Watershed Characterization

FIGURES

TABLES

B1 Methodology and gaps

B1.1 Data Resources Matrix

To organize the data sources required for the drinking water source protection (SWP) watershed characterization, the Province has developed an Excel file called the SWP Data Requirements Matrix. The matrix is intended to:

- Provide a complete list of available data sets for SWP;
- Help inventory and evaluate local data;
- Help identify data gaps;
- Facilitate data request process; and
- Facilitate communications around data between neighbouring Conservation Authorities and their SWP watershed region.

The matrix includes data set names, data descriptions, data access, data sources, and links to metadata. The file also includes a list of data sources required to build particular maps. Requests for data have been made by Central Lake Ontario Source Water Protection Area (CLOSPA) through SWP activities to both the Province and local municipalities. An inventory of the data and metadata received to date is being maintained by Central Lake Ontario Conservation Authority (CLOCA).

B1.2 Monitoring Data Sources

CLOSPA's monitoring networks provide an ongoing source of data sets that support numerous programs, including SWP planning. The source protection process involves the following steps:

- Developing an understanding of the flow system (surface water and groundwater);
- Cataloguing the various potential contaminant sources; and
- Assessing the risk that these potential contaminants pose to the water supply resources on a watershed basis.

CLOSPA's monitoring databases that are relevant to source water protection planning are listed in

Table B-1 which includes data type, status, and spatial coverage. CLOSPA's monitoring network incorporates both provincial and federal monitoring partnership programs. This monitoring network collects information pertaining, but not limited to, the following data types:

- Streamflow (stream gauges and low flows);
  - Quantity — Environment Canada HYDAT and Conservation Authority, and
  - Quality — Conservation Authority and Provincial Water Quality Monitoring Network (PWQMN).
- Climate;
- Groundwater; and
  - Quantity — Water levels, and
  - Quality — Provincial Groundwater Monitoring Network (PGMN).
- Groundwater monitoring networks operated by municipal partners related to the municipal well areas.

Other monitoring programs, such as aquatic ecosystem studies conducted by the Province and conservation authorities, also contribute to the development of a SWP plan.

Climate data is collected, mainly by Environment Canada, at the locations shown on **Figure B-1**. These data are augmented by monitoring stations operated by the conservation authorities. Continuous streamflow gauges are also maintained by the federal government (Water Survey of Canada). These locations are also shown on **Table B-2**. Stream water quality is monitored through the Provincial Water Quality Monitoring Network (PWQMN), and is augmented by other stations operated by the conservation authorities to contribute to various programs. These are described further in the watershed characterization report listed in **Chapter 7**.

Streamflow quality is important to the overall monitoring of watershed health, and is necessary to determine chemical loadings to Lake Ontario, the source of water supply for the majority of the population. Groundwater quality and quantity (water levels) are monitored by the Province and the conservation authorities at the locations shown on **Figure B-1**. Groundwater levels and quality monitoring is also conducted by municipal partners with locations mainly associated with the wellfield areas.

The information obtained from the monitoring network is applied in the various analyses that have or are being conducted as prescribed in the *Technical Rules*.

Table B-1: Monitoring Databases and Data Descriptions

Database Name	Data				
	Type	**Format**	**Period of Record**	**Coverage Area**	**Recording/Collection Frequency**
Durham Region Coastal Wetlands Monitoring Database	Turbidity	access	2002 – present	8 coastal wetlands	Monthly readings
	Water levels	excel	2003 – present	5 coastal wetlands	Continuous readings
	Water temperature	excel	2003 – present	5 coastal wetlands	Continuous readings
	Sediment quality	access	2002	8 coastal wetlands	5-year rotation collection
	Fish community	access	2003 – present	8 coastal wetlands	Monthly collection
	Invertebrate	access	2003 – present	8 coastal wetlands	Monthly collection
	Submerged plants	access	2003 – present	8 coastal wetlands	Monthly collection
Wetland Evaluation Database	MNR evaluation reports	paper	2005	15 wetlands	5 year rotation
ARMP Bio-Monitoring Database	Water Quality Index values (WQI), status and system type	excel	1996 – 2004 (terminated)	ARMPS per watershed	One collection per site per ARMP
	Water temperature	excel	1996 – 2004 (terminated)	ARMPS per watershed	One collection per site per ARMP
OBBN Bio-Monitoring Database	TBD - Reference Condition Approach (RCA)	TBD	Initiated 2005	OBBN sites TBD	TBD
	TBD - Stream morphology	TBD	Initiated 2005	OBBN sites TBD	TBD
Species Database	Terrestrial species attributes	access	2003 – present	Jurisdiction	Seasonal collection
Water Monitoring Network Databases	Groundwater quality (CLOSPA/PGMN)	access	2001 – present	16 sites	2 samples collected per site per year
	Groundwater static measurements (CLOSPA/PGMN)	access	2003 – present	16 sites	2 readings per site per year
	Groundwater continuous levels (CLOSPA/PGMN)	access	2001 – present	16 sites	Continuous readings
	Surface water quality (CLOSPA/PWQMN)	access	1965 – present	19 sites	Monthly collection at PWQMN sites; two samples collected per year at CLOSPA sites;
	Surface water levels	access	1959 – present depending on station	10 locations + 3 in 2005	Continuous
	Surface water flows	access	1959 – present depending on station	5 locations	Continuous

Database Name	Data				
	Type	Format	Period of Record	Coverage Area	Recording/Collection Frequency
	Rainfall	access	1999 – present	7 locations	Continuous
	Snow pack	access	1980 – present	4 locations	Bi-monthly - seasonal
	Humidity	access	2001 – present	2 locations	Continuous
	Barometric pressure	access	2001 – present	2 locations	Continuous
	Wind speed/direction	access	2001 – present	2 locations	Continuous
	Air temperature	access	2001 – present	7 locations	Continuous
	Rainfall	access	1959 – present	7 locations	Continuous
	Low flows (CLOSPA)	access	2000 - present	67 sites	4 – 6 measurements per site per year
	Low flows (ORMGP)	e:DAT	2002	46 sites	1 measurement per site
	Stream morphology	e:DAT	2002	46 sites	1 measurement per site
	Site locations	access	Current	All sites	As added/removed
	Field notes	excel	2001 - present	Most sites	As required
PTTW Database	Potential contaminant threats, locations, and attributes	TBD	2002 - present	83 active sites	As Identified
ORMGP Database	Subsurface/well data	access	1950s – present	Jurisdiction	As identified
	Climatic data	access	1960s – present	Jurisdiction	As identified
	Surface water data	access	1960s – present	Jurisdiction	As identified
	PTTW data	access	2002 – present	Jurisdiction	As identified

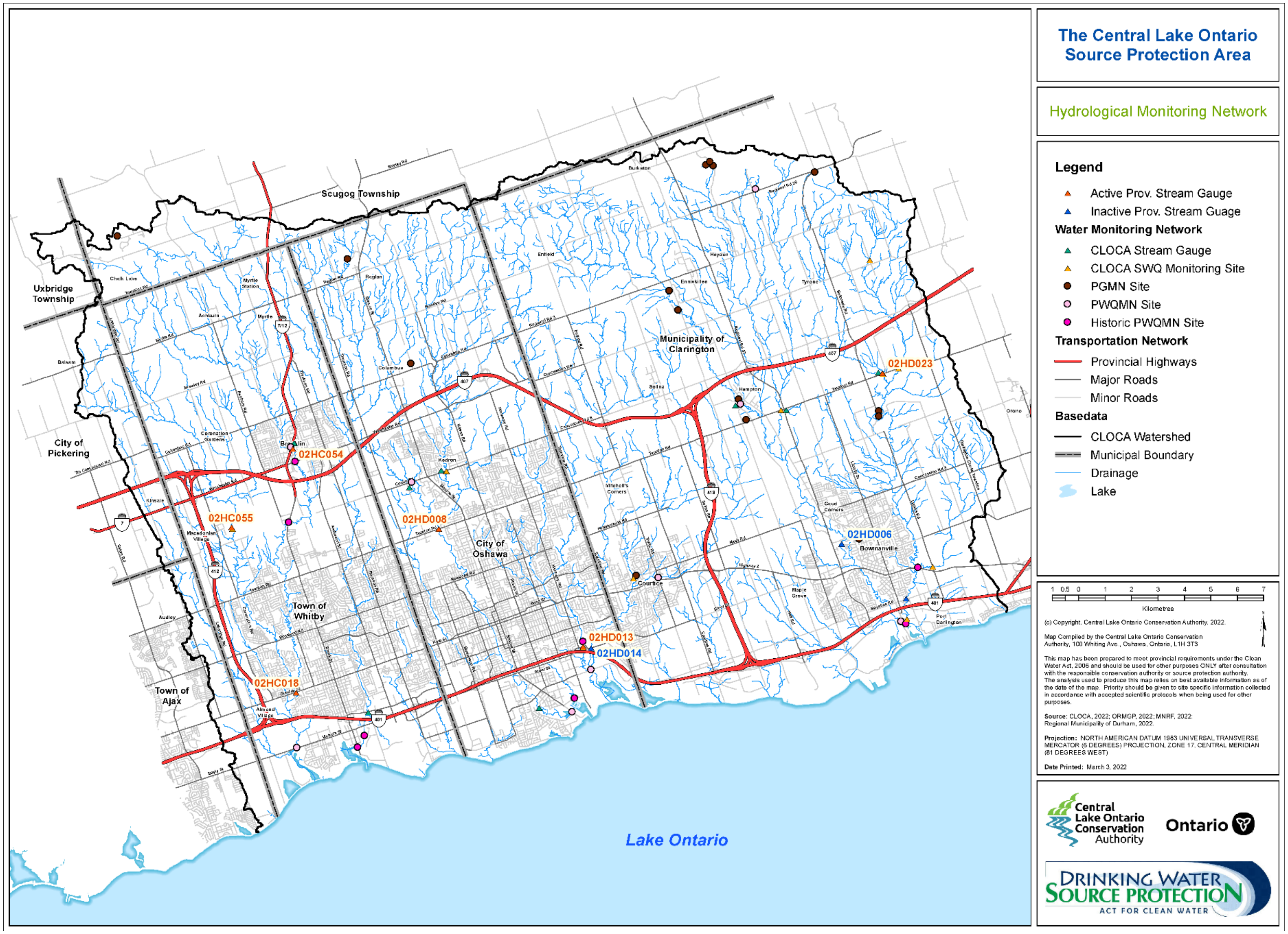

Figure B-1: CLOSPA Water Monitoring Network — 2006

B1.2.1 Stream Flow Gauging

Stream gauge data are required for water budgets, assimilative capacity studies, water takings, aquatic studies, and recharge and discharge analyses. Total flows, base flows, mean daily flows, and mean monthly flow information is derived from the raw level data and stream section and profile survey information.

There are 13 active stations (**Table B-2**), which include both Environment Canada's Water Survey of Canada (WSC) and CLOSPA stations. Active gauge stations do not exist on Black, Farewell, Corbett, Goodman, Robinson, Tooley, Darlington, Westside, and Bennett creeks. Historical records exist for discontinued WSC gauge stations sited on Farewell and Soper creeks. Additional stations will be required to generate the data required for SWP planning initiatives.

