Halifax Regional Municipality

Birch Cove Lakes Watershed Study Final Report

DATA SUMMARY

Project Number:
60221657

Date:
April 2013

Table of Contents

Table 1. Temperature and Precipitation Climate Normals

Air Temperature Climate Normals (1971-2000)				Precipitation Climate Normals (1971-2000)			
Month	Daily Maximum (^{0}C)	Daily Minimum (^{0}C)	Daily Average (^{0}C)	Month	Rainfall (mm)	Snowfall (mm)	Precipitation (mm)
January	-0.2	-8.6	-4.4	**January**	112.3	38.4	150.7
February	-0.1	-8.1	-4.1	**February**	76.2	37.7	113.4
March	3.5	-4.2	-0.3	**March**	106.0	28.4	134.4
April	8.4	0.8	4.6	**April**	111.3	9.8	121.1
May	14.1	5.5	9.8	**May**	118.1	1.2	119.4
June	19.4	10.5	15.0	**June**	108.0	0.0	108.0
July	22.9	14.2	18.6	**July**	105.9	0.0	105.9
August	23.0	14.8	18.9	**August**	98.3	0.0	98.3
September	19.0	11.4	15.2	**September**	107.1	0.0	107.1
October	13.1	5.9	9.6	**October**	134.4	1.0	135.4
November	7.9	1.2	4.5	**November**	146.8	6.9	153.7
December	2.6	-5.1	-1.3	**December**	131.7	28.5	160.2
Year	11.2	3.2	7.2	**Year**	1356.1	151.8	1508

Table 2. Wind Speed and Direction Normals (1971-2000)

Month	Speed (km/h)	Most Frequent Direction	Maximum Hourly Speed (km/h)
January	18.1	W	83.0
February	17.7	NW	97.0
March	17.8	NW	78.0
April	16.9	N	85.0
May	14.0	S	72.0
June	12.8	S	77.0
July	11.3	S	87.0
August	11.1	SW	60.0
September	12.8	SW	97.0
October	14.8	W	80.0
November	16.5	NW	89.0
December	17.7	W	89.0
Year	15.1	W	

Table 3. Evaporation Normals

Month	Lake Evaporation (mm/day)
January	0
February	0
March	0
April	0
May	2.9
June	3.4
July	3.6
August	3.2
September	2.3
October	1.3
November	0
December	0
Year	0
Total	16.70

Table 4. Trophic Status Based Trigger Ranges for Canadian Waters (CCME, 2004)

Trigger Ranges for Total Phosphorus (µg/L)		
Trophic Status	Lakes	Rivers and Streams
Ultra-oligotrophic	<4	-
Oligotrophic	4-10	<25
Mesotrophic	10-20	25-75
Meso-eutrophic	20-35	-
Eutrophic	35-100	>75
Hypereutrophic	>100	-

Table 5. Morphometry of Lakes in Birch Cove

Lake	Surface Area (ha)	Maximum[a] Depth (m)	Average[b] Depth (m)	Volume[1] (m^3)
Little Horseshoe Lake	1.1			
Little Cranberry Lake	1.6			
Flat Lake	1.9			
Hobsons Lake	3.3			
Jack Lake	3.9			
Kearney Lake (upper)	4.0			
Cranberry Lake	4.5			
Charlies Lake	5.7			
McQuade Lake	6.5			
Three Finger Lake	6.6			
Horseshoe Lake	7.7			
Washmill Lake	7.8	8[a]	2.5 [a]	1.93×10^5
Crane Lake	11.1			
Fox Lake	14.1			
Paper Mill Lake	25.1	6[b]	2.2 [b]	5.53×10^5
Ash Lake	29.8			
Quarry Lake	48.1	8[a]	3.5 [a]	1.68×10^6
Kearney Lake (Main)	64.2	27[b]	11.3 [b]	7.40×10^6
Susies Lake	82.7	11[a]	3.7 [a]	2.65×10^6

Notes: [a] from Porter Dillon 1996, [b] from Scott and Hart 2004. [1] Based on surface area and mean depth.

Table 6. Data Sources Used to Establish Current Water Quality in Birch Cove

Sampled by	Sampling Program	Sampling Period	Sampling Locations
Halifax Regional Municipality	HRM Lakes Water Quality Sampling Program	2006 to 2008; three times per year, spring summer and fall	Locations on Kearney Lake and Paper Mill Lake
SNC Lavalin	HRM Water Quality Monitoring for Bedford West Sub Areas 3 & 4	2009 to 2011; three times per year, spring summer and fall	Locations on Kearney Lake, Paper Mill Lake and Black Duck Brook
AECOM		2011 to 2012 – 4 events	Washmill Lake, McQuade Lake, Big Horseshoe Lake, Quarry Lake, and Black Duck Brook

Table 7. Summary of Selected Surface Water Quality Parameters in the Birch Cove Lakes Watershed (2006-2012) with AECOM Data Added

