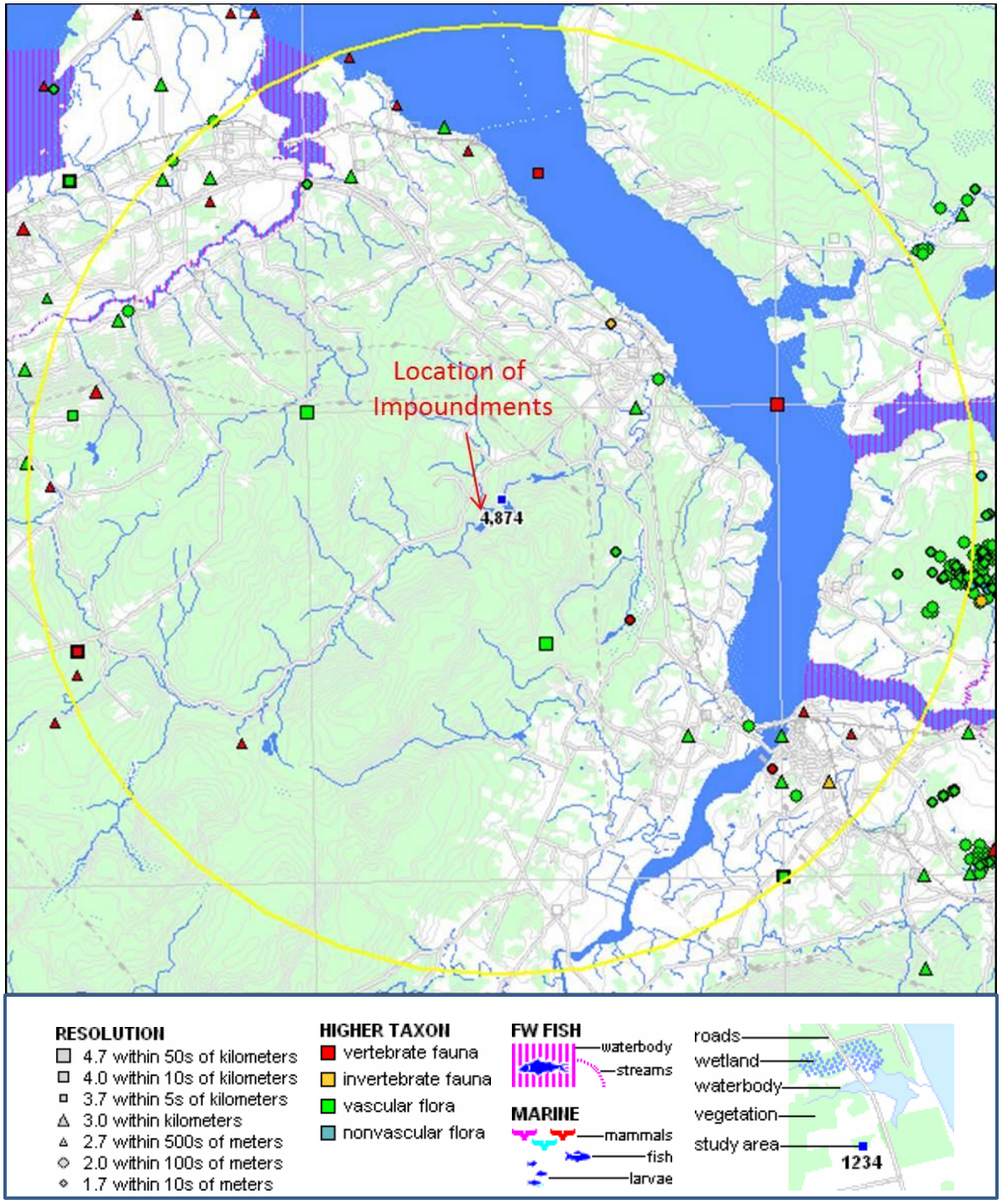

Fig. 4.1 Map showing location of each record set in relation to the location of the two impoundments (the yellow circle delineates the 10 km buffer area).

4.2 Water Quality

Results of water quality analyses carried out by the QE II Environmental Services Laboratory are contained in Appendix III. The locations of the stations at which water quality measurements were made and samples collected in each impoundment are shown in Fig. 4.2.1.

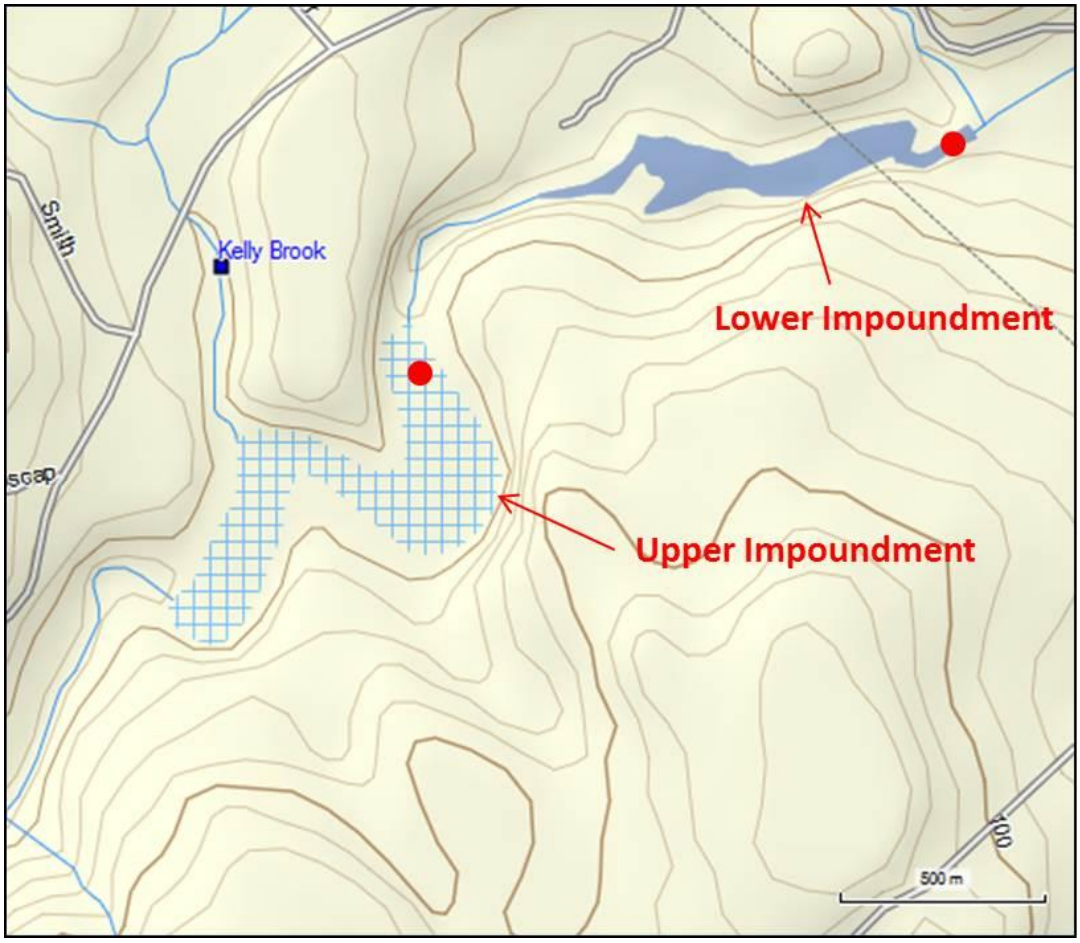

Fig. 4.2.1 Location of water quality sampling stations (●).