Table B-2: Surface Water Gauge Details, CLOSPA/Provincial Stream Gauge Network Stations

Station Id	Watershed	Location	Parameter	Record Frequency	Period Of Record
02HC018 (WSC)	Lynde Creek (main branch)	Dundas St.	Water Level	hr	1959–current
			Rainfall		
02HD008 (WSC)	Oshawa Creek (main branch)	Taunton Rd.	Water Level	hr	1959–current
			Rainfall	15min	
02HD006 (WSC)	Bowmanville Creek (main branch)	Jackman Rd.	Water level	hr	1959–current
			Rainfall		Proposed–2005
02HC055 (WSC)	Lynde Creek (west branch)	Kinsale	Water Level	hr	2002–current
			Rainfall		
			Water Temp		
			Air Temp		
02HC054 (WSC)	Lynde Creek (east Branch)	Brooklin	Water Level	hr	2002–current
			Water Temp		
Hampton	Bowmanville Creek (west branch)	Hampton	Water Level	hr	2003–current
			Rainfall		
			Water Temp		
			Air Temp		
Bowtaunt	Bowmanville Creek (east branch)	Taunton Rd.	Water Level	hr	Installation not complete
			Water Temp		
OshWest	Oshawa Creek (west branch)	Conlin Rd.	Water Level	hr	2001–current
			Air Temp		
OshEast	Oshawa Creek	Conlin Rd.	Water Level	hr	2001–current

Station Id	Watershed	Location	Parameter	Record Frequency	Period Of Record
	(east branch)		Air Temp		
OshMain	Oshawa Creek (main branch)	Thomas St.	Water Level	hr	2001–current
			Air Temp		
Pringle	Pringle Creek (main branch)	Consumers Rd.	Water Level	hr	2000–current
SopEast (02HD223)	Soper Creek (east branch)	Taunton Rd.	Water Level	hr	Proposed–2005
SopWest (02HD222) (WSC)	Soper Creek (west Branch)	Taunton Rd.	Water Level	hr	Proposed–2005

B1.2.2 Precipitation/Meteorological Gauging

Monitoring and measuring precipitation is a fairly simple process. One must obtain an accurate sample of the precipitation falling at the location of the gauge and have sufficient spatial coverage throughout the watershed to permit accurate estimates of the volume of water falling on a watershed. This information is currently compared with runoff volumes and quantitative hydrologic forecasting. Two types of climate station measurement locations operate within the watershed: five rain gauges operated and maintained by CLOSPA, and ten operated by the Atmospheric Environment Service (AES) (**Table B-3**). The data are collected by AES and are available from the Environment Canada website. Historical precipitation records used for the CLOSPA watershed are primarily recorded at the City of Oshawa WPCP station (6155878), which records mean daily rainfall and snowfall events. Data from AES stations are archived and found at: Climate Weather Website

AES data are periodically exported into the Oak Ridges Moraine Groundwater Program database for sites within the study area and are listed in **Table B-3**.

Table B-3: Meteorological Station Details, CLOSPA and AES Stations

Station Id	Watershed	Location	Parameter	Period Of Record
Prec1	Oshawa Creek	Coates Rd.	Rainfall	1999–present
			Temperature	2002-present
			Wind	
			Speed/Direction	
			BP	
			Humidity	
Prec2	Oshawa Creek	Howden Rd.	Rainfall	1999-present
Prec3	Oshawa Creek	Whiting Ave.	Rainfall	1999-present
			Temperature	2001-present
			Wind	
			Speed/Direction	
			BP	
			Humidity	
Prec4	Lynde Creek	Chalk Lake	Rainfall	2003-present
Prec5	Soper Creek	Woodley Rd.		2003-present
02HC018 (WSC)	Lynde Creek	Dundas St.		Current
20HD008 (WSC)	Oshawa Creek	Taunton Rd.		Current
6150830 (AES)	Soper Creek	Mostert	Climate Stn.	Historical
6151042 (AES)	Bowmanville Creek	Burketon McLaughlin		Historical
6154611 (AES)	Bowmanville Creek	Long Sault IHD		Historical
6155874 (AES)	Pringle Creek	Whitby WPCP		Historical
6155876 (AES)	Oshawa Creek	City of Oshawa		Historical
6155877 (AES)	Harmony Creek	Oshawa Fire Hall		Current
6155878 (AES)	Oshawa Creek	Oshawa WPCP		Current
6156634 (AES)	Bennett Creek	Port Darlington WCPC		Current
6157884 (AES)	Soper Creek	Soper Creek WPCP		Current
6159048 (AES)	Bowmanville Creek	Tyrone		Historical

B1.2.3 Snow Cover Monitoring

CLOSPA operates and maintains five snow course survey locations in the watershed (**Table B-4**), located in the Oak Ridges Moraine and Iroquois Beach physiographic regions. A snow course consists of a series of numbered posts driven into the ground 30 metres apart, usually in a straight line. The water is calculated, based on the weight of the snow in a core sampler. One ounce of snow in the sampler contains the equivalent of one inch of water. Snow course measurements are taken twice monthly, from December to May.

Table B-4: Snow Course Station Details, CLOSPA Stations

Station Id	Watershed	Location	Parameter	Record Frequency (Nov-May)	Period Of Record
4701	Lynde Creek	Heron Rd.	Snow	2/month	current
4909	Lynde Creek	Coronation Rd.			
4802	Oshawa Creek	Coates Rd.			
4903	Bowmanville Creek	Woodley Rd.			
4902	Soper Creek	Stephen's Hill Rd.			

B1.2.4 Groundwater Monitoring

In partnership with the Ministry of the Environment and Climate Change (MOECC), CLOSPA operates and maintains a network of 16 groundwater monitoring wells located throughout the watershed (**Table B-5**). Loggers were installed in the monitoring wells from 2000 to 2003 and automatically record water levels and temperature. Dataloggers measure absolute pressure (water pressure + atmospheric pressure), expressed in centimetres of water column.

The data are downloaded and sent electronically to the MOECC Provincial Groundwater Monitoring Information System database (PGMIS). The data are locally exported from PGMIS into the YDPT database using a SITEFX (specialized software) interface. CLOSPA is required to perform QA/QC activities to verify the continued accuracy of the data. Water levels are periodically measured manually to ensure that the automated systems are functioning correctly. QA/QC activities for all CLOSPA wells have not been completed at this time. Efforts are being made to align non-SWP funded program deliverables to support SWP analytical requirements.

Table B-5: PGMN Groundwater Monitoring Well Details

Station Id	Watershed	Location	Period Of Record	Parameter	Record Frequency
W0000040-1	Farewell Creek	Near Courtice Rd.	2001 – present	Water level	hr
W0000042-1	Soper Creek	Region Rd. 20			
W0000043-3	Bowmanville Creek	Fourth St.			
W0000044-2	Soper Creek	Bethesda Rd.			
W0000044-3					
W0000049-1	Oshawa Creek	Raglan Rd.			
W00000167-1	Bowmanville Creek	Holt Rd.	2002 – present		
W00000166-1					
W00000263-1	Lynde Creek	Middle March Rd.			
W00000262-1	Oshawa Creek	Grass Grove Rd.			
W00000261-1	Lynde Creek	Coronation Rd.			
W00000264-1	Bowmanville Creek	Grasshopper Rd.			
W00000264-2					
W00000265-1					

In general, sites monitor significant groundwater recharge areas within the Oak Ridges Moraine and in watersheds that originate from the Lake Iroquois Beach. All wells but one monitor surficial formations.

Water samples are also collected from each well twice a year and are analyzed routinely for general chemistry and metals. Every fourth or fifth year, samples are collected at certain locations and analyzed for volatile organics and/or pesticides. This sampling frequency may be adjusted depending on monitor location, interval, local land use, or other identified contaminant issue. Historical water level and quality data are available in hard copy from wells monitored by the MOECC through the IHD studies undertaken through the 1960s and intermittently into the 1980s.

Groundwater level data collected from listed monitoring wells is locally exported from the provincial PGMIS database into the local ORMGP database for use in analysis. Results of electronic water quality analysis from the laboratory are currently input directly into the local ORMGP database.

B1.2.5 Surface Water Quality

Chemical and physical characteristics of surface water quality in CLOSPA are monitored through the Provincial Surface Water Quality Monitoring Network (PWQMN). CLOSPA participates in this program by collecting monthly samples from April through November. The samples are analyzed for a range of water quality indicators, including temperature, pH, conductivity, turbidity, suspended solids, major ions, nutrients, metals, and pesticides, in order to screen overall water quality. CLOSPA currently monitors nine PWQMN stations located at watershed and subwatershed outlets (**Table B-6**).

Historical data sets have existed for each site extending back to the early 1960s, though significant gaps in the dataset have been identified. In addition to the sites currently monitored, there are eight historical PWQMN sites that also support long-term trend analysis.

Table B-6: Surface Water Quality Station Details, PWQMN and CLOSPA Stations

Current Sites								
MOE Station ID	**CLOSPA ID**	**Creek/Watershed**	**Location**	**First**	**Last**	**Re-started**	**Frequency**	**Program**
6010800102	1	Lynde Creek	Victoria St, Whitby	1964	1997	2003	8/year	PWQMN / CLOSPA
6011100102	2	Oshawa Creek	Simcoe St. South, Oshawa	1964	1997	2003		
6011200302	3	Farewell Creek	Colonel Sam Drive, Oshawa	1980	1997	2003		
6011600102	4	Bowmanville Creek	West Beach Rd, Bowmanville	1964	1997	2003		
6010800402	8	Lynde Creek	Baldwin St, Brooklin	1977	1994	2003		
6011100302	10	Oshawa Creek	Conlin Road, Oshawa	2003				
6011200502	14	Black Creek	Trulls Road, Courtice	2003				
6011600502	15	Bowmanville Creek	Hampton Conservation Area	2003				
6011600602	17	Bowmanville Creek	Long Sault Conservation Area	2003				
6011600202	5	Soper Creek	West Beach Rd, Bowmanville	1967	1994	2003	2/year	CLOSPA
	9	Lynde Creek	Heber Down Conservation Area	2004				
	11	Oshawa Creek	Conlin Road, Oshawa	2004				
6011200102	12	Harmony Creek	Bloor St, Oshawa	1964	1981	2005		
	13	Farewell Creek	Nash Road, Courtice	2005				
	16	Bowmanville Creek	Taunton Rd, Clarington	2004				
	18	Soper Creek (west branch)	Taunton Rd, Clarington	2004				
	19	Soper Creek (east branch)	Taunton Rd, Clarington	2004				
	20	Soper Creek (east branch)	Gibbs Rd north Conc. 7	2004				
	21	Soper Creek (east branch)	Lambs Road, Clarington	2005				

Historical Sites								
MOE Station ID	**CLOSPA ID**	**Creek/Watershed**	**Location**	**First**	**Last**	**Re-started**	**Frequency**	**Program**
06010800202	30	Lynde Creek	Baldwin St, N of Taunton Rd	1977	1978			
06010800302	31	Lynde Creek	Winchester Rd, E of Hwy 7/12	1977	1988			
06010900102	32	Pringle Creek	Brock St, Whitby	1964	1987			
06010900302	33	Pringle Creek	Watson St, Whitby	1972	1994			
06011100202	34	Montgomery Creek	Harbour Rd, Oshawa	1966	1994			
06011600302	35	Soper Creek	King St E, Hwy 2, Bowmanville	1968	1990			

B1.2.6 Low-Flow Stream Flow Surveys

CLOSPA is working with the Ministry of Natural Resources and Forestry, and the MOECC on the Low Water Response Program. This program monitors rainfall and streamflow within the creeks of CLOSPA's watersheds. The Authority has initiated a stream baseflow assessment program. The main objective is to obtain baseflow information to help develop a long-term baseflow monitoring network using a predetermined distribution of measurement sites. These data are also necessary for model calibration in water budgeting exercises, a necessary component for SWP activities.

Table B-7 lists sites where streamflow measurements have been taken annually, beginning in 2002. The field program measures flow taken over spring/summer/fall seasons. Field flow measurements are generally taken at stream crossings and stream gauge stations. These measurements represent a significant source of information that supports aquatic studies, groundwater discharge, and water budgets, including numerical model calibration. Linking low-flow measurements to streamflow gauges was undertaken by CLOSPA between 2006 and 2007 as part of SWP activities.