		TP Surface*	TP Deep*	TKN	Nitrate	Ammonia	Chlorophyll α	TSS	Secchi Depth	E.coli [a]	Dissolved Chloride	N:P Ratio
		µg/L	µg/L	mg/L	mg/L	mg/L	µg/L	mg/L	m	/100mL	mg/L	
Paper Mill Lake[1*]	No of Samples	16	n/a	10	8	14	17	23	11	7	15	
	min	<2		<0.10	0.07	<0.05	0.07	<1.0	2.2	1	24.0	
	max	18		0.40	0.49	<0.05	4.75	8.0	3.5	>250	77.0	
	median	7		0.25	0.17	<0.05	1.17	1.6	2.8	33	58.0	
	average	7		0.27	0.22	<0.05	1.39	2.8	2.8	94	52.5	40
	standard deviation	4		0.11	0.16		1.04	2.2	0.4	112	16.8	
Kearney Lake[2*]	No of Samples	16	3	11	8	14	17	17	14	7	16	
	min	<2	3	0.00	0.10	<0.05	0.35	<1.0	2.4	1	10.0	
	max	13	10	0.80	0.21	<0.05	2.60	17.0	5.0	>250	80.0	
	median	8	8	0.30	0.17	<0.05	0.97	2.0	3.8	15	62.0	
	average	7	7	0.32	0.16	<0.05	1.13	3.3	3.9	60	55.1	45
	standard deviation	3	4	0.22	0.04		0.58	3.9	0.9	90	21.4	
Washmill Lake (KL1 and HRM BC-WL)	No of Samples	11	n/a	4	8	9	13	17	8	9	13	
	min	2		0.10	0.07	<0.05	0.27	<1.0	2.4	1	27.0	
	max	13		0.51	0.21	<0.05	1.73	17.0	5.0	>250	81.0	
	median	8		0.24	0.16	<0.05	0.92	2.0	4.2	24	62.0	
	average	8		0.27	0.15	<0.05	0.99	2.8	3.9	54	58.4	34
	standard deviation	3		0.18	0.05		0.42	3.8	1.1	79	17.1	
Black Duck Brook (KL2 and	No of Samples	12	n/a	4	8	9	13	17	n/a	13	13	
	min	6		0.20	0.06	<0.05	0.21	<1.0		1	9.0	
	max	40		0.32	0.12	0.06	6.05	7.0		1500	25.0	

		TP Surface*	TP Deep*	TKN	Nitrate	Ammonia	Chlorophyll α	TSS	Secchi Depth	E.coli [a]	Dissolved Chloride	N:P Ratio
		µg/L	µg/L	mg/L	mg/L	mg/L	µg/L	mg/L	m	/100mL	mg/L	
HRM BC Black DK)	median	9		0.29	0.08	0.05	0.57	1.0		14	17.0	
	average	14		0.27	0.08	0.05	1.09	2.1		174	17.2	20
	standard deviation	11		0.06	0.02		1.56	1.9		409	4.5	
Quarry Lake	No of Samples	4	n/a	4	4	n/a	4	8	n/a	n/a	4	
	min	3		0.10	<0.05		0.41	<1.0			25.0	
	max	14		0.40	0.07		1.05	2.0			59.0	
	median	6		0.30	0.05		0.99	1.0			49.0	
	average	7		0.27	0.06		0.86	1.2			45.5	38
	standard deviation	5		0.13	0.01		0.30	0.4			16.2	
Big Horseshoe Lake	No of Samples	4	n/a	4	4	n/a	4	8	n/a	n/a	4	
	min	9		0.25	<0.05		1.68	<1.0			3.0	
	max	25		0.70	<0.05		5.06	5.0			4.0	
	median	18		0.59	<0.05		2.77	2.3			3.6	
	average	18		0.53	<0.05		3.07	2.8			3.5	30
	standard deviation	7		0.20			1.56	1.6			0.4	
McQuade Lake	No of Samples	6	n/a	5	5	n/a	5	8	n/a	n/a	5	
	min	2		0.32	0.08		1.62	<1.0			25.0	
	max	22		0.40	0.19		7.44	13.0			47.0	
	median	10		0.40	0.13		4.24	2.0			32.0	
	average	12		0.37	0.14		4.62	3.1			34.6	32
	standard deviation	8		0.04	0.05		2.72	4.0			10.0	

[1]Only TSS samples were collected by AECOM in 2012 for Paper Mill Lake
[2]No additional sampling was conducted by AECOM for Kearney Lake in 2012
*HRM sampling stations only

Table 8. Seasonal Total Phosphorus Concentrations in Kearney and Paper Mill Lakes (µg/L)

		Spring	Summer	Fall and Winter	Annual Value
		April, May, June	July, Aug, Sept	Oct & Nov	
Kearney Lake (surface)	**Number of Samples**	6	5	5	n = 16
	Min	4	7	<2	<2
	Max	9	9	13	13
	Median	7	8	5	7.5
	Mean	7	8	7	7.0
	Standard Deviation	2	1	5	3
Paper Mill Lake	**Number of Samples**	6	5	5	n =16
	Min	<2	2	<2	<2
	Max	18	9	10	18
	Median	7	7	6	7
	Mean	8	6	6	8
	Standard Deviation	5	3	3	4

Table 9. Historical Concentrations of Total Phosphorus (µg/L) in Select Headwater Lakes

Lake	Range (n=2)	Average
Ash	1.8-2.5	2
Charlies	2.1-4.9	4
Big Cranberry	9-8.3	9
Crane	2.5-4.2	3
Fox	1.7-3	2
Hobsons	6.8-7.8	7
Flat	9.7-4.4	7
Three Finger	4.6-3.7	4

Source: Porter Dillon 1996; n = number of samples

Table 10. Nitrogen to Phosphorus Ratio for Lakes in Birch Cove

Lake	TN:TP
Horseshoe Lake	30
Quarry Lake	38
Kearney Lake	45
McQuade Lake	32
Paper Mill Lake	40
Washmill Lake	34