4.2.1 Water Temperature and Water Column Stratification

Depth profiles of water temperature for the summers of 2001 and 2012 are shown in Fig. 4.2.2 and 4.2.3. Within the upper impoundment summer water temperatures and water column stratification were similar in both 2001 and 2012. A strong thermocline existed between two and four metres depth and a relatively cold water layer was contained in a four metre deep

hypolimnion. The difference in temperature between surface and bottom waters in both years was also similar at about 17 °C.

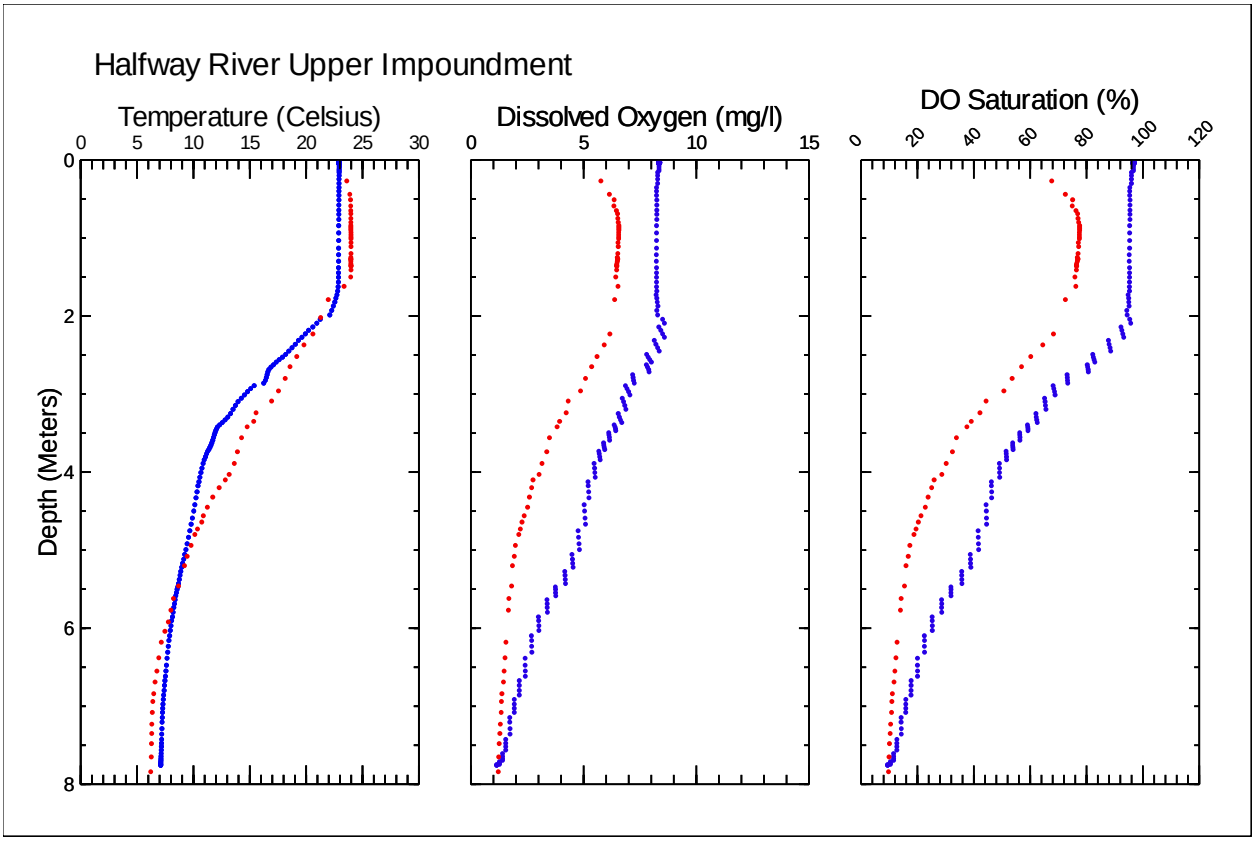

Fig.4.2.2 Temperature, dissolved oxygen and percent dissolved oxygen depth profiles for the upper impoundment during the summer of 2001 (blue) and 2012 (red).

Within the lower impoundment, water temperature and water column stratification were also similar during the summers of 2001 and 2012. Although there was evidence of the presence of a thermocline, it was located very near the bottom and there was no hypolimnion present. This type of stratification is typical of impoundments in which water is withdrawn from the bottom.

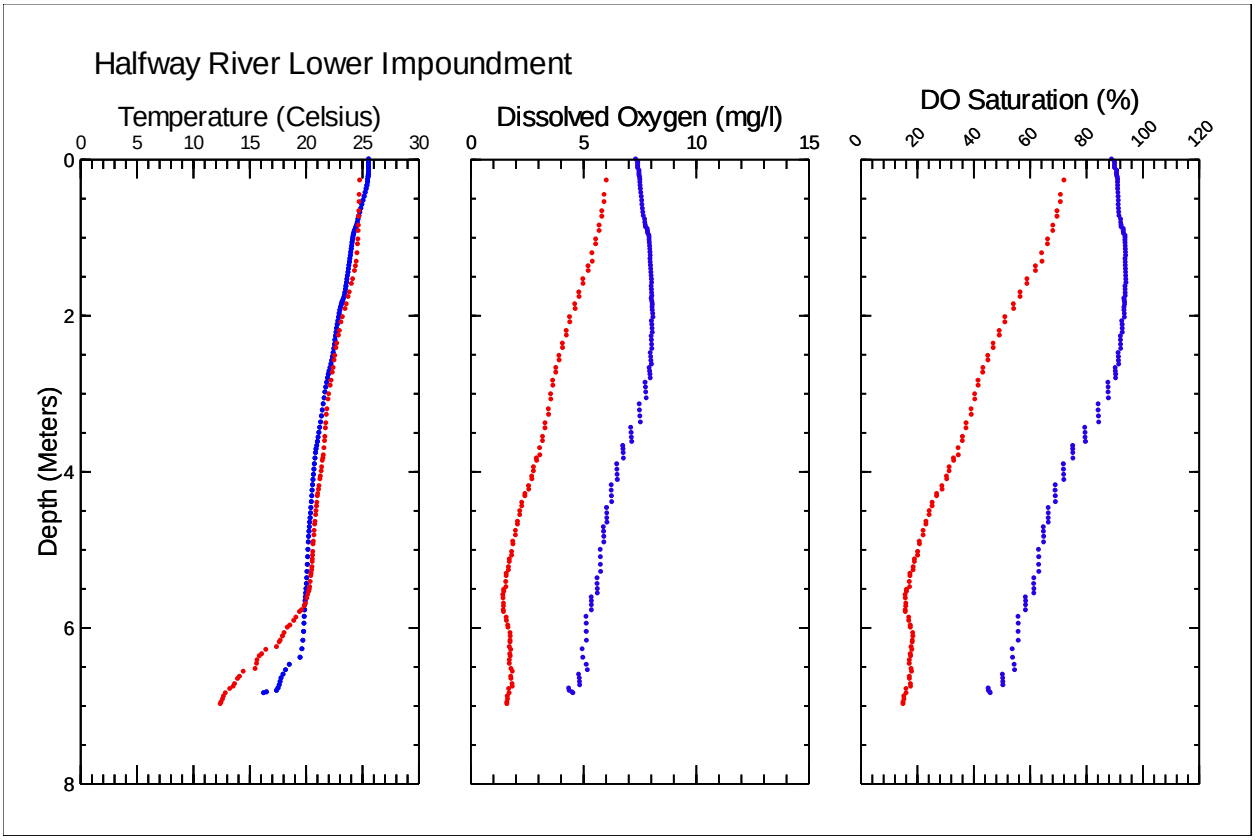

Fig.4.2.3 Temperature, dissolved oxygen and percent dissolved oxygen depth profiles for the lower impoundment during the summer of 2001 (blue) and 2012 (red).