Table B-7: Low-Flow Monitoring Details, CLOSPA Stations

SITE	LOT	CON	WATER-SHED	SITE	LOT	CON	WATER-SHED	SITE	LOT	CON	WATER-SHED
SBF1	10	B.F.C	Soper Creek	FBF4	28	06	Farewell Creek	OBF34	15	09	Oshawa Creek
SBF2	07	01		FBF5	30	06		OBF35	18	07	
SBF3	04	01		FBF6	29	07		OBF36	17	08	
SBF5	08	02		HBF1	04	01	Harmony Creek	OBF37	19	07	
SBF6	06	03		HBF2	05	02		OBF38	19	09	
SBF7	05	05		HBF3	06	02		LBF1	30	01	Lynde Creek
SBF8	07	05		HBF4	34	04		LBF2	28	03	
SBF9	07	07		HBF5	32	04		LBF3	26	04	
SBF10	07	08		HBF6	35	04		LBF4	23	06	
SBF11	07	08		HBF7	03	03		LBF5	22	07	
SBF12	03	05		HBF8	03	04		LBF6	21	08	
SBF13	02	06		HBF9	01	04		LBF7	24	07	
SBF14	03	06		HBF10	34	05		LBF8	24	08	
SBF15	03	06		OBF1	13	04	Oshawa Creek	LBF9	24	09	
SBF16	03	07		OBF2	11	04		LBF10	24	09	
SBF17	05	07		OBF3	06	06		LBF11	25	09	
BBF1	14	02	Bowman-ville Creek	OBF4	06	06		LBF12	25	08	
BBF2	15	04		OBF5	03	06		LBF13	27	09	
BBF3	12	05		OBF6	35	08		LBF14	30	09	
BBF4	11	07		OBF7	32	08		LBF15	04	01	
BBF5	10	08		OBF8	09	06		LBF16	04	01	
BBF6	14	05		OBF9	06	06		LBF17	32	03	
BBF7	14	06		OBF10	06	07		LBF18	31	05	
BBF8	12	08		OBF11	08	06		LBF19	28	06	
BBF9	15	06		OBF12	08	08		LBF20	27	07	
BBF10	14	08		OBF13	02	09		LBF21	29	06	
BBF11	14	09		OBF14	03	08		LBF22	30	07	
BBF12	15	08		OBF15	06	09		LBF23	31	08	
BBF13	16	05		OBF16	07	08		LBF24	32	09	
BBF14	17	06		OBF17	10	06		LBF25	32	06	
BBF15	18	05		OBF18	14	04		LBF26	31	07	
BBF16	19	06		OBF19	13	05		LBF27	34	08	
BBF17	20	06		OBF20	18	05		LBF28	34	08	
BBF18	20	07		OBF21	13	07		LBF29	03	07	
BBF19	21	08		OBF22	12	07		LBF30	02	08	
BBF20	28	08		OBF23	10	08		LBF31	32	06	

SITE	LOT	CON	WATER-SHED	SITE	LOT	CON	WATER-SHED	SITE	LOT	CON	WATER-SHED
BBF21	26	09		OBF24	11	08		LBF32	35	06	
BBF22	16	05		OBF25	12	08		LBF33	31	01	
BLBF1	24	03	Black Creek	OBF26	09	08		LBF34	34	01	
BLBF2	20	04		OBF27	11	08		LBF35	34	03	
BLBF3	21	04		OBF28	10	08		LBF36	34	05	
BLBF4	24	05		OBF29	15	07		LBF37	01	03	
BLBF5	24	06		OBF30	14	08		LBF38	02	05	
FBF1	30	04	Farewell Creek	OBF31	14	08		LBF39	03	05	
FBF2	26	05		OBF32	14	09					
FBF3	25	06		OBF33	15	08					

Additionally, a low-flow survey was conducted under the ORMGP initiative in 2002 by Conestoga Rovers and Associates. Data gathered from the survey, which includes 47 locations within CLOSPA's jurisdiction, are stored in the ORMGP database.

B1.2.7 Biological Monitoring

Biological sampling measures ecological effects, whereas sampling for chemical and physical parameters measures stressors (i.e., environmental contamination). Though source water protection technical guidelines do not directly link the assessment and protection of drinking water to biological assessment, it is recognized that the various components of the watershed are closely linked. Protecting source water is important to the biological health of the watershed, and biological indicators are fundamental in protecting source water. CLOSPA's biological surveys involve sampling creatures, such as benthic macroinvertebrates and fish, found living within the aquatic environment. Benthic macroinvertebrates make good health indicators of aquatic ecosystems because:

- They generally have limited mobility, which makes them vulnerable to many creek stresses that may occur;
- They have short life cycles;
- They are easily collected and identified; and
- Their spatial distribution across the watershed is good.

Historically, CLOSPA's aquatic biological sampling has followed the BioMap protocol (Griffiths, 1999). Sampling was undertaken as part of the Aquatic Resource Management Plan (ARMP) activities for all watersheds within the study area. In CLOSPA, ARMPs have been developed on a watershed-by-watershed basis. To date, two ARMPs have been completed for CLOSPA with three additional ARMPs in progress for a total of five to cover the full CLOSPA jurisdiction.

To coordinate long-term monitoring efforts, CLOSPA joined the Ontario Benthos Biomonitoring Network (OBBN) in 2005. OBBN sites (**Figure B-2**) are closely linked to CLOSPA's PWQMN sites. This provincial network allows CLOSPA to follow a standardized methodology, share resources, and offer technical support.

B1.2.8 Coastal Wetland Monitoring

The Durham Region Coastal Wetland Monitoring Project is designed as a long-term program that will assess the health of 15 wetlands along the north shore of Lake Ontario in the Durham Region (**Figure B-3** and **Table B-8**).

To standardize the collection of biological and physical data among the partner organizations, a methodology handbook was developed by Environment Canada and the Central Lake Ontario Conservation Authority and fieldwork began in the spring of 2002.

Water levels in the Great Lakes have been recorded by the Canadian Hydrographic Service since 1860. These data show that levels in Lake Ontario have varied by up to two metres since that time. In 1958, however, lake level regulation was implemented, which moderated levels. While lake levels still fluctuate, they do not do so to the extent that occurred prior to regulation.