Table 11. GIS Files Received & Downloaded

Data Name	Source	Status	Notes	Project Use
Base Data	HRM	Received from HRM		
Parcels	HRM	Received from HRM		Land use classifications
Zoning	HRM	Received from HRM		Land use classifications
Building Polygons	HRM	Received from HRM	Detailed account of Building footprints	Land use classifications
Contours 1m	HRM	Received from HRM	In the form of DEM/DSM	Land use classifications
Watersheds	HRM	AECOM to Create	In the form of DEM/DSM (Derived by AECOM)	Hydraulic modeling
Lakes	HRM	Received from HRM		Land use classifications
Streams	HRM	Received from HRM		Watershed Delineation / Constraint Mapping
DEM_2m	HRM	Received from HRM	Derived from LiDAR by Monette and Hopkinson of AGRG	Watershed Delineation / Constraint Mapping
Slope Grid	HRM	Received from HRM	In the form of DEM/DSM (Derived by AECOM)	Hydraulic modeling / Constraint Mapping
BANC Development	HRM	Received from HRM		Land use classifications
BMBCL Conceptual Park Boundary	HRM	Received from HRM		Land use classifications
BMBCL Urban Settlement	HRM	Received from HRM		Land use classifications
BMBCL URD USD	HRM	Received from HRM	Urban Reserve / Urban Settlement Designations	Land use classifications
Coxs Lake Park Reserve	HRM	Received from HRM		Land use classifications
Resource Natural Corridor Lands	HRM	Received from HRM		Land use classifications
First Nations Reserves	HRM	Received from HRM	Indian and Northern Affairs Canada	Land use classifications
Sewage Treatment Plants	HRM	Received from HRM		
Soils	HRM	Received from HRM		Water Budget Analysis
GLFUM Reg Plan	HRM	Received from HRM	General Land use planning description	Land use classifications
Proposed HWY 113 Alignment	NSTPW	Received from HRM		Land use classifications
Forest Inventory	NSDNR			Land use classifications
IRM Data	NSDNR			
Flow Accumulation	NSDNR	Downloaded from Website	Used to compare to LiDAR GIS results	Watershed Delineation
Wetlands	NSDNR	Downloaded from Website / Received from HRM		Land use classifications / Constraint Mapping
Significant Habitat	NSDNR	Downloaded from Website / Received from HRM		Land use classifications / Constraint Mapping
Old unique forests	NSDEL (Dept. of Envt & Labour)	Received from HRM		Land use classifications / Constraint Mapping
Ecosites	NSDEL (Dept. of Envt & Labour)			
Highly scientific natural areas	NSDEL (Dept. of Envt & Labour)			

Data Name	Source	Status	Notes	Project Use
Lakes & costal	NSDEL (Dept. of Envt & Labour)			
Sites of Ecological Significance	NSDEL (Dept. of Envt & Labour)			
Ortho	NSDNR	Not Used		
Ortho	BING Imagery	Used via Arc GIS		
Crown Land	NSDNR	Received from HRM		To create Land use classifications
Trails	HRM			
Rare flora	Atlantic Canada Conservation Data Centre			
Special Areas	Atlantic Canada Conservation Data Centre			
ELC (Eco Districts - high level)	Mineral Resource Branch	Downloaded from Website		
Surficial Geology		Downloaded from Website		
Deer Wintering Areas	NSDNR			
Wet Areas	NSDNR	Downloaded from Website		
Restricted & Limited Use	NSDNR	Downloaded from Website	all files	
Transportation & Utility Features	NSDNR	Downloaded from Website		
Mineral Resource Land-Use		Downloaded from Website		

Table 12. Overview of Watershed Modeling

Options	Functions
Hydrological modeling	Creates watersheds and calculates their attributes
Flow direction	Computes the direction of flow for each cell in a DEM
Identify Sinks	Creates a grid showing the location of sinks or areas of internal drainage in a DEM
Fill Sinks	Fills in the sinks in a DEM, creating a new DEM
Flow Accumulation	Calculates the accumulated flow or number of up-slope cells, based on a flow direction grid
Stream Networks	Isolating out areas of concentrated flow
Stream Order	Method of classifying streams based upon their number of tributaries
Pour Point placement	Everything upstream of a pour point will define a single watershed
Watershed	Creates a watershed based upon a user-specified flow accumulation threshold

Table 13. Existing Land Use Classifications

Land Use	Description	General Classification
Bedrock	Rock visible from air photo	Bedrock
Commercial	Shops / malls / box stores	Commercial
Crown Land	Provincial land	Forest
Forest	Significant tree cover	Forest
Forest - Meadow	Open grass lands / minimal tree cover	Forest - Meadow
Forest - Old Growth	Designated old growth by NSDNR	Forest
Forest - Sensitive Habitat	Designated sensitive by NSDNR	Forest
High Density Residential	Parcel < .5ha	Residential
Medium Density Residential	Parcel > 0.5 ha <1.5 ha	Residential
Low Density Residential	Parcel >1.5 ha	Residential
Industrial	Industrial	Industrial
Institutional	Schools / library	Institutional
Open Space	Park or inner city open area	Forest - Meadow
Path	Concrete path too small for car	Roadway
Power Lines	Designated by Zoning	Forest - Meadow
Quarry	Open Pit	Quarry
Roadway	All major / minor road	Roadway
Water	Lakes / Rivers	Water
Wetland	designated wetland by NSDNR	Wetland

Table 14. Changes to Water Quality Parameters from Watershed Development

Water Quality Parameter	Effect of Development	Rationale for inclusion as Indicator Parameter
TP	Increase from fertilizer runoff, stormwater runoff, waste water treatment plant (WWTP) by-passes and overflows, septic systems	Increases in phosphorus can increase growth of algae and aquatic plants which can in turn reduce water clarity and dissolved oxygen
NO3	Increase from fertilizer runoff, WWTP by-passes and overflows, septic systems, urban runoff, stormwater discharge.	Increases in nitrate can increase growth of algae and aquatic plants which can in turn reduce water clarity and dissolved oxygen
Ammonia	Increase from fertilizer runoff, WWTP by-passes and overflows, urban runoff, effluents from some industrial and commercial activities	Un-ionized ammonia is a portion of ammonia that can be toxic to aquatic life at elevated concentrations
TSS	Increase from deforestation, construction activities, gravel operations, WWTP bypasses and overflows, and stormwater runoff from urban areas/hard surfaces	Increases in suspended solids can reduce water clarity, alter habitat, and interfere with feeding, physiological and behavioural in fish and affect benthic production and periphyton communities.

Water Quality Parameter	Effect of Development	Rationale for inclusion as Indicator Parameter
Chloride	Increase due to spray from road salting practices, stormwater runoff, WWTP bypass overflows, and long-range transport	Increases chloride results in increased salinity, thereby affecting the ability of some organisms to osmoregulate (affecting endocrine balance, oxygen consumption, and physiological processes (Holland et al., 2010)).
E. coli	Increase due to septic systems, WWTP bypass overflows, and stormwater runoff	An indicator of fecal contamination in recreational water

Table 15. Water Quality Guidelines and Standards from Canada, USEPA and Vermont.