4.2.2 Dissolved Oxygen and Percent Dissolved Oxygen Saturation

Depth profiles of dissolved oxygen and percent dissolved oxygen stratification during summer (Fig. 4.2.2 and 4.2.3) in both the upper and lower impoundments showed the same trend of a decrease with depth in both 2001 and 2012. Although the levels of both dissolved oxygen and percent dissolved oxygen saturation at all depths in both impoundments were less in 2012 than 2001, neither of the impoundments became completely anoxic.

4.2.3 Nutrient Levels and Trophic Status

The productivity of an aquatic ecosystem is a function of the availability of nutrients and the availability of light. The level of productivity of an aquatic ecosystem is typically characterized by its trophic status. There are five broad trophic states: (1) hyper-oligotrophic systems having very low productivity; (2) oligotrophic systems having low productivity; (3) mesotrophic

systems having moderate productivity; (4) eutrophic systems having high productivity and; (5) hyper-eutrophic systems having very high productivity.

The water quality parameters most commonly used for assessing the trophic status of a freshwater ecosystem have been developed by the Organization for Economic Cooperative Development (OECD 1982). Table 4.1 is a list of the parameters used and the values considered to be representative of each trophic category.

Table 4.1 OECD boundary conditions for trophic categories.

Trophic Category	**Parameter**		
	Total Phosphorus (mg/L)	Chlorophyll *a* (µg/L)	Secchi Depth (m)
Ultra-oligotrophic	< 0.004	< 1.0	≥ 6.0
Oligotrophic	≥ 0.004 - < 0.010	≥ 1.0 - < 2.5	≥ 3.0 - < 6.0
Mesotrophic	≥ 0.010 -.< 0.035	≥ 2.5 - < 8.0	≥ 1.5 - < 3.0
Eutrophic	≥ 0.035 - < 0.100	≥ 8.0 - < 25.0	≥ 0.7 - < 1.5
Hyper-eutrophic	≥ 0.100	≥ 25.0	< 0.7

Trophic status is based primarily on surface water nutrient concentration, surface water algal biomass and water transparency. The nutrient most important in determining the productivity of freshwater systems is phosphorus which, in most freshwater ecosystems, is the limiting factor for algal growth. Secchi Depth is a measure of water transparency and serves as an index of the degree to which light can penetrate into the water column. Algal biomass is normally measured as the concentration of chlorophyll *a*, the major photosynthetic pigment contained in algae. Phosphorous is the causal parameter and chlorophyll *a* and Secchi Disk depth are the response parameters. As phosphorus increases, chlorophyll *a* increases, which results in a decrease in water transparency and Secchi Disk depth.

There are a number of potential shortcomings in applying these criteria to the survey results obtained for this study. One is that the OECD criteria values listed in Table 4.1 are annual mean values, but the surveys for each lake were carried out on only one date which precludes the calculation of annual values.

A second, and more important shortcoming, is that a sixth tropic category, *dystrophic* (which literally means abnormal feeding) exists. Dystrophic lakes are characterized as being highly colored as a result of the run-off of dissolved humic and fluvic acid leachates originating from the decomposition of coniferous plants within a lakes watershed. These leachates impart a dark brown color to the water that can severely limit penetration into the water column. As a result,

dystrophic lakes often have very low Secchi Disk depths that are not indicative of high algal biomass and may be limited by light as well as phosphorous. The OECD criteria is based on the assumption that only phosphorus, and not light, is the factor limiting algal growth. In this case the only valid OECD criterion applicable for determination of trophic status is chlorophyll *a* concentration.

The values of each trophic parameter and the trophic category of each impoundment during the summers of 2001 and 2012 are listed in Table 4.2. These impoundments are obviously dystrophic and relatively unproductive as a result of both low phosphorus levels and low light availability due to dissolved humic substances. The higher chlorophyll *a* levels in 2012 compared to 2001 suggest the former to have been a slightly more productive year, possibly due to lower levels of water colour resulting in greater light availability.[2]

Table 4.2 OECD trophic categories for each impoundment in 2001 and 2012.

Site	Year	Trophic parameter values*			Trophic Category
		Total Phosphorus (mg/L)	Chlorophyll *a* (µg/L)	Secchi Depth (m)	
Lower Impoundment	2001	<0.1	< 0.5	1.8	Ultra-oligotrophic**
	2012	0.006	1.4	1.9	Oligotrophic
Upper Impoundment	2001	<0.1	< 0.5	1.8	Ultra-oligotrophic**
	2012	0.006	1.7	2.1	Oligotrophic

*The method used for measurement of total phosphorus in 2001 lacked the sensitivity required for use of this parameter in the assessment of trophic status.
**Based on chlorophyll *a* alone.

4.2.4 Alkalinity, pH and Related Parameters

Alkalinity, a measure of buffering capacity, and pH are important water quality parameters with respect to the ability of a lake to support healthy aquatic communities. Many Nova Scotia lakes and rivers, particularly those located within the southwestern region of the province, have low alkalinities and have become acidified to the point where pH values are at times as low as four as a result of acid precipitation originating from industrial areas located in western Canada and the

[2] See Section 4.2.6 for colour values.

northeastern United States. Table 4.3 lists the alkalinity, pH and a number of related water quality parameters for each impoundment measured during the summers of 2001 and 2012.

The levels of conductivity (a crude measure of salt content) indicate relatively soft water. Despite this, alkalinity and pH, which are controlled largely by bicarbonates, are both quite high indicating water that is well buffered from changes in pH and that neither of the impoundments has been impacted by high levels of acidic precipitation.

There is little difference between 2001 and 2012 in any of these water quality parameters.

Table 4.3 Levels of alkalinity, pH and related water quality parameters in surface and bottom waters for each impoundment during the summers of 2001 and 2012.

Site	Date	Water Depth (m)	Conductivity (μS/cm)	Bicarbonate (as CaCO3) (mg/L)	Alkalinity (as $CaCO_3$) (mg/L)	pH
Upper Impoundment	2001	0.5	55.0	14.0	14.0	7.2
	2001	7.0	68.0	24.0	24.0	7.3
	2012	0.5	59.7	14.6	14.7	7.6
	2012	7.0	75.8	27.7	27.8	7.6
Lower Impoundment	2001	0.5	54.0	14.0	14.0	7.3
	2001	6.0	54.0	14.0	14.0	7.3
	2012	0.5	57.6	13.7	13.6	7.6
	2012	6.0	60.6	15.4	15.5	7.5

4.2.5 Metals

The concentration of 18 different metals was measured for surface and bottom waters at each impoundment. The results are contained in Appendix III. The Canadian Council of Ministers for the Environment (CCME) has established water quality guidelines for the protection of aquatic life for eight of these metals (CCME 1999). These guidelines and the levels measured in the impoundments during the summers of 2001 and 2012 are listed in Table 4.4.

In most instances metal concentrations were below the CCME guidelines. Exceptions were slightly higher aluminum concentrations in the bottom waters of the upper impoundment in both 2001 and 2012, and high iron levels in both surface and bottom waters of the upper impoundment during both 2001 and 2012, and in bottom waters of the lower impoundment during 2012. Bottom waters had the highest iron levels which is most likely a result of the soluble nature of iron compounds under conditions of low dissolved oxygen concentration and their subsequent movement from sediments into the water column.