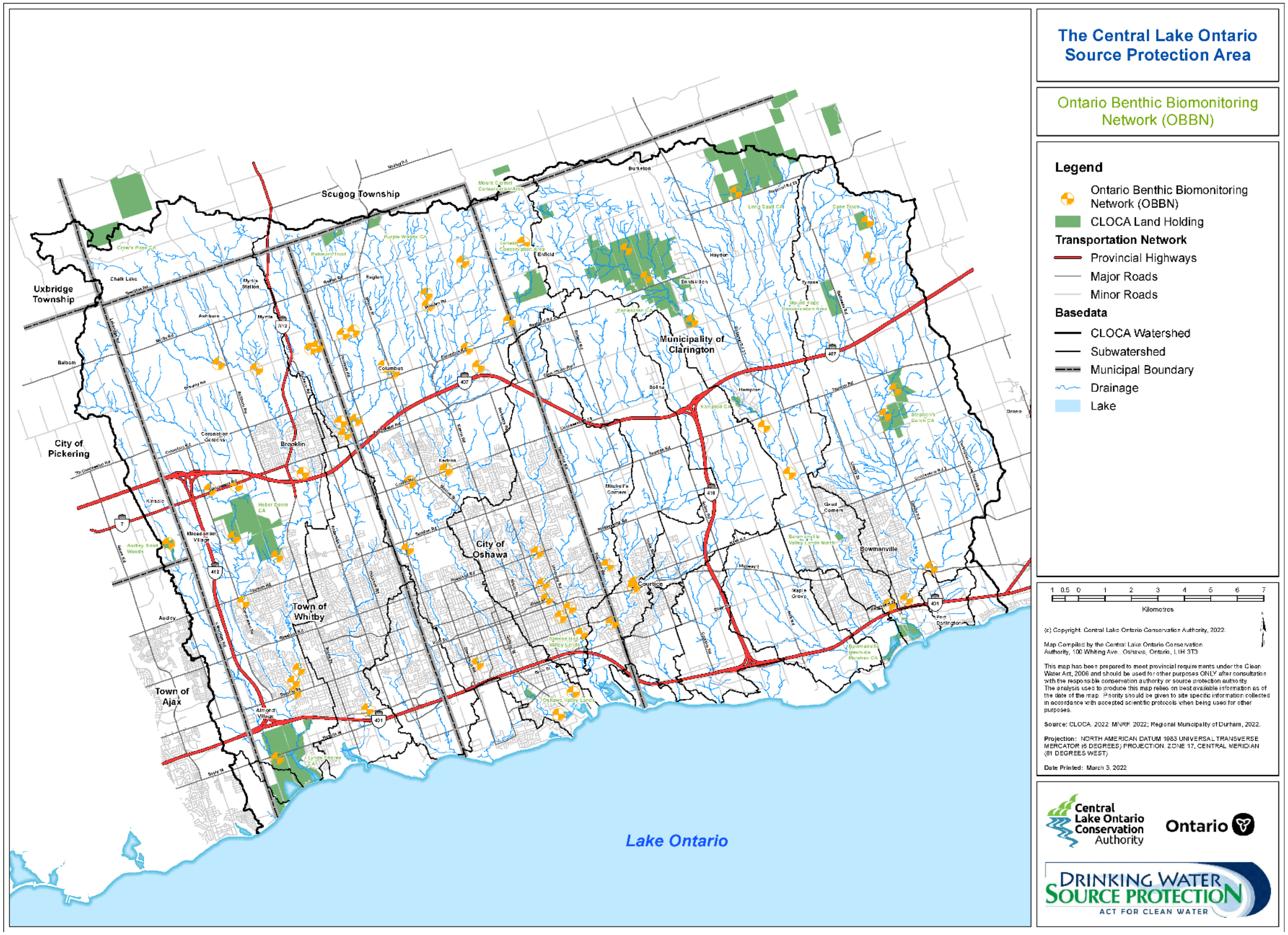

Figure B-2: Ontario Benthic Biomonitoring Network (OBBN) within the Study Area

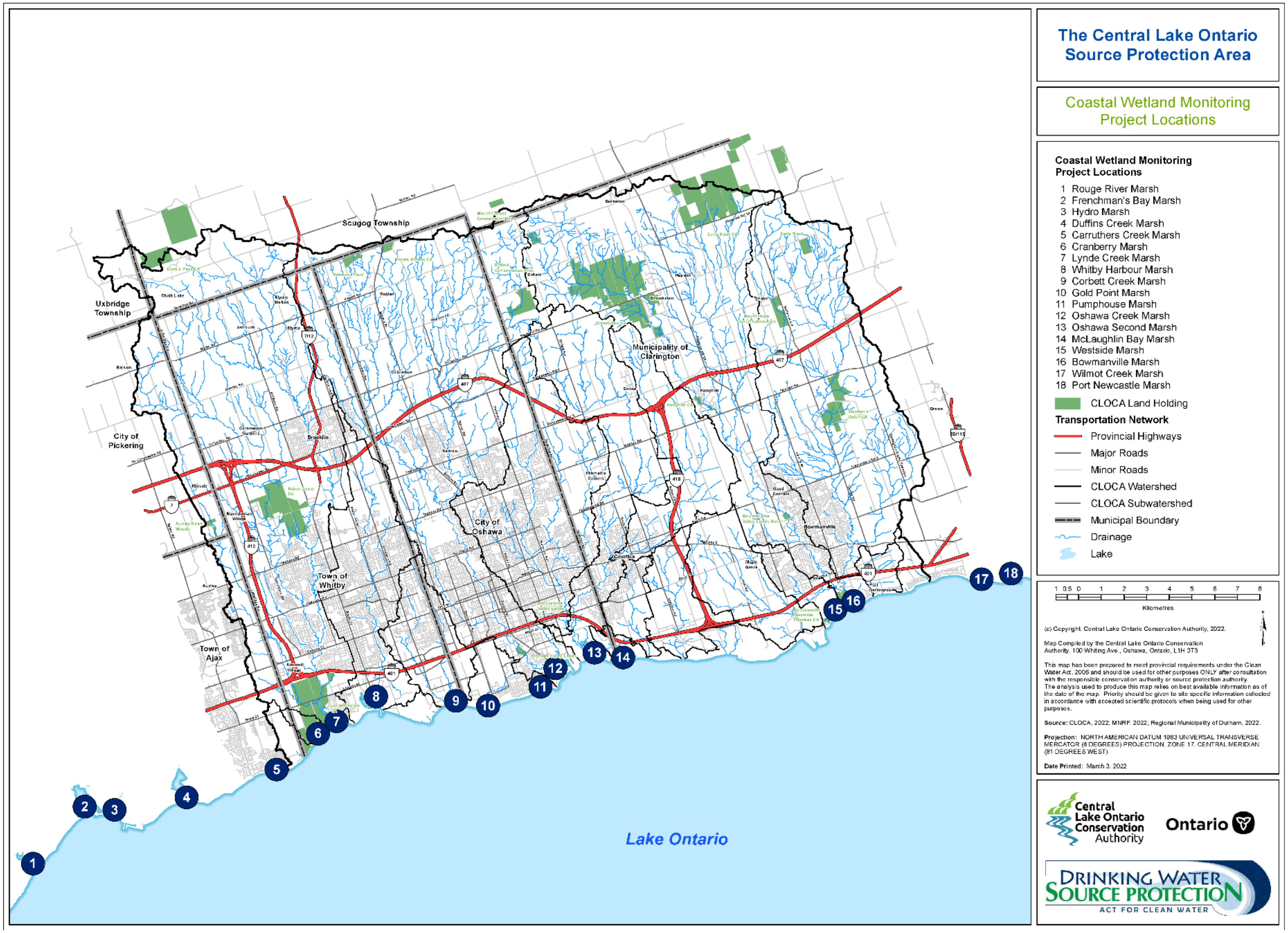

Figure B-3: Coastal Wetland Monitoring Project Locations, Durham Region

Table B-8: Durham Region Coastal Wetlands Currently Monitored

#	Wetland	SPA	#	Wetland	SPA*
1	Rouge River Marsh	TRSPA	9	Pumphouse Marsh	CLOSPA
2	Frenchman's Bay Marsh	TRSPA	10	Oshawa Second Marsh	CLOSPA
3	Hydro Marsh	TRSPA	11	McLaughlin Bay Marsh	CLOSPA
4	Duffins Creek Marsh	TRSPA	12	Westside Marsh	CLOSPA
5	Carruthers Creek Marsh	TRSPA	13	Bowmanville Marsh	CLOSPA
6	Cranberry Marsh	CLOSPA	14	Wilmot Creek Marsh	GRSPA
7	Lynde Creek Marsh	CLOSPA	15	Port Newcastle Wetland	GRSPA
8	Corbett Creek Marsh	CLOSPA	*TRCA: Toronto and Region Source Protection Area CLOSPA: Central Lake Ontario Source Protection Area GRSPA: Ganaraska Region Source Protection Area		

The Durham Region Coastal Wetlands Project monitors both physical features and biological communities. The following physical features or aspects are observed within the Coastal Wetland Monitoring Program:

- **Water Quality**—Measure various water quality parameters, including turbidity (clarity of water), conductivity, nitrogen, and phosphorus;
- **Water Levels**—For wetlands that can be cut off from Lake Ontario due to the formation of a barrier beach, measure water levels throughout the vegetation growing season (May to October);
- **Sediment Quality**—Collect recently deposited sediments to analyze for various contaminants including pesticides, metals, PCBs and PAHs;
- **Bathymetry**—Map wetland basin topography to reveal contours;
- **Watershed Vegetation**—Ecological Land Classification to Community Series level summarized for each wetland's watershed;
- **Land-use Change in Adjacent Uplands**—Compare current land use in 1000 meter zone around wetland with expected land use according to municipal and regional Official Plans. Obtain percentages of change for each land use category; and
- **Land-use Change in Watershed**—In conjunction with Watershed Management Plans, compare current land usage with expected land usage according to municipal and regional Official Plans Sediment and Nutrient Loading Computer modelling incorporating a Digital Elevation Model (DEM). This step is to be completed when technology becomes available.

The following biological communities are observed within the Coastal Wetland Monitoring Program:

- **Birds**—Survey marsh breeding bird communities using the Marsh Monitoring Program methodology;
- **Amphibians**—Survey amphibian communities using the Marsh Monitoring Program methodology;
- **Fish**—Survey wetland fish community using electrofishing boat;
- **Macroinvertebrates**—Sample wetland macroinvertebrates by sweep-netting through water column;
- **Wetland Vegetation**—Use Ecological Land Classification to define vegetation communities at each wetland and surrounding 500 metres;
- **Submerged Plants**—Sample submerged aquatic vegetation using 20 randomly placed quadrants; and
- **Identifying Key Habitats**—Over time, identify and track habitats associated with species at risk (i.e., endangered, threatened, or of special concern).

B1.3 Information Management System

Sources of information (details and descriptions) identified through source protection activities are to be tracked through CLOSPA's current information management system (IMS). IMS is an updatable and searchable database that contains metadata related to reports, documents, and correspondence. Folders are assigned IMS numbers (ID #) and updated information related to a particular folder is linked using the same IMS number as the parent folder.

The database is searchable by keyword, municipality, watershed, name, address, municipality number, permit number, date/owner, and folder ID number or attachment ID number. Information added to the database may contain a description of the report or data. Folders may be linked or cross-referenced by ID numbers. CLOSPA's IMS is regularly backed up and the database is accessible through the LAN by an IMS interface loaded on each workstation. Centralized updates or edits to IMS are typically required to maintain standardization of format within the system. IMS directly links digital files though the local area network. Hard copies of information are tracked in IMS to facilitate accessibility either within individual office cabinets or in the main administrative file location.

B1.4 Methods of Analysis

The Watershed Characterization is a description of the local watershed area and was developed by compiling all the available information about the area. It will include topics such as watershed features, the water quality, the wells and intakes that draw drinking water, and the natural and human-made influences. Maps were produced to provide a visualization of the watershed. This information gathering process will be iterative and continuous and will occur wherever possible to enhance the available data.

The watershed features include topography, physiography, geology, hydrology (surface water flow system) and hydrogeology (groundwater flow system), ecology, naturally vegetated areas, and climate. This information provides the background necessary for a more in-depth analysis in subsequent phases of the Assessment Report, including the Water Budget and Stress Assessment, the Vulnerability Analysis, and the Summary of Threats and Issues.

The water quality conditions and long-term trends in the watershed were identified. Maps and graphics are used to illustrate these trends. The objective was to describe the quality of surface water and groundwater using existing information and to determine whether the water quality is improving, deteriorating, or remaining constant.

The current water use was inventoried, as were historical takings, to illustrate where most of the water is going and at what times during the year. The inventory estimated population growth in the watershed area, which has a significant impact on future water demands.

The SPA also identified land-use activities that are known to pose a threat to the quality or quantity of drinking water to determine human and ecological impacts.

A Watershed Characterization Report has been prepared for the Source Protection Areas (Central Lake Ontario Conservation Authority, 2007). Workshops involving the conservation authority and municipal partners were held in late 2006 and early 2007 to review the contents of earlier versions of these reports. The most recent versions include edits and updates that are the result of the comments provided. The Province has established a panel to review the Watershed Characterization Reports. Comments from this review panel were received on January 8, 2008, and were incorporated into the final Assessment Report.

B1.5 Surface Water Quality Data Analysis and Reporting

The analysis and reporting of surface water quality data were accomplished in three steps:

- Exploratory analysis;
- Statistical analysis; and
- Reporting results.

B1.5.1 Exploratory Analysis

The first step involves plotting water quality observations to visually examine the attributes of the data (e.g., outliers and data entry errors). Each water quality observation is represented as a single point or dot. The y-axis (the dependent axis) is the concentration of a water quality parameter, and the x-axis (the independent axis) is time, usually represented as months or years. Specifically, a plot of water quality results against time allows for the:

- Observation of seasonal and annual trends;
- Identification of anomalous results and potential errors;
- Comparison of results to water quality criteria (e.g., Provincial Water Quality Objectives, Canadian Water Quality Guidelines);
- Observation of changes in water quality over time;
- Identification of missing periods of record (data gaps); and
- Identification of biases introduced by the timing of water quality measurements.

B1.5.2 Statistical Analysis

The second step in the analysis of surface water quality data involves the selection and application of statistical tests to establish the significance of differences, trends, and relationships that were identified in the exploration of the data.

B1.5.3 Reporting Results

The third step involves the use of graphics such as maps and boxplots to present selected results in a format consistent with the information needs and technical knowledge of the target audience. Results that are selected for reporting should describe the prevailing surface water quality conditions in the watershed (**Table B-9**).