Parameter	CWQG	USEPA	Vermont
TP	Trophic Status Approach	Ecoregion Based Approach	Lake specific – maximum increase of 1 mg/L
NO_3	13 mg NO_3/L	n/a	5.0 mg/L as NO_3-N
Un-ionized Ammonia	0.019 mg/L	Temperature/pH dependent	EPA values
TSS	Short term exposure: 25 mg/L increase Long term exposure: 5 mg/L increase	<10 % of the seasonal value	Water Class dependent
Chloride	120 mg/L (chronic toxicity guideline) 640 mg/L (acute toxicity guideline)	230 mg/L chronic concentration (CC) 860 mg/L maximum concentration (MC)	n/a
E. coli	2000 *E. coli*/L[1] (geometric mean of 5 samples)	126 *E. coli*/100mL (geometric mean of 5 samples)	Water Class dependent

1. Health Canada Guidelines for Recreational Water Quality

Table 16. Recommended Water Quality Objectives for Birch Cove Lakes Watershed Excluding TP

Parameter	Derivation of Objective	Birch Cove Watershed Water Quality Objective	Early Warning Alert Value	Evaluation Method for Objective/Alert Value
NO_3 – Nitrate	CCME	13 mg NO_3/L	≤10 mg/L	75^{th} percentile of 3 year historical data
Un-ionized Ammonia	CCME	0.019 mg/L	≤0.014 mg/L	75^{th} percentile of 3 year historical data
Total Suspended Solids (TSS)	CCME	Short term: 25 mg/L increase Long term: 5 mg/L increase	Lake dependent	75^{th} percentile of 3 year historical data not to exceed base line by more than 5 mg/L
Chloride	CCME	120 mg/L	≤90 mg/L	75^{th} percentile of 3 year historical data
E. coli	Nova Scotia and Health Canada	200 *E. coli*/100mL (geometric mean of 5 samples)	200 *E. coli*/100mL	Geometric mean of 5 samples

Table 17. Provincial Water Quality Objectives for Total Phosphorus (µg/L)

	Lakes	Rivers
British Columbia	5-15	
Alberta	50	
Manitoba	25	50
Ontario	10, 20	30
Quebec	Background + 50% increase (upper limits of 10 and 20 µg/L)	

Table 18. Pooled Total Phosphorus (µg/L) Data for Kearney, Paper Mill, and Washmill Lakes and Black Duck Brook (2006 to 2012).

	Kearney Lake	Paper Mill Lake	Washmill Lake	Black Duck Brook
Number of Samples	37	30	11	12
Min	<2	<2	<2	6
Max	26	30	13	40
Median	7	7	8	9
Mean	7	8	8	14
Standard Deviation	5	6	3	11

Table 19. Water Quality Objectives, Early Warning Alert Value and Proposed Evaluation Methodology for Alert Values for Total Phosphorus (µg/L) in Birch Cove Lakes Watershed

Parameter	Derivation of Objective	Birch Cove Objective or Lake Objective	Early Warning Alert Value	Evaluation Method for Objective/Alert Value
TP - Ash Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP - Charlies Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP – Cranberry Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP – Crane Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP – Flat Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP – Fox Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP – Hobsons Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP – Horseshoe Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP - McQuade Lake	Mesotrophic	≤20	15	3 year running mean of Black Duck Brook measurements
TP - Susies Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP - Quarry Lake[2]	Oligotrophic	≤10	8	3 year running mean at outfall
TP – Three Finger Lake	Oligotrophic	≤10	10	Based on modeling results[1]
TP - Washmill Lake	Oligotrophic	≤10	8	3 year running mean of data
TP - Kearney Lake	Oligotrophic	≤10	8	3 year running mean of data
TP - Paper Mill Lake	Oligotrophic	≤10	8	3 year running mean of data

[1]No recent water quality data to verify model predicted water quality results. Data should be collected to validate objective and proposed alert value. Until additional data are available, the evaluation is dependent upon modeling and the early warning alert value is based on the upper TP limit of the oligotrophic state due to uncertainty in the model.
[2]Only four samples taken. Objective needs to be validated with additional analytical data and proposed alert value confirmed.

Table 20. Summary of Existing Land Use Areas used for LCM Modeling

Land Use Classification	Area (ha)														
	Ash	Charlies	Cranberry	Crane	Flat	Fox	Hobsons	Horseshoe	McQuade	Quarry	Susies	Three Finger	Washmill	Kearney	Paper Mill
Drainage Basin Area (excl. of lake area)	96.01	49.450	39.288	48.73	11.02	82.010	151.95	59.74	52.27	147.591	520.33	139.959	308.732	556.124	851.315
Land Use 1 - Bedrock	3.381	10.021		0.392		17.725	5.415			15.950		24.402	8.482		4.639
Land Use 2 - Forest	88.671	38.260	30.611	42.472	9.587	62.943	132.828	49.736		127.663	373.607	101.448	79.411	288.185	509.527
Land Use 3 - Forest - Meadow	2.591		3.826	5.871	0.396		5.282	6.226			7.785	12.087		15.990	3.353
Land Use 4 - Wetland	1.365	0.346	3.210		1.037	1.339	7.330	2.666		2.708	27.709	2.018	16.549	2.954	21.383
Land Use 5 - Water		0.669	1.646				0.366	1.114	0.051	0.692	0.560	0.004	3.892	1.619	10.333
Land Use 6 - Industrial														9.803	30.205
Land Use 7 - Institutional											5.984				1.912
Land Use 8 - Commercial											55.744		5.974	1.536	22.053
Land Use 9 - Quarry										0.578	3.952		67.432	4.179	
Land Use 10 - Roadway							0.729		5.972		26.630		36.938	53.132	104.361
Land Use 11 - High Density Residential											16.863		62.353	11.902	59.711
Land Use 12 - Medium Density Residential		0.154											16.44	24.787	75.066
Land Use 13 - Low Density Residential									46.042					138.413	4.563
Land Use 14 - Open Space									0.203		1.497		11.261	3.623	4.21

Table 21. Measured and Modeled Ice-Free Lake Phosphorus Concentrations (µg/L) (LCM)