Table 4.4 Concentration of eight metals measured for surface and bottom waters in each impoundment during the summers of 2001 and 2012, and the CCME levels established for the protection of aquatic life in freshwater systems (numbers in bold indicate levels that exceed the CCME guideline).

Site	Year	Water Depth (m)	Aluminum	Chromium	Copper	Iron	Lead	Nickel	Selenium	Zinc
	CCME Guideline (µg/L) ►		<100	<8.9	<4	<300	<3	<25	<1.6	<30
Upper Impoundment	2001	0.5	20	<2	<2	**320**	<0.5	<2	<2	4
	2001	7.0	**120**	<2	<2	**5300**	<0.5	2	<2	6
	2012	0.5	52	<2	<2	**359**	<2	<2	<2	<6
	2012	7.0	**125**	<2	4	**6546**	<2	2	<2	9
Lower Impoundment	2001	0.5	10	<2	2	230	<0.5	<2	<2	6
	2001	6.0	10	<2	<2	260	<0.5	<2	<2	4
	2012	0.5	38	<2	<2	**374**	<2	<2	<2	<6
	2012	6.0	54	<2	3	**923**	<2	<2	<2	12

4.2.6 Turbidity, Suspended Particulate Matter and Colour

Turbidity, a measure of the scattering of light due to suspended particles, and suspended particulate matter (SPM), a direct gravimetric measure of the concentration of suspended particulate matter, were relatively low within the surface waters of both impoundments during

the summers of both 2001 and 2012 (Table 4.5). Water colour, however, was relatively high, especially for bottom waters.

The low values for turbidity and SPM suggest that shoreline erosion or sediment input by overland flow or river inputs were also low during the survey periods.

Table 4.5 Turbidity, SPM and colour for surface and bottom waters in each impoundment during the summers of 2001 and 2012.

Site	Date	Water Depth (m)	Turbidity (NTUs)	SPM (mg/L)	Colour (NTUs)
Upper Impoundment	2001	0.0	1.20	3.0	21
	2001	7.0	14.40	6.8	144
	2012	0.5	1.75	3.0	11
	2012	7.0	25.70	11.0	66
Lower Impoundment	2001	0.5	0.60	2.4	22
	2001	6.0	3.20	5.2	40
	2012	0.5	1.47	2.0	11
	2012	6.0	5.63	4.0	10

5. Fish Surveys

Gill nets and minnow traps were set within the upper impoundment on September 13-14 and within the lower impoundment on September 17-18. Two gillnets and two minnow traps were set in each of impoundments. The minnow traps were set along the shoreline in shallow water and in close proximity to each gill net. The location of each gill net set is shown in Fig. 5.1.

5.1 Fish Species Diversity and Relative Abundance

A total of five species of fish were collected from the two impoundments. These included white sucker (*Catostomus commersoni*), American eel (*Anguilla rostrata*), banded killifish (*Fundulus diaphanous*), golden shiner (*Notemigonus cryoleucas*) and creek chub (*Semotilus atrmaculatus*). White sucker, American eel and creek chub were collected in both impoundments. Banded killifish and golden shiner were only collected in the lower impoundment. The most common species caught was white sucker.

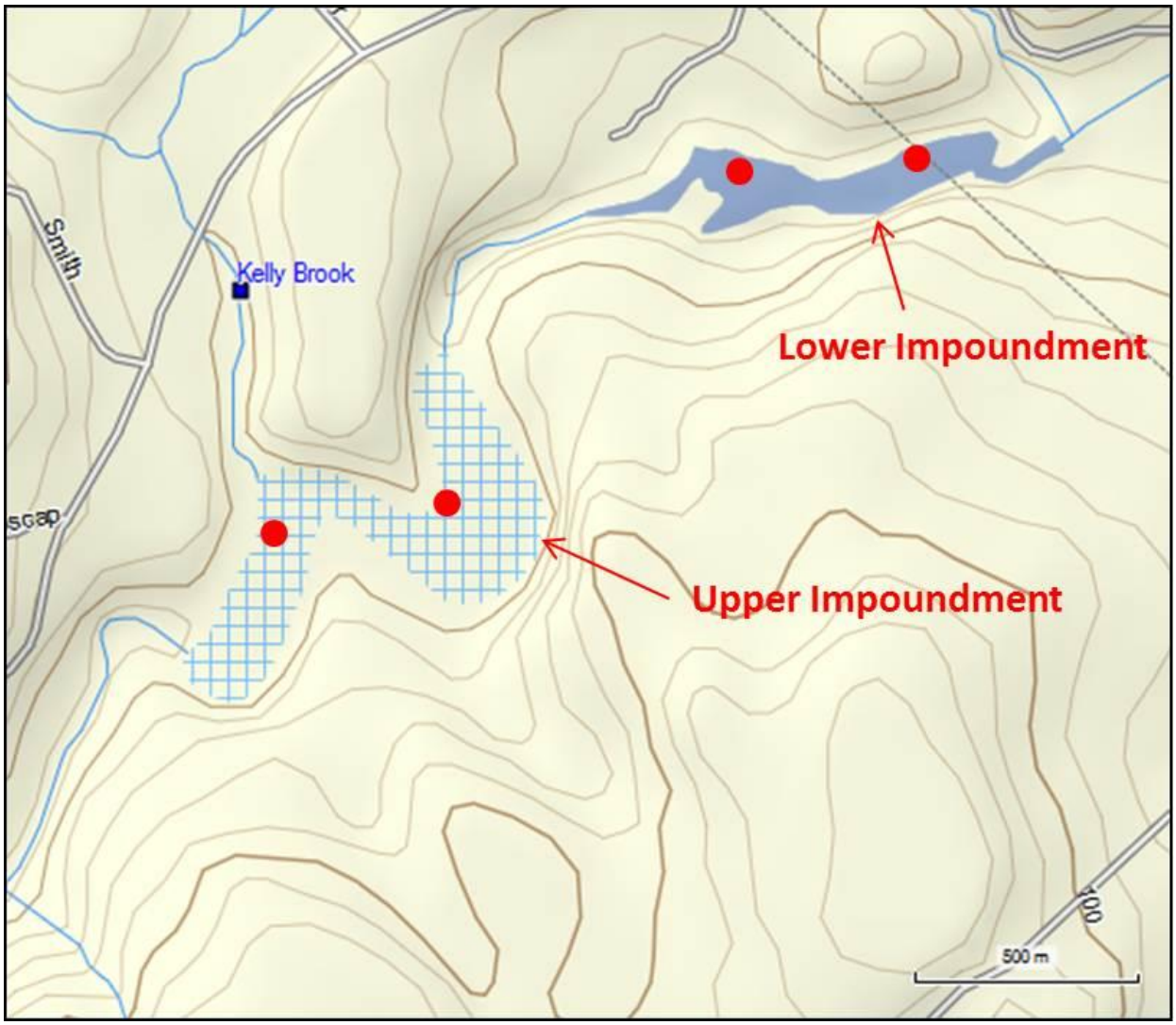

Fig. 5.1 Location of gill net and minnow trap sets in 2012.

Eels were collected in both impoundments, but only in low numbers and in minnow traps as they are not typically captured in gill nets. However, they may be quite numerous in both impoundments as there was considerable predation on fish that had been captured by the gill nets.

No brook trout (*Salvelinus fontinalis*) were collected from either impoundment. Neither of the impoundments appears to have suitable summer habitat for cold-water fish species such as book trout. Water temperatures within the upper water layers of the impoundments were near or above 20 C, which is above the temperature tolerance of brook trout and, although both impoundments contain cold water within the water column below five metres, percent dissolved oxygen saturation levels below two metres depth are less than 50 % (see Section 4.2.1) which is considered to be the lower tolerance limit for most aquatic organisms.