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
SWQ1 (Lynde)													
Phosphorus, Total	30	µg/l	69	8	280	39.80	37	17.800	31	68.40	7	0.031	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	23	0.084	1.59	0.63	0.352	0.229	0.58	1.08	83	2.170	Red-Increasing Trend
Nitrate as N	10	mg/l	47	0.17	2.64	0.79	0.526	0.277	0.62	1.49	77	0.700	No Trend
Cl	250	mg/l	70	26	661	97.20	79.400	56.200	86.80	116.40	179	0.900	No Trend
Cu	5	µg/l	70	0.200	5.80	1.53	0.960	0.630	1.33	2.46	174	0.880	No Trend
Cd	0.1 - 0.5	µg/l	53	0.100	1.09	0.33	0.337	0.100	0.10	0.88	164	1.250	No Trend
Co	0.9	µg/l	62	0.007	1.47	0.42	0.332	0.200	0.30	0.81	278	1.680	No Trend
Fe	0.3	mg/l	70	0.003	1.17	0.26	0.204	0.104	0.21	0.37	164	0.830	No Trend
Ni	25	µg/l	63	0.064	3.96	0.85	0.730	0.100	0.83	1.38	116	0.680	No Trend
Pb	5 - 25	µg/l	55	0.043	6	1.32	1.440	0.140	0.70	3.23	285	2.060	Decreasing Trend
Zn	30	µg/l	69	0.100	18	2.87	3.040	0.660	2.10	5.20	45	0.228	No Trend
SWQ8 (Lynde)													
Phosphorus, Total	30	µg/l	119	3	562	37	74.700	6	18	66	770	1.770	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	25	0.554	1.21	0.774	0.158	0.610	0.746	0.95	40	0.91	No Trend
Nitrate as N	10	mg/l	46	0.455	1.78	0.910	0.340	0.614	0.815	1.43	126	1.18	No Trend
Cl	250	mg/l	119	9.400	209	37.600	24.400	13.600	39.400	56.90	3854	8.85	r-Increasing Trend
Cu	5	µg/l	93	0.089	7	0.940	1.080	0.200	0.600	1.98	438	1.45	No Trend
Cd	0.1 - 0.5	µg/l	46	0.075	1.14	0.208	0.226	0.100	0.100	0.50	337	3.18	Decreasing Trend
Co	0.9	µg/l	45	0.038	2.4	0.350	0.353	0.200	0.200	0.56	59	0.57	No Trend
Fe	0.3	mg/l	96	0.001	4.36	0.211	0.530	0.054	0.092	0.37	579	1.83	No Trend
Ni	25	µg/l	46	0.100	6	0.650	0.980	0.100	0.400	1	66	0.62	No Trend
Pb	5 - 25	µg/l	86	0.005	13	3.230	2.780	0.100	5	5	1870	7	Decreasing Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Zn	30	µg/l	88	0.018	220	6.340	23.800	0.395	1.750	12.90	1279	4.60	No Trend
SWQ9 (Lynde)													
Phosphorus, Total	30	µg/l	43	6	470	35.700	69.2	13	22	41.60	-78	-0.81	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	43	0.280	3.03	1.030	0.510	0.596	0.860	1.63	-25	-0.25	No Trend
Cl	250	mg/l	43	19.700	131	48.200	20.300	32.500	42.100	57.90	100	1.04	No Trend
Cu	5	µg/l	43	0.200	8	0.720	1.170	0.200	0.600	1	200	2.08	Red-Increasing Trend
Cd	0.1 - 0.5	µg/l	43	0.100	0.50	0.112	0.0625	0.100	0.100	0.10	-35	-0.36	No Trend
Co	0.9	µg/l	43	0.200	1.90	0.274	0.275	0.200	0.200	0.30	256	2.67	No Trend
Fe	0.3	mg/l	43	0.0333	3.18	0.207	0.466	0.088	0.133	0.20	-156	-1.62	No Trend
Ni	25	µg/l	43	0.100	4	0.460	0.71	0.10	0.20	0.96	456	4.76	Red-Increasing Trend
Pb	5 - 25	µg/l	43	0.100	8	0.680	1.10	0.10	0.70	0.70	-369	-3.85	Decreasing Trend
Zn	30	µg/l	43	0.100	20	1.200	3.03	0.20	0.50	1.66	-92	-0.95	No Trend
SWQ2 (Oshawa)													
Phosphorus, Total	30	µg/l	68	6	115	26.100	21.40	8.70	18.50	47	67	0.35	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	23	0.397	2.30	0.840	0.37	0.52	0.82	1.09	65	1.69	Red-Increasing Trend
Nitrate as N	10	mg/l	46	0.590	3.04	1.090	0.55	0.66	0.84	1.79	89	0.83	No Trend
Cl	250	mg/l	69	10.800	200	68.800	29.70	45	62.10	89.30	351	1.81	Red-Increasing Trend
Cu	5	µg/l	69	0.200	9.40	1.430	1.38	0.30	1	2.52	310	1.60	No Trend
Cd	0.1 - 0.5	µg/l	58	0.029	1.54	0.328	0.35	0.10	0.10	0.82	156	1.04	No Trend
Co	0.9	µg/l	57	0.237	1.77	0.505	0.44	0.20	0.30	1.19	60	0.41	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Fe	0.3	mg/l	69	0.001	0.57	0.193	0.12	0.09	0.18	0.36	80	0.41	No Trend
Ni	25	µg/l	68	0.081	25.50	1.820	3.38	0.37	1.25	2.20	377	2	Red-Increasing Trend
Pb	5 - 25	µg/l	51	0.099	11.20	1.590	2.16	0.10	0.70	3.50	33	0.26	No Trend
Zn	30	µg/l	65	0.400	34.60	3.400	4.76	0.81	1.98	6.70	256	1.44	No Trend
SWQ10 (Oshawa)													
Phosphorus, Total	30	µg/l	68	5	130	17.600	20.30	6	11.50	33.20	18	0.09	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	23	0.524	1.27	0.760	0.190	0.565	0.73	0.98	65	1.69	Red-Increasing Trend
Nitrate as N	10	mg/l	45	0.370	2.26	0.950	0.400	0.650	0.76	1.54	176	1.71	Decreasing Trend
Cl	250	mg/l	68	22.400	80	33.100	9.700	25.100	29.80	43.70	513	2.70	Red-Increasing Trend
Cu	5	µg/l	50	0.057	5	0.570	0.730	0.200	0.40	0.90	32	0.26	No Trend
Cd	0.1 - 0.5	µg/l	44	0.012	0.94	0.142	0.147	0.100	0.10	0.21	67	0.67	No Trend
Co	0.9	µg/l	43	0.024	1.4	0.305	0.272	0.169	0.20	0.50	6	0.05	No Trend
Fe	0.3	mg/l	54	0.056	0.64	0.127	0.103	0.068	0.10	0.18	191	1.42	No Trend
Ni	25	µg/l	48	0.100	2.13	0.445	0.490	0.100	0.20	0.93	105	0.92	No Trend
Pb	5 - 25	µg/l	45	0.100	10	1.540	2.360	0.100	0.70	3.90	495	4.83	Decreasing Trend
Zn	30	µg/l	43	0.057	11.2	0.990	1.880	0.178	0.40	1.84	16	0.16	No Trend
SWQ11 (Oshawa)													
Phosphorus, Total	30	µg/l	42	6	230	16.200	35.100	6	6	30.30	12	0.12	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	42	0.760	2.06	1.150	0.282	0.910	1.07	1.56	-256	-2.76	Decreasing Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Cl	250	mg/l	42	21.100	38	25.100	3.370	22	23.80	29.50	193	2.08	Red-Increasing Trend
Cu	5	µg/l	42	0.200	5	0.550	0.756	0.200	0.40	0.89	181	1.95	Red-Increasing Trend
Cd	0.1 - 0.5	µg/l	42	0.100	1	0.133	0.151	0.100	0.10	0.10	-6	-0.05	No Trend
Co	0.9	µg/l	42	0.10	1.60	0.28	0.257	0.20	0.20	0.30	140	1.51	No Trend
Fe	0.3	mg/l	42	0.06	1.43	0.13	0.214	0.06	0.08	0.20	-205	-2.20	Decreasing Trend
Ni	25	µg/l	42	0.10	2	0.34	0.46	0.10	0.10	0.79	397	4.30	Red-Increasing Trend
Pb	5 - 25	µg/l	42	0.10	1.10	0.56	0.284	0.10	0.70	0.70	-291	-3.15	Decreasing Trend
Zn	30	µg/l	42	0.10	6.50	0.82	1.35	0.20	0.40	1.93	-7	-0.07	No Trend
SWQ12 (Harmony)													
Phosphorus, Total	30	µg/l	9	8	66	28.10	19.4	8	25	50	5	0.42	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	9	0.75	2.28	1.17	0.484	0.79	1	1.66	-2	-0.10	No Trend
Cl	250	mg/l	9	42	413	228.90	121.5	91.60	244	363.40	-14	-1.36	No Trend
Cu	5	µg/l	9	1	4.10	2.06	0.88	1.32	1.90	2.90	5	0.42	No Trend
Cd	0.1 - 0.5	µg/l	9	0.10	0.10	0.10	0	0.10	0.10	0.10	0	0	No Trend
Co	0.9	µg/l	9	0.20	0.50	0.29	0.105	0.20	0.30	0.42	15	1.46	No Trend
Fe	0.3	mg/l	9	0.14	0.35	0.21	0.071	0.15	0.19	0.30	2	0.10	No Trend
Ni	25	µg/l	9	0.10	1.70	0.86	0.53	0.10	0.90	1.38	23	2.30	Red-Increasing Trend
Pb	5 - 25	µg/l	9	0.20	0.70	0.56	0.219	0.28	0.70	0.70	-16	-1.60	No Trend
Zn	30	µg/l	9	1.30	7	3.30	1.97	1.54	2.30	5.90	15	1.46	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
SWQ3 (Farewell)													
Phosphorus, Total	30	µg/l	68	6	1310	59.50	160.70	12	28	81.40	223	1.18	Decreasing Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	22	0.650	3.40	1.41	0.57	0.74	1.35	1.81	4	0.09	No Trend
Nitrate as N	10	mg/l	46	0.750	5.23	1.57	0.78	1	1.34	2.54	231	2.18	Decreasing Trend
Cl	250	mg/l	68	32.400	594	142.90	77.30	82.60	134	191.60	7	0.03	Red-Increasing Trend
Cu	5	µg/l	68	0.200	67.80	2.90	8.10	0.70	1.65	3.76	241	1.27	Decreasing Trend
Cd	0.1 - 0.5	µg/l	56	0.010	1.51	0.30	0.35	0.10	0.10	0.72	288	2.03	No Trend
Co	0.9	µg/l	51	0.120	2	0.46	0.38	0.20	0.30	0.91	25	0.20	No Trend
Fe	0.3	mg/l	68	0.001	2.04	0.26	0.27	0.13	0.21	0.36	116	0.61	Decreasing Trend
Ni	25	µg/l	66	0.0001	50	1.50	6.10	0.10	0.72	1.30	174	0.96	No Trend
Pb	5 - 25	µg/l	51	0.027	67.30	3.04	9.60	0.20	0.70	4.75	423	3.43	Decreasing Trend
Zn	30	µg/l	68	0.250	394	9.40	47.60	0.95	2.20	7	410	2.17	Decreasing Trend
SWQ13 (Farewell)													
Phosphorus, Total	30	µg/l	42	6	150	19.10	24.50	6.10	12	30.70	124	1.33	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	42	0.740	4.80	1.86	0.59	1.44	1.77	2.40	-102	-1.10	No Trend
Cl	250	mg/l	42	18.20	63.30	29.60	10	20.70	27	38.70	96	1.03	No Trend
Cu	5	µg/l	42	0.200	3	0.676	0.560	0.20	0.55	1.10	201	2.17	Red-Increasing Trend
Cd	0.1 - 0.5	µg/l	42	0.100	0.40	0.107	0.046	0.10	0.10	0.10	-25	-0.26	No Trend
Co	0.9	µg/l	42	0.100	0.50	0.233	0.082	0.20	0.20	0.30	237	2.56	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Fe	0.3	mg/l	42	0.033	0.49	0.089	0.078	0.04	0.07	0.15	18	0.18	No Trend
Ni	25	µg/l	42	0.100	1.20	0.255	0.253	0.10	0.10	0.49	410	4.43	Red-Increasing Trend
Pb	5 - 25	µg/l	42	0.100	0.90	0.543	0.259	0.10	0.70	0.70	-337	-3.65	Decreasing Trend
Zn	30	µg/l	42	0.100	18.30	1.29	2.900	0.20	0.50	1.79	281	3.04	Red-Increasing Trend
SWQ14 (Black)													
Phosphorus, Total	30	µg/l	67	6	318	73.700	55.500	21	64	143.20	70	0.37	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	21	0.410	1.75	0.905	0.323	0.67	0.84	1.29	66	1.96	Decreasing Trend
Nitrate as N	10	mg/l	46	0.200	3.28	1	0.540	0.50	0.82	1.64	247	2.33	Decreasing Trend
Cl	250	mg/l	67	21.600	151	72.600	30.400	40.40	63.40	115	99	0.53	No Trend
Cu	5	µg/l	54	0.109	6.30	1.150	1.160	0.21	0.87	2.30	308	2.3	Red-Increasing Trend
Cd	0.1 - 0.5	µg/l	44	0.030	1.86	0.200	0.307	0.10	0.10	0.48	200	2.01	Decreasing Trend
Co	0.9	µg/l	44	0.0187	1.59	0.307	0.260	0.20	0.20	0.52	9	0.08	No Trend
Fe	0.3	mg/l	54	0.051	0.58	0.184	0.103	0.10	0.16	0.32	70	0.52	No Trend
Ni	25	µg/l	49	0.014	1.20	0.510	0.345	0.10	0.50	0.97	131	1.12	No Trend
Pb	5 - 25	µg/l	45	0.0710	15	1.42	2.50	0.10	0.700	3.32	332	3.24	Decreasing Trend
Zn	30	µg/l	54	0.3600	20.10	4.33	3.90	1.53	2.950	9.70	96	0.71	No Trend
SWQ4 (Bowmanville)													
Phosphorus, Total	30	µg/l	65	6	165	23.80	25.20	6	15	60	91	0.51	Decreasing Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	19	0.3930	1.93	0.79	0.43	0.41	0.636	1.46	39	1.33	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Nitrate as N	10	mg/l	46	0.4000	3.97	0.99	0.68	0.49	0.660	1.75	112	1.05	No Trend
Cl	250	mg/l	65	13.6000	282	28.70	33	16.30	23.500	36.10	480	2.70	Red-Increasing Trend
Cu	5	µg/l	65	0.0262	2.1	0.74	0.44	0.20	0.700	1.34	614	3.47	Decreasing Trend
Cd	0.1 - 0.5	µg/l	58	0.0010	1.31	0.28	0.32	0.10	0.100	0.82	29	0.19	Decreasing Trend
Co	0.9	µg/l	53	0.0860	1.71	0.36	0.32	0.20	0.200	0.66	76	0.58	No Trend
Fe	0.3	mg/l	66	0.0005	0.44	0.13	0.10	0.06	0.106	0.23	87	0.48	Decreasing Trend
Ni	25	µg/l	57	0.0292	2.12	0.37	0.44	0.10	0.191	0.97	261	1.79	Decreasing Trend
Pb	5 - 25	µg/l	51	0.0272	21.4	2.30	4.24	0.10	0.700	5.17	338	2.74	Decreasing Trend
Zn	30	µg/l	60	0.0480	9.80	1.84	1.71	0.55	1.180	3.76	106	0.67	Decreasing Trend
SWQ15 (Bowmanville)													
Phosphorus, Total	30	µg/l	69	5	104	21	17.200	6	17	35.20	390	2.01	Decreasing Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	22	0.465	1.30	0.630	0.195	0.520	0.556	0.90	33	0.90	No Trend
Nitrate as N	10	mg/l	47	0.440	1.78	0.780	0.370	0.480	0.600	1.43	325	2.97	Decreasing Trend
Cl	250	mg/l	69	8	20	12.200	3.340	8.700	11.200	17.30	473	2.44	Red-Increasing Trend
Cu	5	µg/l	49	0.053	1.80	0.395	0.287	0.200	0.300	0.65	182	1.56	No Trend
Cd	0.1 - 0.5	µg/l	45	0.009	1.13	0.155	0.175	0.100	0.100	0.28	203	1.98	Decreasing Trend
Co	0.9	µg/l	46	0.027	0.89	0.233	0.168	0.100	0.200	0.30	41	0.38	No Trend
Fe	0.3	mg/l	56	0.063	0.32	0.115	0.046	0.074	0.105	0.17	230	1.62	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Ni	25	µg/l	43	0.093	1.04	0.230	0.230	0.100	0.100	0.67	51	0.52	No Trend
Pb	5 - 25	µg/l	42	0.100	13.30	1.250	2.320	0.100	0.700	2.92	443	4.80	Decreasing Trend
Zn	30	µg/l	46	0.025	2.50	0.546	0.477	0.200	0.400	1.10	270	2.55	Red- Increasing Trend
SWQ16 (Bowmanville)													
Phosphorus, Total	30	µg/l	44	6	128	21.100	25.100	6	11.500	37	-13	-0.12	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	44	0.0300	1.62	0.770	0.330	0.526	0.655	1.30	-148	-1.49	No Trend
Cl	250	mg/l	44	11	22.80	15.400	3.500	12	14.200	20.80	216	2.17	Red- Increasing Trend
Cu	5	µg/l	44	0.100	1.50	0.434	0.295	0.20	0.35	0.80	76	0.76	No Trend
Cd	0.1 - 0.5	µg/l	44	0.100	0.20	0.105	0.021	0.10	0.10	0.10	-46	-0.46	No Trend
Co	0.9	µg/l	44	0.100	0.60	0.198	0.079	0.10	0.20	0.20	-90	-0.9	Decreasing Trend
Fe	0.3	mg/l	44	0.037	0.23	0.083	0.044	0.05	0.07	0.13	-202	-2.03	Decreasing Trend
Ni	25	µg/l	44	0.100	0.80	0.177	0.179	0.10	0.10	0.44	310	3.13	Red- Increasing Trend
Pb	5 - 25	µg/l	44	0.100	0.70	0.510	0.273	0.10	0.70	0.70	-396	-4	Decreasing Trend
Zn	30	µg/l	44	0.100	19.20	1.330	2.870	0.30	0.65	2.50	-91	-0.91	No Trend
SWQ17 (Bowmanville)													
Phosphorus, Total	30	µg/l	35	5	39	19.100	8.200	10.40	18	29.60	116	1.63	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	22	0.122	0.19	0.166	0.017	0.14	0.17	0.18	108	3.02	Decreasing Trend
Nitrate as N	10	mg/l	13	0.132	0.20	0.162	0.022	0.14	0.16	0.19	9	0.49	No Trend
Cl	250	mg/l	35	0.900	1.30	1.070	0.107	0.90	1.10	1.20	15	0.20	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Cu	5	µg/l	12	0.113	0.56	0.303	0.161	0.12	0.27	0.53	30	1.99	Red-Increasing Trend
Cd	0.1 - 0.5	µg/l	9	0.008	0.76	0.328	0.260	0.11	0.26	0.70	4	0.31	No Trend
Co	0.9	µg/l	11	0.012	1.60	0.630	0.476	0.04	0.62	1.04	11	0.78	No Trend
Fe	0.3	mg/l	22	0.042	0.17	0.074	0.030	0.05	0.07	0.10	83	2.31	Red-Increasing Trend
Ni	25	µg/l	8	0.285	1.18	0.600	0.360	0.30	0.47	1.16	4	0.37	No Trend
Pb	5 - 25	µg/l	9	0.364	4.70	1.920	1.400	0.77	1.61	3.86	8	0.73	No Trend
Zn	30	µg/l	14	0.315	4.76	0.87	1.14	0.363	0.52	0.96	1	0	No Trend
SWQ5 (Soper)													
Phosphorus, Total	30	µg/l	48	6	102	30.60	25	6	24.50	71	-165	-1.46	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	3	0.990	2.75	1.80	0.89	1.13	1.68	2.54	-1	0	No Trend
Nitrate as N	10	mg/l	45	0.810	3.95	1.66	0.79	1.06	1.36	2.87	7	0.06	No Trend
Cl	250	mg/l	48	19.200	246	33.50	33.50	20.7	25.80	37.40	59	0.52	No Trend
Cu	5	µg/l	48	0.200	2.4	0.76	0.55	0.2	0.60	1.56	51	0.44	No Trend
Cd	0.1 - 0.5	µg/l	46	0.100	0.67	0.13	0.10	0.1	0.10	0.10	-81	-0.76	No Trend
Co	0.9	µg/l	47	0.100	0.71	0.26	0.12	0.2	0.20	0.44	251	2.30	No Trend
Fe	0.3	mg/l	48	0.031	0.41	0.14	0.09	0.0575	0.11	0.26	-257	-2.28	Decreasing Trend
Ni	25	µg/l	46	0.100	1.1	0.30	0.29	0.1	0.20	0.80	420	3.97	Red-Increasing Trend
Pb	5 - 25	µg/l	46	0.100	8.3	0.80	1.26	0.1	0.70	0.70	-329	-3.10	Decreasing Trend
Zn	30	µg/l	48	0.500	9.4	2.20	1.86	0.67	1.55	4.63	-131	-1.16	No Trend
SWQ21 (Soper - East)													
Phosphorus, Total	30	µg/l	9	20	100	54.30	25.90	21.6	53	83.20	-12	-1.15	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	9	3.060	5.96	4.34	0.96	3.26	4.27	5.66	20	1.98	Red-Increasing Trend
Cl	250	mg/l	9	27.600	37.10	33.90	2.830	31.40	34.40	36.50	18	1.77	Red-Increasing Trend
Cu	5	µg/l	9	0.200	1.10	0.68	0.303	0.20	0.80	0.94	5	0.42	No Trend
Cd	0.1 - 0.5	µg/l	9	0.100	0.20	0.11	0.033	0.10	0.10	0.12	-2	-0.11	No Trend
Co	0.9	µg/l	9	0.200	0.60	0.27	0.132	0.20	0.20	0.36	13	1.26	No Trend
Fe	0.3	mg/l	9	0.090	0.28	0.18	0.057	0.10	0.19	0.22	-10	-0.94	No Trend
Ni	25	µg/l	9	0.100	1.20	0.39	0.390	0.10	0.20	0.88	17	1.68	Red-Increasing Trend
Pb	5 - 25	µg/l	9	0.100	0.70	0.51	0.285	0.10	0.70	0.70	-18	-1.80	Decreasing Trend
Zn	30	µg/l	9	0.600	1.70	1.17	0.316	0.84	1.20	1.46	-1	0	No Trend
SWQ18 (Soper-East)													
Phosphorus, Total	30	µg/l	44	6	72	16.40	13.800	6	10.50	33.30	-55	-0.55	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	44	0.810	2.20	1.23	0.247	1	1.17	1.52	-283	-2.85	Decreasing Trend
Cl	250	mg/l	44	8.600	23.90	19.20	3.300	17.60	19.70	21.80	366	3.70	Red-Increasing Trend
Cu	5	µg/l	44	0.100	1	0.35	0.197	0.20	0.30	0.57	126	1.26	No Trend
Cd	0.1 - 0.5	µg/l	44	0.100	0.20	0.10	0.015	0.10	0.10	0.10	-25	-0.24	No Trend
Co	0.9	µg/l	44	0.100	0.40	0.21	0.068	0.10	0.20	0.27	41	0.41	No Trend
Fe	0.3	mg/l	44	0.010	0.30	0.06	0.059	0.02	0.04	0.12	-235	-2.37	Decreasing Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Ni	25	µg/l	44	0.100	0.9	0.198	0.203	0.10	0.10	0.50	354	3.57	Red-Increasing Trend
Pb	5 - 25	µg/l	44	0.100	0.7	0.505	0.280	0.10	0.70	0.70	-426	-4.30	Decreasing Trend
Zn	30	µg/l	44	0.100	2.3	0.560	0.494	0.20	0.40	0.97	-40	-0.40	No Trend
SWQ19 (Soper-East)													
Phosphorus, Total	30	µg/l	44	6	62	16.600	14.600	6	10.50	36.30	-1	0	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	44	0.790	2.28	1.410	0.293	1.18	1.36	1.77	40	0.40	No Trend
Cl	250	mg/l	44	8.200	62.8	12.100	8.400	8.50	9.95	16.6	101	1.01	No Trend
Cu	5	µg/l	44	0.100	2.6	0.370	0.387	0.20	0.20	0.50	154	1.55	No Trend
Cd	0.1 - 0.5	µg/l	44	0.100	0.1	0.100	0	0.10	0.10	0.10	0	0	No Trend
Co	0.9	µg/l	44	0.100	0.5	0.207	0.073	0.10	0.20	0.30	-9	-0.08	No Trend
Fe	0.3	mg/l	44	0.023	0.436	0.072	0.068	0.03	0.05	0.13	-132	-1.33	No Trend
Ni	25	µg/l	44	0.100	17.9	0.670	2.7	0.10	0.10	0.67	334	3.37	Red-Increasing Trend
Pb	5 - 25	µg/l	44	0.100	1.5	0.523	0.315	0.10	0.70	0.70	-421	-4.25	Decreasing Trend
Zn	30	µg/l	44	0.100	3.5	0.820	0.870	0.20	0.45	2.10	14	0.13	No Trend
SWQ20 (Soper-East)													
Phosphorus, Total	30	µg/l	6	6	14	7.700	3.200	6	6	11	-5	-0.77	No Trend
Nitrate (Total, Unfiltered Reactive)	10	mg/l	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0	0	No Trend
Nitrate as N	10	mg/l	6	0.750	1.08	0.93	0.14	0.78	0.945	1.07	-15	-2.63	Decreasing Trend
Cl	250	mg/l	6	6	9.80	7.54	1.69	6.10	6.900	9.60	7	1.13	No Trend
Cu	5	µg/l	6	0.200	1.20	0.53	0.39	0.25	0.350	1	-4	-0.57	No Trend