	Measured TP	Scenario 1: Existing Conditions	Scenario 2: Approved and Planned Developments	Scenario 3: Scenario 2 Plus Hwy. 102 West Corridor Lands	Scenario 4: Scenario 3 Minus Lands within Park Boundary
Ash	2[1]	2	2	4	2
Charlies	4[1]	4	4	28	27
Cranberry	9[1]	4	4	4	4
Crane	3[1]	3	3	3	3
Flat	7[1]	3	3	3	3
Fox	2[1]	3	3	28	3
Hobsons	7[1]	6	6	6	6
Horseshoe	18	4	4	4	4
McQuade[2]	12	14	78	80	78
Quarry	7	1	1	5	3
Susies	NA	4	4	7	6
Three Finger	4[1]	5	5	5	5
Washmill	8[3]	6	6	14	13
Kearney	7[3]	8	12	15	14
Paper Mill	8[3]	9	16	17	17

Notes: [1]Indicates historical water quality data as per Table 9
[2]No change to land use, lower septic system retention coefficients were modeled in the development scenarios.
[3]From Table 18 (mean)
Shading indicates land use changes from development

Table 22. Land Use For Sub-watersheds Showing Percent Changes Relative to Existing Conditions[1]

	Ash			Charlies			Fox			Quarry			Susies			Washmill			Kearney			Paper Mill		
	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4	Scenario 2	Scenario 3	Scenario 4
Bedrock	0%	0%	0%	0%	-99%	-99%	0%	-66%	0%	0%	-88%	-10%				0%	-100%	-97%				-93%	-93%	-93%
Forest	0%	-4%	0%	-5%	-27%	-21%	0%	-45%	0%	0%	-76%	-60%	-3%	-30%	-22%	-2%	-85%	-60%	-49%	-51%	-51%	-60%	-60%	-60%
Forest - Meadow	0%	0%	0%										0%	0%	0%				0%	0%	0%	-15%	-15%	-15%
Wetland	0%	-4%	0%	7%	7%	-100%	0%	4%	0%	0%	-16%	0%	0%	0%	0%	0%	0%	0%	130%	130%	130%	-19%	-19%	-19%
Water				2%	2%	58%				0%	1%	1%	0%	-18%	-15%	-2%	-2%	-2%	-2%	-2%	-2%	4%	4%	4%
Industrial																			0%	0%	0%	1%	1%	1%
Institutional													0%	0%	0%				NA	NA	NA	1397%	1397%	1397%
Commercial													17%	17%	8%	0%	0%	0%	279%	279%	279%	337%	337%	337%
Quarry										0%	-65%	-100%	0%	-86%	-86%	0%	-90%	-82%	0%	-93%	-93%			
Roadway													0%	0%	0%	0%	0%	0%	37%	37%	37%	48%	48%	48%
High Density Residential													-3%	-3%	-3%	0%	0%	0%	536%	536%	536%	241%	241%	241%
Medium Density Residential				1492%	1492%	-100%										11%	11%	11%	70%	70%	70%	13%	13%	13%
Low Density Residential																			0%	0%	0%	0%	0%	0%
Open Space													0%	0%	0%	0%	0%	0%	20%	20%	20%	269%	269%	269%
Commercial and Residential		NA			NA	NA		NA			NA	NA		NA	NA		NA	NA	NA	NA	NA			

Notes: Changes are relative to current land use
NA – represents instances in which the previous area was 0.

[1] *Lakes not listed in this table will have no proposed land use changes over the study period: Cranberry, Crane, Flat, Hobsons, Horseshoe, McQuade, and Three Finger.*

Table 23. Predicted Effect of Removing Septic Systems on Total Phosphorus Concentrations in Birch Cove Lakes (µg/L)

	Measured TP	Scenario 1: Existing Conditions	Scenario 2: Approved and Planned Developments		Scenario 3: Scenario 2 + Hwy. 102 West Corridor Lands		Scenario 4: Scenario 3 Minus Lands within Park Boundary	
			With Septics	Septics Removed	With Septics	Septics Removed	With Septics	Septics Removed
Ash	2[1]	2	2		3		2	
Charlies	4[1]	4	4		28		27	
Cranberry	9[1]	4	4		4		4	
Crane	3[1]	3	3		3		3	
Flat	7[1]	3	3		3		3	
Fox	2[1]	3	3		28		3	
Hobsons	7[1]	6	6		6		6	
Horseshoe	18	4	4		4		4	
McQuade[2]	12	14	78[4]	14	80[4]	14	78[4]	14
Quarry	7	1	1		5		4	
Susies	NA	4	4		7		6	
Three Finger	4[1]	5	5		5		5	
Washmill	8[3]	6	6	6	14	14	13	12
Kearney	7[3]	8	12	7	15	10	14	9
Paper Mill	8[3]	9	16	14	17	15	17	15

Notes: [1]Indicates historical water quality data as per Table 9
[2]No change to land use, lower septic system retention coefficients were modeled in the development scenarios.
[3]From Table 18
[4]Assumes in the model that McQuade Lake will start to show effect of nutrient loadings from septic systems which in future will retain only 33% of the phosphorus load from septic systems.
Shading indicates land use changes from development

Table 24. Summary of Select Design Storm Outflows for Each Lake (m^3/sec)