Table 5.1.1 contains the number and species of fish collected during the summers of 2001 and 2012.

Table 5.1 Summary of fish collections within the upper and lower impoundments during the summers of 2001 and 2012.

Site	Year	Method			Location		Total Number Fish Collected	Total Number Species Collected	Species					
		Gill Net	Angling	Minnow Trap	Northing	Easting			*S. fontinalis*	*C. commersoni*	*A. rostrata*	*F. diaphanous*	*N. cryoleucas*	*S. atromaculatus*
Upper Impoundment	2001	X			4987834	403765	3	1		3				
	2001	X			4987811	403932	31	2	2	29				
	2001			X	4987627	403653	30	2		20			10	
	2001			X	4987627	403653	0	0						
	2001			X	4987627	403653	13	2		12				
	2001			X	4987627	403653	0	0						
	2012	X			4987688	403764	3	2		2				1
	2012	X			4987803	404110	3	23		21	1		1	
	2012			X	4987688	403764	0	0						
	2012			X	4987803	404110	7	1						7
Lower Impoundment	2001	X			4988562	405452	6	1		6				
	2001	X			4988497	405139	7	1		7				
	2001			X	4988599	404863	0	0						
	2001			X	4988599	404863	7	2				6		
	2001			X	4988599	404863	7	2		1		6		
	2001			X	4988599	404863	0	0						
	2012	X			4988615	404841	0	0						
	2012	X			4988564	405193	7	1		6			1	
	2012			X	4988615	404841	7	3		1		3		3
	2012			X	4988564	405193	2	1			2			

With the exception of the one brook trout collected in the upper impoundment during the summer of 2001, the species present and their relative abundances collected in 2012 were very similar.

5.2 Condition Indices and Tissue Mercury Levels

The only recreationally or commercially important fish species collected form the two impoundments was the American eel and the total number was only three individuals, an insufficient number to carry out a meaningful analysis of length/weight relationships and condition indices. Tissue mercury levels, however, were determined for the three American eels collected. All of the eels were collected in the minnow traps set alongside the gill nets. One eel was collected in the Upper Impoundment and two were collected from the Lower Impoundment. The one eel from the Upper Impoundment, which was 47.3 cm in total length and weighed 152.5 grams, had tissue mercury content of 0.31 mgHg/Kg wet weight. Of the two eels collected from the Upper Impoundment one had a total length 40.0 cm, a total weight of 281 grams and a tissue mercury level of 0.37 mgHg/Kg wet weight, and the other had a total length of 54.0 cm, a total weight of 307 grams and a tissue mercury level of 0.7 mgHg/Kg wet weight. Only the latter exceeded the Health Canada guideline of 0.5 mgHg/Kg wet weight.

6. Discussion

Although both the lower and upper impoundments are characterized by low productivity and low biological diversity with respect to the species of fish present, they appear to be relatively pristine. There is little evidence that they are being impacted by some of the more common problems encountered by aquatic systems within Nova Scotia such as nutrient over-enrichment leading to eutrophication, acidic precipitation, high sediment loading due to shoreline or upstream erosion, and introduction of exotic fish species such as smallmouth bass and pickerel.

The ACCDC survey produced very few records of significant wildlife habitats, rare, endangered or species at risk within the areas that are influenced by management of water levels in these impoundments.

Comparison of the results obtained in this survey differed very little form the results obtained in a similar summer survey carried out in 2001 suggesting that both impoundments have undergone little change over the past eleven years.

7. References

CCME. 1999. Canadian water quality guidelines for the protection of aquatic life. Canadian Environmental Guidelines. Canadian Council of Ministers of the Environment.

Daborn, G.R., M. Brylinsky and R. Newell. 2001. Environmental studies of the Halfway River System, Nova Scotia. Report prepared for Minas Basin Pulp and Power Company Limited. Acadia Centre for Estuarine Research Publication No. 62. 127p.

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APPENDIX I. Water Quality Parameters and Metals Measured at Each Site.

Parameters	Metals
Conductivity	Aluminum
pH	Antimony
Alkalinity as CaCO3	Barium
Total Nitrogen	Beryllium
Nitrate Nitrite (N) Low Range	Boron
Ammonia (N) Low Range	Cadmium
Ortho Phosphorus (P) Low Range	Chromium
Total Phosphorus Low Range	Cobalt
Silica	Copper
Sulfate	Iron
Chlorophyll *a*	Lead
Calcium	Magnesium
Chloride	Manganese
Potassium	Nickel
Sodium	Selenium
Suspended Solids	Tin
Total Organic Carbon	Vanadium
Turbidity	Zinc

APPENDIX II - ACCDC Report

Atlantic Canada Conservation Data Centre
Centre de données sur la conservation du Canada Atlantique

DATA REPORT 4874: Halfway River, AC

Prepared 12 September, 2012
by C.D. Spicer, Assoc. Data Manager

CONTENTS OF REPORT

1.0 PREFACE

The Atlantic Canada Conservation Data Centre (ACCDC) is part of a network of circa 85 NatureServe data centres and heritage programs in 50 states, 10 provinces and 1 territory, plus several Central and South American countries. The NatureServe network is more than 30 years old and shares a common conservation data methodology. The ACCDC was founded in 1997, and maintains data for the jurisdictions of New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador. Although a non-governmental agency, the ACCDC is supported by 6 federal agencies, plus 4 provincial governments, outside grants and data processing fees. URL: www.ACCDC.com.

Upon request and for a fee, the ACCDC reports known observations of rare and endangered flora and fauna, in and near a specified study area. As a supplement to that data, the ACCDC includes locations of managed areas with some level of protection, and also known sites of ecological interest. Data summarised in each report is attached as DBF files which may be opened from within data software (Excel, Access) or mapped in GIS (ArcView, MapInfo, AutoCAD).

1.1 RESTRICTIONS

The ACCDC makes a strong effort to verify the accuracy of all the data that it manages, but it shall not be held responsible for any inaccuracies in data that it provides. By accepting ACCDC data, recipients assent to the

following limits of use:
a.) Data is restricted to use by trained personnel who are sensitive to landowner interests and the potential threat of the information contained here to rare and/or endangered flora and fauna.
b.) Data is restricted to use by the specified Data User; any third party requiring data must make its own data request. c.) The ACCDC requires Data Users to cease using and delete data 12 months after receipt.
d.) ACCDC data responses are restricted to that data in our Data System at the time of the data request.
e.) Data is qualified in regard to locational uncertainy and period of observation; cf Data Dictionary for details. f.) ACCDC data responses are not to be construed as exhaustive inventories of taxa in an area.
g.) The non-occurrence of a taxon cannot be inferred by its absence in an ACCDC data response.

1.2 ADDITIONAL INFORMATION

Please direct biological questions about ACCDC data to: Stefen Gerriets, ACCDC: (506) 364-2657, and technical data queries to: Diane Amirault, CWS: (506) 364-5060.

For provincial information on rare taxa and protected areas, or information on game animals, deer yards, old growth forest, archeological sites, fish habitat etc, please contact Sean Blaney, ACCDC: (506) 364-2658

2.0 RARE AND ENDANGERED TAXA

A 10km buffer around the study area contains 376 records of 83 taxa from 27 sources, a relatively low density of records (quintile 1): 0.01 rec/km2.