Parameter	Provincial Limits	Unit	Number of Samples	Minimum	Maximum	Arithmetic Mean	Standard Deviation	10th Percentile	Median 50th Percentile	90th Percentile	Mann-Kendall Statistic indicating increasing or decreasing trend	Mann-Kendall Statistic, approximate Z value for calculating probability	Mann-Kendall Result 95% significance
Cd	0.1 - 0.5	µg/l	6	0.100	0.10	0.1	0	0.10	0.100	0.10	0	0	No Trend
Co	0.9	µg/l	6	0.100	0.20	0.15	0.06	0.10	0.150	0.20	-9	-1.56	No Trend
Fe	0.3	mg/l	6	0.024	0.13	0.07	0.04	0.03	0.075	0.11	-11	-1.88	Decreasing Trend
Ni	25	µg/l	6	0.100	0.60	0.33	0.21	0.10	0.350	0.55	6	0.96	No Trend
Pb	5 - 25	µg/l	6	0.100	10.20	2.08	4	0.10	0.700	5.45	-5	-0.78	No Trend
Zn	30	µg/l	6	0.200	1.60	0.67	0.59	0.20	0.400	1.40	-6	-0.94	No Trend

Table B-9: Statistical Results for Select Surface Water Quality Sites within CLOSPA

All analysis was completed with AquaChem Water Quality software.

B1.6 Groundwater Quality Data Analysis and Reporting

B1.6.1 Data Compilation

Groundwater quality data may be available from a wide variety of sources, including:

- The Provincial Groundwater Monitoring Network (PGMN);
- Private well sampling;
- Municipal water sampling programs;
- Health departments; and
- Other groundwater studies.