	Scenario 1: Existing Conditions			Scenario 2: Approved and Planned Developments			Scenario 3: Scenario 2 plus Hwy. 102 West Corridor Lands			Scenario 4: Scenario 3 minus Lands within Park Boundary		
Design Storm	100 Year	10 Year	2 Year	100 Year	10 Year	2 Year	100 Year	10 Year	2 Year	100 Year	10 Year	2 Year
Ash Lake	14.54	8.39	2.34	14.54	8.39	2.34	15.06	8.87	2.52	14.54	8.39	2.34
Charlies Lake	7.65	4.67	1.30	7.78	4.79	1.36	8.89	5.75	2.20	8.79	5.68	2.10
Big Cranberry Lake	12.93	6.66	2.07	12.93	6.66	2.07	12.93	6.68	2.08	12.93	6.66	2.07
Little Cranberry	1.79	1.01	0.22	1.79	1.01	0.22	1.79	1.01	0.22	1.79	1.01	0.22
Crane Lake	8.52	4.18	1.23	8.47	4.16	1.22	8.80	4.66	1.36	8.40	4.12	1.20
Flat Lake	1.67	0.94	0.30	1.65	0.94	0.29	1.65	0.94	0.25	1.65	0.94	0.28
Fox Lake	12.74	7.77	2.28	12.74	7.77	2.28	17.30	11.49	5.85	12.74	7.77	2.28
Hobsons Lake	13.40	6.83	1.65	13.40	6.83	1.65	13.40	6.83	1.65	13.40	6.83	1.65
Little Horseshoe Lake	2.71	1.36	0.30	2.71	1.36	0.30	2.71	1.36	0.30	2.71	1.36	0.30
Big Horseshoe Lake	16.17	9.17	2.57	16.17	9.17	2.57	16.17	9.17	2.57	16.17	9.17	2.57
McQuade Lake	1.90	1.01	0.63	1.90	1.01	0.63	1.90	1.01	0.63	1.90	1.01	0.63

	Scenario 1: Existing Conditions			Scenario 2: Approved and Planned Developments			Scenario 3: Scenario 2 plus Hwy. 102 West Corridor Lands			Scenario 4: Scenario 3 minus Lands within Park Boundary		
Jack Lake	0.48	0.18	0.13	0.48	0.18	0.13	0.48	0.18	0.13	0.48	0.18	0.13
Three Finger Lake	15.93	8.56	2.15	15.93	8.56	2.15	15.93	8.56	2.15	15.93	8.56	2.15
Susie Lake	47.90	20.21	6.20	49.17	21.50	6.37	65.65	34.30	13.62	51.22	22.62	7.34
Quarry Lake	45.61	18.11	4.15	46.60	18.45	4.26	44.67	25.79	12.90	48.16	19.04	4.48
Washmill Lake	30.33	12.97	4.90	30.49	13.07	4.96	34.34	18.73	10.66	31.43	14.36	8.32
Kearney Lake	39.66	15.23	4.52	46.24	18.77	7.62	60.66	22.93	8.02	51.67	20.19	7.83
Paper Mill Lake	25.72	10.50	2.06	28.72	11.34	4.39	32.55	14.23	4.39	29.70	11.97	4.39

Table 25. Percent Changes in Land Use Between the Modeled Scenarios

A: % Land Use Change from Scenario 1: Existing Conditions to Scenario 2: Approved and Planned Developments
B: % Land Use Change from Scenario 2: Approved and Planned Developments to Scenario 3: Scenario 2 plus Hwy. 102 West Corridor Lands
C: % Land Use Change from Scenario 2: Approved and Planned Developments to Scenario 4: Scenario 3 minus Lands within the Park Boundary

	Forest	Grass	Meadow	Bare	Bedrock	Roof	Quarry	Pavement	Gravel	Wetland	Water
A: Change in Land use from Scenario 1 to Scenario 2											
Ash Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Charlies Lake	**-2.3%**	**1.4%**	0.0%	0.0%	0.0%	**0.8%**	0.0%	**0.4%**	0.0%	0.0%	0.0%
Cranberry Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crane Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Flat Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fox Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hobsons Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Horseshoe Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
McQuade Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Three Finger Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Susies Lake	**-1.7%**	**0.2%**	0.0%	0.0%	0.0%	**0.4%**	0.0%	**1.1%**	0.0%	0.0%	0.0%
Quarry Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Washmill Lake	**-0.4%**	**0.2%**	0.0%	0.0%	0.0%	**0.1%**	0.0%	**0.1%**	0.0%	0.0%	0.0%
Kearney Lake	**-19.9%**	**8.4%**	0.0%	0.0%	0.0%	**6.1%**	0.0%	**5.2%**	**0.2%**	0.0%	0.0%
Paper Mill Lake	**-33.0%**	**12.3%**	**-0.1%**	0.0%	**-0.5%**	**9.1%**	0.0%	**11.9%**	0.3%	0.0%	0.0%
B: Change in Land use from Scenario 2 to Scenario 3											
Ash Lake	**-2.8%**	**0.7%**	0.0%	0.0%	0.0%	**1.0%**	0.0%	**1.2%**	0.0%	0.0%	0.0%
Charlies Lake	**-15.3%**	**8.3%**	0.0%	0.0%	**-17.9%**	**11.6%**	0.0%	**13.3%**	0.0%	**-0.2%**	0.0%
Cranberry Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crane Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Flat Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fox Lake	**-29.5%**	**10.4%**	0.0%	0.0%	**-12.2%**	**14.6%**	0.0%	**16.7%**	0.0%	0.0%	0.0%
Hobsons Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Horseshoe Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
McQuade Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Three Finger Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Susies Lake	**-16.7%**	**4.3%**	0.0%	0.0%	0.0%	**6.1%**	**-0.6%**	**6.9%**	0.0%	0.0%	0.0%
Quarry Lake	**-49.4%**	**14.2%**	0.0%	0.0%	**-7.1%**	**19.9%**	**-0.2%**	**22.8%**	0.0%	**-0.2%**	0.0%

	Forest	Grass	Meadow	Bare	Bedrock	Roof	Quarry	Pavement	Gravel	Wetland	Water
Washmill Lake	**-20.8%**	**10.6%**	0.0%	0.0%	**-2.7%**	**14.9%**	**-19.1%**	**17.0%**	0.0%	0.0%	0.0%
Kearney Lake	**-0.9%**	**0.4%**	0.0%	0.0%	0.0%	**0.5%**	**-0.6%**	**0.6%**	0.0%	0.0%	0.0%
Paper Mill Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
C: Change in Land use Scenario 2 to Scenario 4											
Ash Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Charlies Lake	**-12.6%**	**5.1%**	0.0%	0.0%	**-7.9%**	**7.2%**	0.0%	**8.2%**	0.0%	**-0.2%**	0.0%
Cranberry Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Crane Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Flat Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Fox Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Hobsons Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Horseshoe Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
McQuade Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Three Finger Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Susies Lake	**-3.1%**	**0.8%**	0.0%	0.0%	0.0%	**1.1%**	0.0%	**1.2%**	0.0%	0.0%	0.0%
Quarry Lake	**-2.0%**	**0.9%**	0.0%	0.0%	**-1.6%**	**1.3%**	0.0%	**1.5%**	0.0%	0.0%	0.0%
Washmill Lake	**-14.4%**	**8.6%**	0.0%	0.0%	**-2.6%**	**12.1%**	**-17.4%**	**13.8%**	0.0%	0.0%	0.0%
Kearney Lake	**-0.9%**	**0.4%**	0.0%	0.0%	0.0%	**0.5%**	**-0.6%**	**0.6%**	0.0%	0.0%	0.0%
Paper Mill Lake	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%