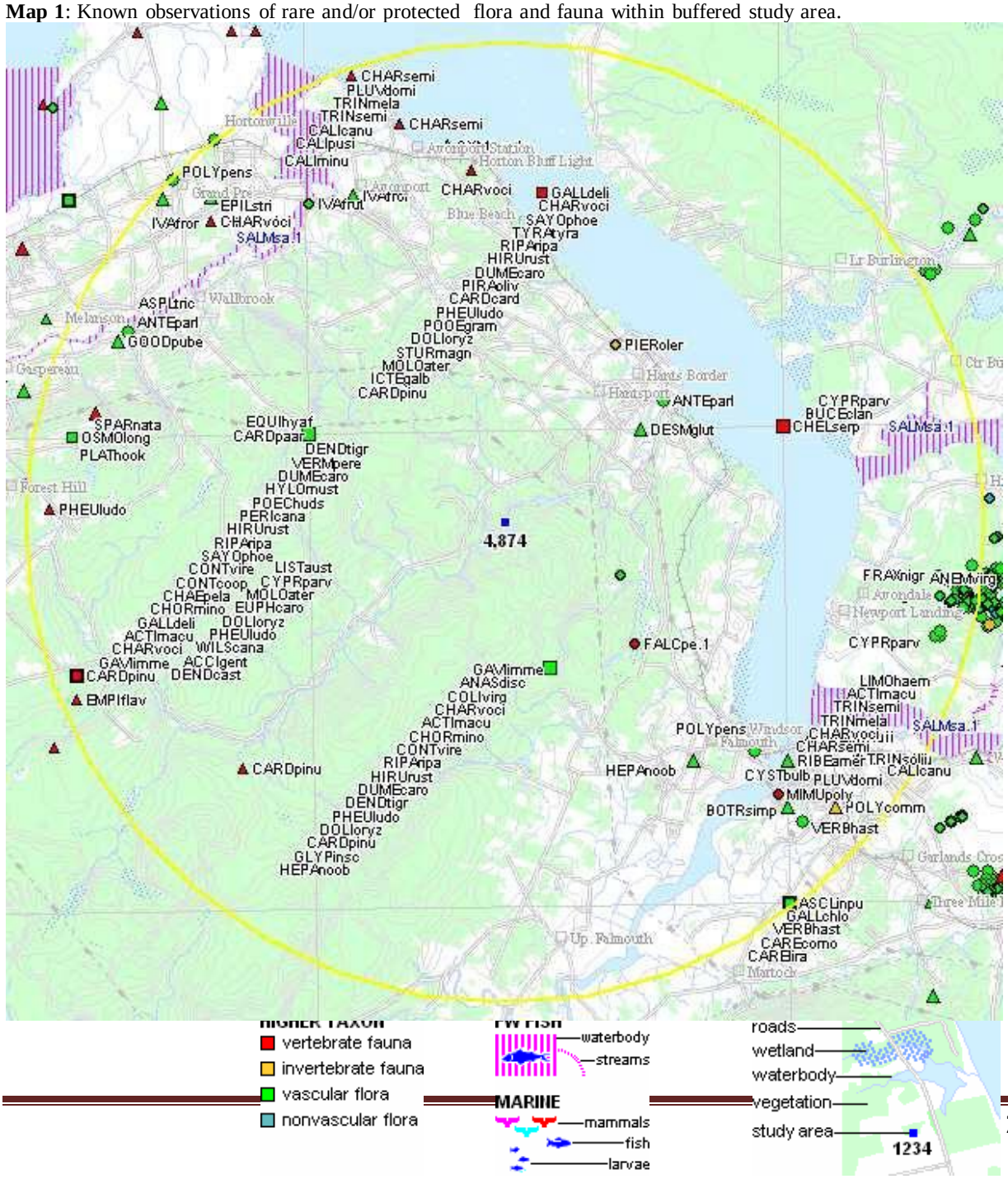
2.1 FLORA

A 10km buffer around the study area contains 106 records of 31 vascular, 0 records of nonvascular flora (see attached *ob.dbf).

2.2 FAUNA

A 10km buffer around the study area contains 267 records of 50 vertebrate, 3 records of 2 invertebrate fauna (cf attached *ob.dbf). Sensitive data: Wood Turtles are PRESENT in the study area (cf attached WOTU.rtf). Peregrine Falcons are PRESENT in the study area (cf attached PEFA.rtf).

Map 1: Known observations of rare and/or protected flora and fauna within buffered study area.



RESOLUTION

- 4.7 within 50s of kilometers
- 4.0 within 10s of kilometers
- 3.7 within 5s of kilometers
- 3.0 within kilometers
- 2.7 within 500s of meters
- 2.0 within 100s of meters
- 1.7 within 10s of meters

3.0 SPECIAL AREAS

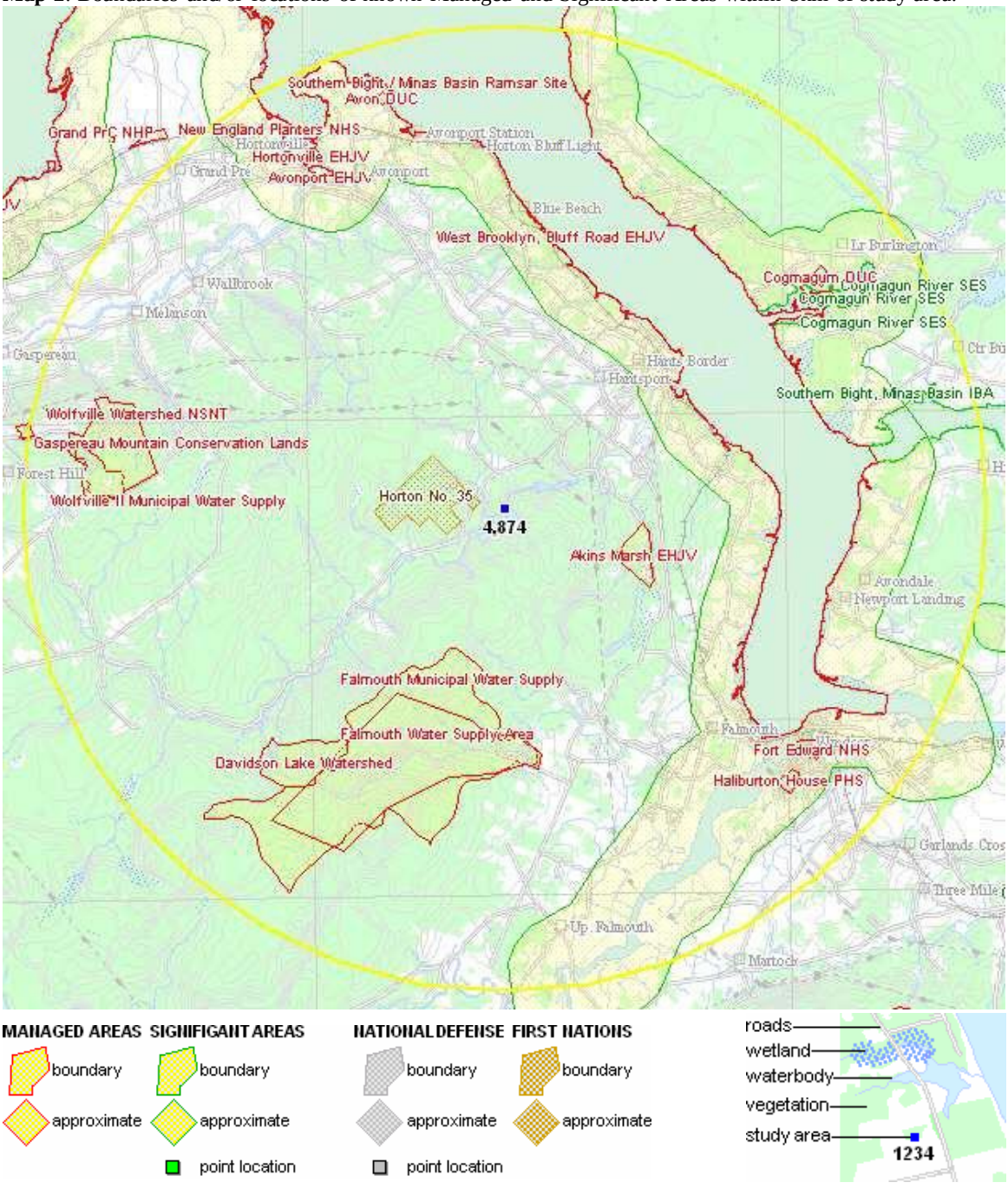
3.1 MANAGED AREAS

The GIS scan identified 16 Managed Areas with some degree of protected status, in the vicinity of the study area (see attached *ma.dbf).