B1.6.2 Data Analysis

The assemblage and integration of information that will provide an understanding of groundwater quality on watershed basis can be performed a number of ways, including:

- The assemblage of GIS layers;
- The construction of binary plots;
- The construction of maps and cross sections;
- The construction of vertical and horizontal iso-chemical contour maps;
- The construction of groundwater quality diagrams (e.g., Durov, Piper, Stiff, Rose);
- The construction of chemical concentration versus time plots;
- The preparation of tables that compare water quality concentrations to water quality criteria (e.g., Ontario Drinking Water Standards, Provincial Water Quality Standards); and
- The use of statistical methods.

Parameters that exceed the standard can be highlighted, as some parameters naturally exceed water quality standards. Naturally elevated parameters can be present due to the geological materials in the area, the recharge environment, or other factors.

B1.6.3 Analysis of Trends at Each Monitoring Well

Time versus concentration plots can help determine whether levels of water quality are changing. Time-concentration plots are generated from water quality data for one parameter, usually in one monitoring well, with time across the x-axis, and the concentration for that parameter along the y-axis. Statistical trend analysis packages (e.g., packages built into Excel) can be used to determine if there is a trend. See **Table B-10**.

Alternatively, the data can be visually interpreted to determine whether there is a trend. Trends usually occur over a longer term, though there may be a blip or short-term spike in concentration indicating a short-term event, such as a spill or controlled release into the environment. Trends can also occur seasonally or cyclically. Seasonal or cyclic trends occur where water quality fluctuates through seasons or through wet or dry years.

Where water quality impairments have been identified in a watershed (i.e., concerns, known contamination), the parameters typical for those impairments can also be evaluated through time-concentration plots to determine whether the trends are increasing or decreasing. Trend analysis can provide an indication of contamination, changes in groundwater recharge, a connection to surface water, or general changes within an aquifer. Significant increasing or decreasing trends should be identified in the individual monitoring wells. By doing this, we can identify areas where water quality is influenced by surface activities, including precipitation, and therefore may be more vulnerable to surface activities.

Table B-10: List of all Groundwater Quality Samples within CLOSPA with Parameters that have Exceeded the ODWS at Least once

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
Ontario Drinking Water Standards (MAC, *AO*)		1 µg/L	0.1 mg/L	250 mg/L	0.3 mg/L	0.05 mg/L	20 mg/L	10 µg/L	10 µg/L	5000 µg/L	5 TCU	5 mg/L	80 mg/L	5 NTU
W0000263-1	31/07/2003	0.05	0.0319	Red-268	0.0490	0.0032	Red-203	0.05	0	0.2		1.3		
W0000263-1	15/06/2004		0.0079	388	0.0021	<0.0001	Red-196	<0.7	<2	1.9	2		345	0.087
W0000263-1	09/07/2004		0.0065	232	<0.0002	<0.0001	Red-171	<0.7	<2	2.1	<1		219	0.072
W0000263-1	27/06/2005		<0.0007	241	0	<0.0001	Red-194	<0.7	<2	0	2		221	0.080
W0000263-1	18/10/2005		<0.0007	221	0	<0.0001	Red-170	<0.7	<2	0	1		174	0.080
W0000263-1	15/06/2006		<0.0007	Red-334	0.0056	<0.0001	Red-233	<0.7	<2	0.4	1		231	0.135
W0000263-1	30/10/2006		<0.0007	Red-331	0.0060	<0.0001	Red-221	<0.7	<2	2	3		259	0.105
W0000263-1	11/05/2007			145	0.0436	0.0022	Red-132	0.1	0.3	0.8	2		191	0.366
W0000263-1	29/05/2007			157	0.0070	<0.0001	Red-134	<0.7	<2	0.3	Red-11		183	0.086
W0000263-1	29/05/2008		0.0177	122	0.0229	0.0011	Red-122	<0.7	0.1	0.8	3		155	0.250
W0000263-1	10/06/2008		0.0123	224	0.0040	0.00097	Red-145	0.04	0	0.9		1.3	Red-192	
W0000040-1	14/08/2003	0.05	0.0011	238	0.0010	0.00022	Red-106	0.04	1	2.2		2.2	Red-628	
W0000040-1	23/06/2004		0.0021	168	0.0036	<0.0001	Red-70.4	<0.7	3	2.4	2		475	0.069
W0000040-1	20/10/2004		0.0034	Red-462	0.0023	<0.0001	Red-155	<0.7	<2	1.8	<1		734	0.119
W0000040-1	11/03/2005		<0.0007	Red-555	0.0100	<0.0001	Red-229	<0.7	<2	0	3		751	0.080

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000040-1	07/06/2005		<0.0007	Red-318	0.0100	<0.0001	Red-113	<0.7	<2	0	1		603	0.080
W0000040-1	11/01/2006		<0.0007	115	0.0091	<0.0001	Red-82.8	<0.7	<2	0.2	<1		403	0.083
W0000040-1	06/12/2006		<0.0007	119	0.0061	<0.0001	Red-79.7	<0.7	<2	<0.2	1		382	0.103
W0000040-1	13/06/2007			133	0.0149	<0.0001	Red-70.4	<0.7	<2	0.4	1		381	0.068
W0000040-1	20/11/2007			Red-667	0.0077	0.0020	Red-271	<0.7	0.7	0.8	3		779	0.245
W0000040-1	06/02/2008		0.0009	111	0.0002	0.0001	Red-84.4	<0.7	0.3	0.6	2		336	0.121
W0000040-1	18/09/2008		0.0008	110	0.0060	0.0026	Red-91.3	0.11	1	1.1		1.3	Red-213	
W0000044-2	18/09/2002	0.05	0.0013	19.3	0.1840	Red-0.1330	7.8	0.24	0	613		1.4	Red-306	
W0000044-2	07/06/2004		0.0075	19.3	0.2220	Red-0.1030	7.6	<0.7	<2	776	<1		304	0.901
W0000044-2	10/06/2004		0.0037	19	Red-0.5050	Red-0.1190	7.6	<0.7	<2	799	Red-5		300	2.150
W0000044-2	16/06/2005		<0.0007	19.8	Red-0.5500	0.1000	7.4	<0.7	<2	880	Red-36		297	3.460
W0000044-2	26/10/2005		0.0300	19.7	Red-0.5500	Red-0.1500	7.7	<0.7	<2	960	Red-18		309	3.730
W0000044-2	06/08/2006		Red-0.165	18	0.2300	Red-0.0607	7.8	Red-11.9	<2	2100	Red-28		254	Red-25.400
W0000044-2	19/10/2006		Red-9.4400	19.8	Red-18	Red-0.5760	7.8	Red-193	2	Red-51300	Red-7		273	1.540
W0000044-2	10/09/2008		0.0213	21.7	0.2920	Red-0.1340	7.5	4.17	0	1667.4		1.3	Red=305	
W0000264-2	08/12/2003	Red-2	Red-0.2380	34	Red-1.0200	0.0400	Red-129	9.69	0	20.5		0.2	Red-393	
W0000264-2	10/05/2004		<0.0007	2.4	<0.0002	0.0038	10.5	<0.7	<2	13.6	3		149	0.176
W0000264-2	16/06/2004		Red-0.1480	4.44	0.0471	0.0037	Red-30	<0.7	<2	3.1	Red-16		97.5	4.42

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000264-2	20/07/2004		0.0977	3.42	0.0537	0.0047	Red-21	<0.7	<2	19.9	Red-6		118	0.469
W0000264-2	18/10/2006		Red-0.6050	5.33	0.247	0.0032	3.36	<0.7	<2	1.6	Red-28		162	Red-7.48
W0000264-2	30/05/2007			6.7	0.0443	0.0017	3.5	<0.7	<2	0.7	Red-6		183	0.399
W0000264-2	16/09/2008		Red-0.2410	5.8	0.196	0.022	3.16	0.4	0	3		0.2	Red-171	
W0000167-1	28/11/2002	0.05	0.0019	20.9	Red-1.310	Red-0.189	12.6	0	0	1		Red-6	Red-329	
W0000167-1	21/06/2004		<0.0007	22.3	Red-1.090	Red-0.167	14.4	<0.7	<2	0.3	Red-19		291	Red-8.02
W0000167-1	09/08/2004		<0.0007	18.1	Red-0.991	Red-0.186	16.1	<0.7	<2	1.9	Red-24		325	4.16
W0000167-1	26/05/2005		<0.0007	24.1	Red-1.150	Red-0.240	11	<0.7	<2	0	Red-19		283	4.63
W0000167-1	19/10/2005		0	16.1	Red-1.680	Red-0.310	12.6	<0.7	<2	0	Red-20		312	Red-7.34
W0000167-1	06/06/2006		0.0581	22.6	Red-4.520	Red-0.283	12.9	<0.7	<2	0.7	Red-51		284	Red-48.8
W0000167-1	16/10/2006		<0.0007	17.6	Red-2.490	Red-0.278	13.3	<0.7	<2	0.2	Red-23		298	Red-8.13
W0000167-1	11/07/2007			11.8	Red-3.670	Red-0.283	10.9	<0.7	<2	0.2	Red-30		268	Red-19.2
W0000167-1	06/12/2007			15.7	Red-1.740	Red-0.234	11.5	<0.7	<2	0.5	Red-37		279	Red-13.1
W0000167-1	27/05/2008		0.0014	32.7	Red-1.170	Red-0.192	10.9	<0.7	0.3	0.1	Red-57		296	2.65
W0000167-1	15/09/2008		0.00158	26.1	Red-1.360	Red-0.218	12.9	0	0	4.9		4.9	Red-310	
W0000049-1	24/10/2002	0.05	0.0003	2.4	Red-0.311	0.008	Red-276	0	0	0.2		0.7	Red-2100	
W0000049-1	29/06/2004		0.004	2.6	Red-0.465	0.007	11.9	<0.7	<2	0.2	3		153	1.96
W0000049-1	14/09/2004		0.0012	2.4	Red-0.476	0.007	11.9	<0.7	<2	1.7	Red-12		152	1.18

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000049-1	28/06/2005		<0.0007	2.9	Red-0.630	0.010	12.3	<0.7	<2	0	Red-18		160	1.09
W0000049-1	11/07/2005		<0.0007	2.8	Red-0.480	0.010	12.6	<0.7	<2	0	Red-7		160	0.81
W0000049-1	11/01/2006		<0.0007	2.9	Red-0.409	0.007	12.6	<0.7	<2	<0.2	4		159	2.29
W0000049-1	15/06/2006		<0.0007	2.57	Red-0.551	0.0084	12.8	<0.7	<2	<0.2	Red-8		158	2.06
W0000049-1	29/05/2007			2.9	Red-0.618	0.0116	11.9	<0.7	<2	<0.2	Red-11		161	1.55
W0000049-1	15/11/2007			3.2	Red-0.500	0.0096	11.4	<0.7	<2	<0.2	Red-7		163	1.05
W0000049-1	29/05/2008		0.0003	3.5	Red-0.468	0.0104	11	<0.7	<2	0.2	Red-8		169	1.53
W0000049-1	18/09/2008		0.0001	4.1	Red-0.408	0.0105	10.9	0.02	0	0.2		0.5	173	
W0000262-1	29/07/2003	0.05	0.0024	9.3	0.021	0.0498	6.8	0.03	0	1		0.4	300	
W0000262-1	15/09/2008		0.0016	26.1	Red-1.360	Red-0.2180	12.9	0.02	0	4.9		4.9	310	
W0000261-1	31/07/2003	0.05	0.0012	1.3	0	0.0022	3	0.02	1	0.1		0.7		
W0000261-1	28/05/2007			1.9	0.011	<0.0001	2.5	<0.7	<2	0.3	Red-8		227	0.09
W0000261-1	15/09/2008		0.0012	1.3	0.006	0.0012	2.5	0.01	0	0.5		0.4	Red-229	
W0000166-1	09/11/2003	0.05	0.0004	2.3	Red-0.454	0.0187	6.8	0	0	1.1		0.6	Red-181	
W0000166-1	21/06/2004		0.0008	2.4	Red-0.396	0.0155	7.8	<0.7	<2	<0.2	Red-6		169	2.28
W0000166-1	09/08/2004		0.0028	2.5	Red-0.342	0.0154	7.9	<0.7	<2	1.8	2		167	1.43
W0000166-1	06/09/2005		<0.0007	2.7	Red-0.440	0.0200	8.2	<0.7	<2	0	1		165	2.73
W0000166-1	19/10/2005		<0.0007	2.4	Red-0.420	0.0200	8.6	<0.7	<2	0	3		167	1.81
W0000166-1	06/06/2006		<0.0007	2.1	Red-0.318	0.0152	8.5	<0.7	<2	<0.2	2		157	1.64
W0000166-1	11/09/2006		<0.0007	2.7	Red-0.429	0.0202	9	<0.7	<2	<0.2	Red-10		162	1.77