Table 26. Modeled Ice Free and Measured Lake TSS Concentrations (mg/L) (SWMM)

Lake	Measured TSS	Scenario 1: Existing Conditions	Scenario 2: Approved and Planned Developments	Scenario 2 with SWM[1]	Scenario 3: Scenario 2 plus Hwy. 102 West Corridor Lands	Scenario 3 with SWM[1]	Scenario 4: Scenario3 Minus Lands Within Park Boundary	Scenario 4 with SWM[1]
Ash		5.7	5.7		6.2	5.8	5.7	
Charlies		4.1	4.3	4.2	6.8	4.7	6.1	4.5
Cranberry		3.2	3.2		3.2		3.2	
Crane		3.3	3.3		3.3		3.3	
Flat		1.5	1.5		1.5		1.5	
Fox		5.7	5.7		9.7	6.5	5.7	
Hobsons		2.6	2.6		2.6		2.6	
Horseshoe	2.6	3.8	3.8		3.8		3.8	
McQuade	1.8	5.7	5.7		5.7		5.7	
Three Finger		3.5	3.5		3.5		3.5	
Susies	1.3	5.5	5.7	5.5	7.2	5.8	6.0	5.6
Quarry		6.1	6.2	6.1	9.8	6.8	6.7	6.2
Washmill	3.0	7.1	7.2	7.1	10.7	7.8	8.7	7.4
Kearney	3.3	7.7	8.9	8.0	12.0	8.6	10.1	8.2
Paper Mill	3.2	7.0	10.4	7.7	12.6	8.1	11.2	7.8

[1]SWM removal rates assume an 80% reduction in TSS

Table 27. Modeled TSS Mass (kg/yr)

Lake	Scenario 1: Existing Conditions	Scenario 2: Approved and Planned Developments (% increase over Existing Conditions)		Scenario 2: with SWM [1] (% increase over Existing Conditions)		Scenario 2: Predicted Mass Removed by SWM[1]	Scenario 3: Scenario 2 plus Hgy. 102 West Corridor Lands (% increase over Existing Conditions)		Scenario 3: with SWM (% increase over Existing Conditions)		Scenario 3: Predicted Mass Removed by SWM1	Scenario 4: Scenario 3 minus Lands Within Park Boundary (% increase over Existing Conditions)		Scenario 4: with SWM (% increase over Existing Conditions)		Scenario 4: Predicted Mass Removed by SWM[1]
	KG/Year	KG/Year	%	KG/Year	%	KG/Year	KG/Year	%	KG/Year	%	KG/Year	KG/Year	%	KG/Year	%	KG/Year
Ash	33,958	33,958					36,746		34,516		2,231	33,958				
Charlies	11,261	11,746	4%	11,358	1%	388	17,088	52%	12,426	10%	4,661	15,619	39%	12,133	8%	3,487
Cranberry	64,039	64,039					64,039					64,039				
Crane	13,625	13,625					13,625					13,625				
Flat	2,608	2,608					2,608					2,608				
Fox	24,552	24,552					40,063	63%	27,654	13%	12,408	24,552				
Hobsons	38,825	38,825					38,825					38,825				
Horseshoe	54,083	54,083					54,083					54,083				
Kearney	282,349	335,365	19%	292,952	4%	42,412	477,209	69%	321,321	14%	155,888	380,931	35%	302,066	7%	78,865
McQuade	33,954	33,954					33,954					33,954				
Three Finger	49,888	49,888					49,888					49,888				
Susies	178,283	186,476	5%	179,922	1%	6,554	252,533	42%	193,133	8%	59,400	197,195	11%	182,065	2%	15,130
Quarry	214,027	220,182	3%	215,258	1%	4,924	363,644	70%	243,950	14%	119,694	232,729	9%	217,767	2%	14,962
Washmill	289,568	296,273	2%	290,909	0%	5,364	490,977	70%	329,850	14%	161,127	359,081	24%	303,471	5%	55,610
Kearney	282,349	335,365	19%	292,952	4%	42,412	477,209	69%	321,321	14%	155,888	380,931	35%	302,066	7%	78,865
Paper Mill	238,586	506,629	112%	292,194	22%	214,435	685,822	187%	328,033	37%	357,789	608,799	155%	312,628	31%	296,171

[1] *SWM removal rates assume an 80% reduction in TSS*

Table 28. Modeled Ice Free and Measured Lake TP Concentrations (µg/L)

Lake	Measured Concentration	Scenario 1: Existing Conditions	Scenario 2: Approved and Planned Develop-ments	Scenario 2 with SWM[2]	Scenario 3: Scenario 2 plus Hwy. 102 West Corridor Lands	Scenario 3 with SWM[2]	Scenario 4: Scenario 3 minus Lands Within Park Boundary	Scenario 4 with SWM[2]
Ash	2[1]	6	6		6	6	6	
Charlies	4[1]	4	5	5	7	6	6	5
Cranberry	9[1]	3	3		3		3	
Crane	3[1]	3	3		3		3	
Flat	7[1]	2	2		2		2	
Fox	2[1]	6	6		10	8	6	
Hobsons	7[1]	3	3		3		3	
Horseshoe	18	4	4		4		4	
McQuade	12[3]	6	6		6		6	
Three Finger	4[1]	3	3		3		3	
Susies		6	6	6	7	7	6	6
Quarry	7	6	6	6	10	8	7	7
Washmill	8[3]	7	7	7	10	9	9	8
Kearney	8[3]	8	9	9	13	10	11	9
Paper Mill	7[3]	7	10	9	13	10	11	9