3.2 SIGNIFICANT AREAS

The GIS scan also identified 5 biologically significant sites in the vicinity of the study area; such sites are known for exceptional biotic richness but may or may not have legal status (see attached *sa.dbf).

Map 2: Boundaries and/or locations of known Managed and Significant Areas within 5km of study area.



4.0 TAXON LISTS

Rare and/or endangered taxa within the buffered area listed in order of concern, beginning with legally listed taxa, with the number of observations per taxon and the distance in kilometers from study area centroid to the closest observation. [p] = vascular plant, [n] = nonvascular plant, [a] = vertebrate animal, [i] = invertebrate animal, [c] = community.

4.1 FLORA

	scientific name	common name	prov. rarity	prov. status	COSEW	IC	obs dist.km
p	Cypripedium arietinum	Ram's-Head Lady's-Slipper	S1	Endangered		14	10 ±0.1
p	Cryptogramma stelleri	Steller's Rockbrake	S1			1	9 ±0.1
p	Carex livida var. radicaulis	Livid Sedge	S1			1	10 ±10
p	Ribes americanum	Wild Black Currant	S1			1	8 ±1
p	Desmodium glutinosum	Large Tick-Trefoil	S1			2	3 ±1
p	Antennaria parlinii	Parlin's Pussytoes	S1			6	4 ±0.1
p	Hepatica nobilis var. obtusa	Round-lobed Hepatica	S1S2			4	3 ±0
p	Asplenium trichomanes	Maidenhair Spleenwort	S2			5	9 ±1
p	Spiranthes lucida	Shining Ladies'-Tresses	S2			1	8 ±1
p	Listera australis	Southern Twayblade	S2			1	10 ±10
p	Goodyera pubescens	Downy Rattlesnake-Plantain	S2			1	9 ±1
p	Carex comosa	Bearded Sedge	S2			1	10 ±5
p	Anemone virginiana	Virginia Anemone	S2			1	10 ±0.1
p	Vaccinium caespitosum	Dwarf Bilberry	S2			1	9 ±1
p	Shepherdia canadensis	Soapberry	S2			8	10 ±0.1
p	Cardamine parviflora var. arenicola	Small-flowered Bittercress	S2			1	5 ±10
p	Symphyotrichum undulatum	Wavy-leaved Aster	S2			2	8 ±1
p	Iva frutescens ssp. oraria	Big-leaved Marsh-elder	S2			2	8 ±1
p	Iva frutescens	Big-leaved Marsh-elder	S2			1	8 ±0
p	Osmorhiza longistylis	Smooth Sweet Cicely	S2			1	9 ±5
p	Botrychium simplex	Least Moonwort	S2S3			1	8 ±1
p	Cypripedium parviflorum	Yellow Lady's-slipper	S2S3			25	6 ±10
p	Fraxinus nigra	Black Ash	S2S3			11	9 ±0.1
p	Asclepias incarnata ssp. pulchra	Swamp Milkweed	S2S3			3	10 ±5
p	Sparganium natans	Small Burreed	S3			1	9 ±5
p	Platanthera hookeri	Hooker's Orchid	S3			1	9 ±5
p	Verbena hastata	Blue Vervain	S3			3	9 ±0.1
p	Polygonum pensylvanicum	Pennsylvania Smartweed	S3			3	7 ±0.1
p	Epilobium strictum	Downy Willowherb	S3			1	9 ±1
p	Equisetum hyemale var. affine	Common Scouring-rush	S3S4			1	5 ±10
p	Cystopteris bulbifera	Bulblet Bladder Fern	S3S4			1	8 ±1

4.2 FAUNA

	scientific name	common name	prov. rarity	prov. status	COSEW	IC	obs dist.km
a	Calidris canutus rufa	Red Knot	S2S3M	Endangered	E	11	9 ±0.5
a	Salmo salar pop. 1	Atlantic Salmon - Inner Bay of Fundy pop.	S2		E	3	16 ±0
a	Colinus virginianus	Northern Bobwhite			E	1	3 ±5
a	Chaetura pelagica	Chimney Swift	S2S3B	Endangered	T	1	10 ±5
a	Chordeiles minor	Common Nighthawk	S3B	Threatened	T	3	3 ±5
a	Glyptemys insculpta	Wood Turtle	S3	Vulnerable	T	2	3 ±10
a	Sturnella magna	Eastern Meadowlark	S1B		T	1	7 ±5
a	Wilsonia canadensis	Canada Warbler	S3B		T	4	10 ±5
a	Hirundo rustica	Barn Swallow	S3B		T	5	3 ±5
a	Contopus cooperi	Olive-sided Flycatcher	S3B		T	2	10 ±5
a	Dolichonyx oryzivorus	Bobolink	S3S4B		T	7	3 ±5
a	Falco peregrinus pop. 1	Peregrine Falcon - anatum/tundrius	S1B	Vulnerable	SC	1	4 ±0.1
a	Euphagus carolinus	Rusty Blackbird	S2S3B		SC	1	10 ±5
a	Chelydra serpentina	Snapping Turtle	S5		SC	3	6 ±10
a	Gavia immer	Common Loon	S3B,S4N		NAR	2	3 ±5
a	Accipiter gentilis	Northern Goshawk	S3S4		NAR	2	10 ±5
a	Tringa solitaria	Solitary Sandpiper	S1?B,S4S5M			4	9 ±0.5
a	Hylocichla mustelina	Wood Thrush	S1B			1	10 ±5
a	Gallinula chloropus	Common Moorhen	S1B			1	10 ±5
a	Calidris minutilla	Least Sandpiper	S1B,S5M			24	8 ±0.5
a	Charadrius semipalmatus	Semipalmated Plover	S1S2B,S5M			16	8 ±0.5
i	Polygonia comma	Eastern Comma	S2			1	9 ±1
i	Pieris oleracea	Mustard White	S2			2	4 ±0
a	Piranga olivacea	Scarlet Tanager	S2B			1	7 ±5
a	Bucephala clangula	Common Goldeneye	S2B,S5N			1	6 ±10
a	Icterus galbula	Baltimore Oriole	S2S3B			1	7 ±5
a	Molothrus ater	Brown-headed Cowbird	S2S3B			2	7 ±5
a	Pooecetes gramineus	Vesper Sparrow	S2S3B			1	7 ±5
a	Tringa semipalmata	Willet	S2S3B			10	8 ±0.5