Notes: [1]Indicates historical water quality data as per Table 9; [2]SWM removal rates assume a 50% reduction in TP; [3]From Table 18

Table 29. Predicted Trophic States using Modified LCM and SWMM

<table>
<tr><th rowspan="2"></th><th rowspan="2">Current Trophic State</th><th colspan="2">Scenario 1: Existing Conditions</th><th colspan="2">Scenario 2: Approved and Planned Developments</th><th colspan="2">Scenario 3: Scenario 2 plus HWY 102 West Corridor Lands</th><th colspan="2">Scenario 4: Scenario 3 Minus HWY 102 Lands Within Park Boundary</th></tr>
<tr><th>LCM</th><th>SWMM</th><th>LCM</th><th>SWMM</th><th>LCM</th><th>SWMM</th><th>LCM</th><th>SWMM</th></tr>
<tr><td>Ash, Cranberry, Crane, Flat, Hobsons, Horseshoe, Quarry, Susies, Three Finger</td><td>Oligotrophic</td><td colspan="8">No change in trophic state but TP will increase in Susies and Quarry Lake</td></tr>
<tr><td>Fox</td><td>Oligotrophic</td><td colspan="2">no change</td><td colspan="2">no change</td><td colspan="2">Mesotrophic</td><td colspan="2">no change</td></tr>
<tr><td>Charlies</td><td>Oligotrophic</td><td colspan="2">no change</td><td colspan="2">no change</td><td>Mesotrophic</td><td>no change</td><td>Mesotrophic</td><td>no change</td></tr>
<tr><td>Washmill</td><td>Oligotrophic</td><td colspan="2">no change</td><td colspan="2">no change</td><td colspan="2">Mesotrophic</td><td>Mesotrophic</td><td>no change</td></tr>
<tr><td>McQuade</td><td>Mesotrophic</td><td colspan="2">no change</td><td>Eutrophic</td><td>N/A</td><td>Eutrophic</td><td>N/A</td><td>Eutrophic</td><td>N/A</td></tr>
<tr><td>Kearney</td><td>Oligotrophic</td><td colspan="2">no change</td><td>Mesotrophic</td><td>no change</td><td colspan="2">Mesotrophic</td><td colspan="2">Mesotrophic</td></tr>
<tr><td>Paper Mill</td><td>Oligotrophic</td><td colspan="2">no change</td><td colspan="2">Mesotrophic</td><td colspan="2">Mesotrophic</td><td colspan="2">Mesotrophic</td></tr>
</table>

NA = model is not applicable

Table 30. Minimum Water Sampling Program Recommended for Birch Cove Lakes Watershed

Lake	General Location	Access	Sample Timing	Other
Kearney Lake	Outflow to Paper Mill	shore	Spring, summer, fall	Co-locate with flow station and level/temperature logger
Paper Mill Lake	Outflow from lake	shore	Spring, summer fall	Co-locate with flow station and level/temperature logger
Quarry Lake	Outflow from lake at dam	shore	Spring, summer fall outlet at Quarry Lake Dam	Co-locate with flow station and level/temperature logger – confirm similarity of Quarry and Susies Lake water quality as a special assessment
Washmill Lake	Outflow from lake to Kearney Lake	shore	Spring, summer fall	Co-locate with flow station and level/temperature logger - Sample at road crossing at inflow to Kearney Lake
Big Horseshoe Lake	Outflow from lake	shore	Spring, summer fall	sample at trail crossing of outlet on hydro cut – special study to understand high TP concentrations analysis of biologically available phosphorus
McQuade Lake	Outflow from lake	shore	Spring, summer fall	Co-locate with flow station and level/temperature logger – sample at crossing at Kingsway Drive

Table 31. Effect of Water Level Fluctuations for Flood Management

Lake	Water Level Fluctuation (m)	Average Depth (m)	Change to Average Depth (%)	Maximum Depth (m)	Change to Maximum Depth (%)	Surface Area (ha)	Relative Change\ (%)
Paper Mill	1.2	2.2	-55	6	-20	25.1	-21
Kearney	1.0	11.3	-9	27	-4	64.2	-8
Quarry plus Suzies*	1.0 (assumed)	3.5/3.7	-29/-27 (estimate)	8 and 11** (estimate)	-13 and -9** (estimate)	130.8	Not quantified due to lack of data

*These two lakes are hydrologically connected and thus have to be considered as a single lake

**Quarry and Suzies respectively

Table 32. Estimate of Conceptual Residual Capacity Remaining for Each Lake Following Approved Developments as per Scenario 2

Lake	Measured and Predicted TP Concentration Following Implementation of Approved and Planned Developments from Table 21 (Scenario 2)	Birch Cove Objective or Lake Objective	Early Warning Alert Value	Conceptual Residual Capacity (Determined as difference between Objective or Measured Concentration [whichever is highest] of Modeled Concentration Following Implementation of Scenario 2)
Ash Lake	2/2	≤10	10	8
Charlies Lake	4/4	≤10	10	6
Cranberry Lake	9/4	≤10	10	1
Crane Lake	3/3	≤10	10	7
Flat Lake	7/3	≤10	10	3
Fox Lake	2/3	≤10	10	7
Hobsons Lake	7/6	≤10	10	3
Horseshoe Lake	18/4	≤10	10	6[1]
McQuade Lake	12/78	≤20	15	Nil
Susies Lake	-/4	≤10	10	6
Quarry Lake[2]	7/1	≤10	8	3
Three Finger Lake	4/5	≤10	10	5
Washmill Lake	8/6	≤10	8	2
Kearney Lake	7/12	≤10	8	Nil
Paper Mill Lake	8/16	≤10	8	Nil

[1]Assumed that modeled TP concentration is indicative of biologically available phosphorus