a	Poecile hudsonica	Boreal Chickadee		S3	2	10 ±5
a	Dendroica tigrina	Cape May Warbler		S3?B	2	3 ±5
a	Mimus polyglottos	Northern Mockingbird		S3B	1	8 ±0.1
a	Dumetella carolinensis	Gray Catbird		S3B	4	3 ±5
a	Riparia riparia	Bank Swallow		S3B	4	3 ±5
a	Anas discors	Blue-winged Teal		S3B	1	3 ±5
a	Tringa melanoleuca	Greater Yellowlegs	S3B,S5M		33	8 ±0.5
a	Calidris pusilla	Semipalmated Sandpiper		S3M	23	8 ±0.5
a	Limosa haemastica	Hudsonian Godwit		S3M	5	9 ±0.5
a	Pluvialis dominica	American Golden-Plover		S3M	12	8 ±0.5
a	Cardinalis cardinalis	Northern Cardinal		S3S4	1	7 ±5
a	Perisoreus canadensis	Gray Jay		S3S4	3	10 ±5
a	Pheucticus ludovicianus	Rose-breasted Grosbeak	S3S4B		5	3 ±5

a	Dendroica castanea	Bay-breasted Warbler	S3S4B	2	10 ±5
a	Vermivora peregrina	Tennessee Warbler	S3S4B	2	10 ±5
a	Tyrannus tyrannus	Eastern Kingbird	S3S4B	1	7 ±5
a	Sayornis phoebe	Eastern Phoebe	S3S4B	4	7 ±5
a	Empidonax flaviventris	Yellow-bellied Flycatcher	S3S4B	1	10 ±0.5
a	Contopus virens	Eastern Wood-Pewee	S3S4B	2	3 ±5
a	Gallinago delicata	Wilson's Snipe	S3S4B	2	7 ±5
a	Actitis macularius	Spotted Sandpiper	S3S4B	25	3 ±5
a	Charadrius vociferus	Killdeer	S3S4B	18	3 ±5
a	Carduelis pinus	Pine Siskin	S3S4B,S5N	4	3 ±5

4.3 RANGE MAPS

The legally protected taxa listed below are linked to the study area by predictive range maps based upon expert estimates of distribution. Taxa listed here but not in the observation data above, are unknown within the study area but perhaps present. Ranges of rank 1 indicate possible occurrence, those of rank 2 and 3 increasingly less probable.

	scientific name	common name	prov. rarity	prov. status	COSEWIC	range
a	Glyptemys insculpta	Wood Turtle	S3 S3	Vulnerable	T	1
p	Listera australis	Southern Twayblade	S2 S2 S1	Endangered		1
p	Isoetes prototypus	Prototype Quillwort	S2 S2	Endangered	Vulnerable	SC 1
i	Danaus plexippus	Monarch	S3B S2B S1B		SC	1
a	Glaucomys volans	Southern Flying Squirrel	SNA S2S3	NAR		1
a	Bucephala islandica	Barrow's Goldeneye (Eastern pop.)	S2N S1N S2N		SC	2
a	Salmo salar pop. 1	Atlantic Salmon - inner Bay of Fundy	S2 S2		E	1
a	Falco peregrinus anatum	Peregrine Falcon anatum ssp	S1B S1B SNA	Endangered	VulnerableSC	2
a	Asio flammeus	Short-eared Owl	S3B S1S2 S1S2B		SC	1

5.0 SOURCE BIBLIOGRAPHY

The recipient of this data shall acknowledge the ACCDC and the data sources listed below in any documents, reports, publications or presentations, in which this dataset makes a significant contribution.

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APPENDIX III –Water Quality Parameters

Metals

Concentration (µg/L) of metals measured for surface and bottom waters in each impoundment during the summers of 2001 and 2012.

Site	Date	Depth (m)	Aluminum	Antimony	Barium	Beryllium	Boron	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Molybdenum	Nickel	Selenium	Tin	Vanadium	Zinc
Upper Halfway	2001	0.5	20	<2	<2	<5	14	<0.3	<2	<1	<2	320	<0.5	-	18	<2	<2	<2	<2	<2	4
		7.0	120	<2	2	<5	9	<0.3	<2	1	<2	5300	<0.5	-	1700	<2	2	<2	<2	<2	6
Upper Halfway	2012	0.5	52	<2	33	<2	6	<1	<2	<2	<2	359	<2	1.8	47	-	<2	<2	<2	<2	<6
		7.0	125	<2	73	<2	<5	<1	<2	4	4	6546	<2	1.9	4490	-	2	<2	<2	<2	9
Lower Halfway	2001	0.5	10	<2	<2	<5	7	<0.3	<2	<1	2	230	<0.5	-	10	<2	<2	<2	<2	<2	6
		6.0	10	<2	<2	<5	8	<0.3	<2	<1	<2	260	<0.5	-	32	<2	<2	<2	<2	<2	4
Lower Halfway	2012	0.5	38	<2	26	<2	6	<1	<2	<2	<2	374	<2	1.7	49	-	<2	<2	<2	<2	<6
		6.0	54	<2	42	<2	6	<1	<2	<2	3	923	<2	1.8	754	-	<2	<2	<2	<2	12

Nutrients

Site	Date	Water Depth (m)	Total Nitrogen (mg/L)	Nitrite-N (mg/L)	Nitrate-N (mg/L)	Ammonia-N (mg/L)	Nitrite+Nitrate (mg/L)	Total Phosphorus (mg/L)	Ortho-phosphate-P (mg/L)	Reactive Silicate (mg/L)
Upper Halfway	2001	0.5	0.3	<0.01	0.08	0.05	-	<0.1	<0.01	4.7
	2001	7.0	0.4	<0.01	<0.05	0.53	-	<0.1	<0.01	4.8
Upper Halfway	2012	0.5	0.2	-	-	0.03	0.08	0.006	<0.005	4.9
	2012	7.0	0.6	-	-	0.55	<0.01	0.016	<0.005	4.4
Lower Halfway	2001	0.5	0.3	<0.01	<0.05	<0.05	-	<0.1	<0.01	3.9
	2001	6.0	0.3	<0.01	<0.05	0.07	-	<0.1	<0.01	4.4
Lower Halfway	2012	0.5	0.2	-	-	0.01	<0.01	0.006	<0.005	4.3
	2012	6.0	0.2	-	-	0.03	<0.01	0.011	<0.005	4.7

Trophic Status Parameters

Site	Year	**Depth** (m)	**Total Phosphorus** (mg/L)	**Secchi Depth** (m)	**Chlorophyll *a*** (µg/L)	**Color** (TCUs)
Upper Halfway	2001	0.5	<0.1	1.8	0	11
		7.0	<0.1	-	0	66
Upper Halfway	2012	0.5	0.006	1.9	1.4	21
		7.0	0.016	-	1.8	144
Lower Halfway	2001	0.5	<0.1	1.8	0	11
		6.0	<0.1	-	0	10
Lower Halfway	2012	0.5	0.006	2.1	1.7	22
		6.0	0.011	-	2.7	40

Physical and Related Parameters

Site	**Year**	**Depth** (m)	**Turbidity** (NTUs)	**Suspended Solids** (mg/L)	**Color** (TCUs)	**Total Organic Carbon** (mg/L)
Upper Halfway	2001	0.0	1.20	3.0	21	2.8
		7.0	14.40	6.8	144	3.2
Upper Halfway	2012	0.5	1.75	3.0	11	3.7
		7.0	25.70	11.0	66	6.6
Lower Halfway	2001	0.0	0.60	2.4	22	3.0
		6.0	3.20	5.2	40	2.9
Lower Halfway	2012	0.5	1.47	2.0	11	4.0
		6.0	5.63	4.0	10	4.2