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000166-1	19/06/2007			2.9	Red-0.415	0.0182	8.6	<0.7	<2	<0.2	3		159	1.21
W0000166-1	19/11/2007			2.8	Red-0.445	0.0209	8.8	<0.7	<2	<0.2	Red-7		164	1.81
W0000166-1	06/03/2008		0.0004	2.5	Red-0.422	0.0204	8.4	<0.7	0.1	0.6	3		161	0.48
W0000166-1	17/09/2008		0.0001	2.7	Red-0.357	0.0167	8.76	0.01	0	0.4		0.5	Red-153	
W0000264-3	08/12/2003	0.05	0.0012	3	0.137	0.0155	Red-26.4	0.03	0	3.3		0.8	Red-165	
W0000264-3	16/09/2008		0.0008	2	0.174	0.0094	2.94	0.01	0	0.6		0.1	Red-190	
W0000042-1	28/11/2002	0.05	0.0006	84.4	0.015	0.0040	Red-33.2	0.07	0	0.7		0.5	Red-248	
W0000042-1	23/06/2004		<0.0007	93.2	0.018	0.0016	Red-36.5	<0.7	<2	2.9	<1		266	0.157
W0000042-1	20/10/2004		<0.0007	82.1	0.016	0.0041	Red-33.4	<0.7	<2	1.8	<1		262	0.094
W0000042-1	11/07/2005		<0.0007	67.5	0.010	0	Red-26.9	<0.7	<2	0	<1		262	0.080
W0000042-1	06/09/2005		<0.0007	70.9	0.020	0	Red-29	<0.7	<2	0	1		255	0.130
W0000042-1	11/09/2006		<0.0007	74.4	0.015	0.0012	Red-30.9	<0.7	<2	0.4	<1		266	0.100
W0000042-1	06/12/2006		<0.0007	54.9	0.014	0.0026	Red-23.8	<0.7	<2	<0.2	<1		250	0.218
W0000042-1	13/06/2007			76.8	0.027	0.0019	Red-31.2	<0.7	<2	0.3	1		261	0.154
W0000042-1	14/11/2007			76.2	0.034	0.0041	Red-33.5	<0.7	<2	<0.2	<1		261	0.214
W0000042-1	06/02/2008		0.0009	63.5	0.012	0.0023	Red-28.3	<0.7	0.2	0.5	1		252	0.193
W0000042-1	17/09/2008		<0.0010	75	0.023	0.0068	Red-30.1	0.14	2	0.6		0.5	Red-255	
W0000168-1	21/11/2002	0.05	0.0018	13.1	0.124	0.0135	17.6	0.11	0	0.5		1.1	Red-177	
W0000168-1	07/12/2004		0.0056	11.8	<0.0002	0.0110	17.4	<0.7	<2	1	Red-5		135	0.164

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000168-1	10/12/2004		Red-1.8900	11.3	Red-1.170	0.0170	17.7	<0.7	<2	5.3	2		141	Red-96
W0000044-3	11/05/2002	0.05	0.0006	Red-360	0.084	0.0204	Red-192	1.15	2	487		3	Red-156	
W0000044-3	07/06/2004		0.0105	83.3	0.001	<0.0001	Red-60.2	<0.7	<2	98.4	3		21.4	0.228
W0000044-3	10/06/2004		Red-0.4290	71.8	Red-0.575	0.0227	Red-60.2	1.8	<2	275	3		28.5	1.380
W0000044-3	16/06/2005		<0.0007	58.1	0.010	0	Red-57.1	<0.7	<2	40	4		23.3	0.620
W0000044-3	06/08/2006		Red-0.613	51.2	Red-0.375	0.0115	Red-60.5	<0.7	<2	66.7	Red-124		49.6	Red-265
W0000044-3	19/10/2006		Red-7.51	53.5	Red-6.55	Red-0.077	Red-56.4	Red-13.1	<2	1250	Red-30		35.5	Red-34
W0000044-3	10/09/2008		0.0149	52.4	0.036	0.0017	Red-55	2.42	0	53.4		1.5	14.2	
W0000043-3	11/05/2002	0.05	0.0090	100	0.010	0.0150	Red-69.4	0.53	1	133		Red-85	Red-91	
W0000043-3	07/06/2004		0.0073	Red-368	0.046	0.0141	Red-195	<0.7	<2	225	1		147	0.177
W0000043-3	10/06/2004		0.0206	Red-358	0.109	0.0160	Red-198	2.7	<2	485	3		153	0.554
W0000043-3	11/03/2005		<0.0007	Red-366	0.080	0.0100	Red-198	<0.7	<2	350	Red-5		152	0.220
W0000043-3	16/06/2005		Red-0.14	Red-361	Red-0.740	Red-0.1100	Red-199	<0.7	<2	20	3		151	0.250
W0000043-3	06/08/2006		<0.0007	Red-363	0.066	0.0067	Red-212	<0.7	<2	123	2		151	0.580
W0000043-3	30/10/2006		0.0376	Red-359	0.102	0.0097	Red-209	<0.7	<2	397	3		156	3.210
W0000043-3	11/05/2007			Red-341	0.094	0.0152	Red-196	1.9	<2	270	2		141	0.177
W0000043-3	19/06/2007			Red-374	0.094	0.0137	Red-209	0.8	<2	460	3		159	0.170
W0000043-3	26/05/2008		0.0406	Red-342	0.145	0.0132	Red-196	1	Red-11.4	420	1		140	0.575

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000043-3	17/09/2008		Red-1.19	Red-348	Red-1.120	0.0465	Red-194	6.65	5	1750		1.1	Red-165	
W0000041-1	21/11/2002	0.05	0.0009	40.8	0.199	0.0195	Red-38.4	0.04	2	0.6		0.7	Red-83.5	
W0000041-1	13/09/2004		0.0012	31.7	Red-0.406	0.0325	Red-29.5	<0.7	<2	1.7	Red-9		99.3	0.578
W0000041-1	07/12/2004		0.0016	33.5	0.289	0.0258	Red-30.4	<0.7	<2	<0.2	Red-6		96.2	0.441
W0000041-1	06/06/2005		<0.0007	34.1	Red-0.420	0.0500	Red-29	<0.7	<2	0	Red-7		104	0.890
W0000041-1	20/10/2005		<0.0007	33.1	Red-0.410	0.0400	Red-29.2	<0.7	<2	<0.2	Red-7		104	0.580
W0000041-1	16/10/2006		<0.0007	45.3	Red-0.326	0.0251	Red-33.2	<0.7	<2	<0.2	3		92.5	0.394
W0000041-1	06/12/2006		<0.0007	56.4	0.202	0.0169	Red-37.6	<0.7	<2	<0.2	Red-5		91.2	0.405
W0000041-1	11/07/2007			33.8	Red-0.601	0.0432	Red-29.5	<0.7	<2	<0.2	Red-5		106	0.823
W0000041-1	06/12/2007			38.7	0.217	0.0243	Red-30.6	<0.7	<2	<0.2	3		92.9	0.286
W0000041-1	26/05/2008		<0.0002	37.3	0.154	0.0287	Red-30.5	<0.7	0.6	1.5	1		94.3	0.286
W0000041-1	10/06/2008		0.00004	36.9	Red-0.860	Red-0.0608	Red-30.5	0.01	0	0.4		1.1	Red-104	
W0000265-2	08/12/2003	0.05	0.0028	3.2	0.102	0.0130	Red-28.4	0.02	0	1.8		1.8	Red-94.5	
W0000265-2	10/05/2004		<0.0007	3.1	0.148	0.0161	Red-24.9	<0.7	<2	2.4	Red-6		110	0.160
W0000265-2	16/06/2004		0.0047	3.2	0.131	0.0126	Red-25.3	<0.7	<2	0.2	Red-7		106	0.129
W0000265-2	19/07/2004		<0.0007	3.1	0.113	0.0120	Red-24.5	<0.7	<2	2	Red-8		108	0.136
W0000265-2	15/06/2005		<0.0007	3.2	0.140	0.0100	Red-24.4	0	<2	0	Red-6		110	0.160
W0000265-2	24/10/2005		<0.0007	3.0	0.160	0.0200	Red-24.4	<0.7	<2	0	Red-6		110	0.170

Station ID	Sampling Date	1,4-Dichlorobenzene	Al	Cl	Fe	Mn	Na	Pb	Se	Zn	Colour	Carbon; dissolved organic	Hardness as CaCO3	Turbidity
W0000265-2	06/07/2006		<0.0007	2.8	0.146	0.0150	Red-24.7	<0.7	<2	0.5	Red-6		108	0.214
W0000265-2	18/10/2006		<0.0007	3.2	0.140	0.0151	Red-25	<0.7	<2	<0.2	Red-6		110	0.179
W0000265-2	30/05/2007			3.6	0.155	0.0161	Red-24.7	<0.7	<2	<0.2	Red-6		110	0.149
W0000265-2	13/11/2007			3.0	0.151	0.0167	Red-24.6	<0.7	<2	0.2	Red-5		110	0.197
W0000265-2	28/05/2008		0.0011	3	0.130	0.0149	Red-24.5	<0.7	<2	0.1	Red-5		108	0.237
W0000265-2	16/09/2008		0.00107	3.1	0.098	0.0128	Red-24.3	0.01	0	0.3		0.9	Red-104	

All instances are highlighted in red.

B1.6.4 Aquifer Characterization

Groundwater quality data was also analyzed on a watershed basis to look for larger-scale trends in water quality. Monitoring wells from similar aquifer units can be grouped to determine the typical maximum, minimum, and average water quality ranges for the aquifer units. Where little information is available to determine whether monitoring wells are in the same aquifer, water quality data can be compared through Piper diagrams, Stiff diagrams, Rose diagrams, and other geochemistry tools to determine whether water samples are of a similar nature, and potentially of similar origin.

B1.7 Limitations: Data, Assumptions, and Methods

B1.7.1 Data

Database management that relates to the structure or approach was developed for each of the conservation authority partners and the CTC Region to manage data. Currently, a three-database system is being considered within the overall database management system. This system includes:

- Internal relational databases that house aquatic ecosystem and stream survey information conducted by CLOSPA;
- The Oak Ridges Moraine Groundwater Program database that includes subsurface information (e.g., boreholes, wells, water levels, chemistry); and
- The contaminant inventory database, to be provided by the Province.

Data that are undergoing refinement have been identified for source protection planning purposes and are summarized in **Table B-11.**

Table B-11: Data Identified

Identified Data that is undergoing Refinement (not available at the time of reporting)			
Watershed Characterization			
Component	**Data Set Name or Source**	**Data Problem**	**Comment**
GIS Database	CLOCA/external data sources	Requires update	Internal GIS data, grids, shape file reorganization. Metadata tracking system to be developed.
Rating Tables within Hydrologic Database	CLOCA — Engineering department hydraulic data	Requires update	Updated for WSC sites annually. CLOCA sites to be surveyed and calibrated. Need to be generated for 2005 - 2006.
Integrated Hydrologic Database	CLOCA's hydrologic data	Requires update	Data currently exists in various formats. Need to develop a consistent format and relational database to maintain data relating to climate, rating curves, water levels, streamflow, spot baseflow, and water quality measurements.

Identified Data that is undergoing Refinement (not available at the time of reporting)			
Watershed Characterization			
Component	**Data Set Name or Source**	**Data Problem**	**Comment**
Oak Ridges Moraine Groundwater Program Hydrogeologic Database	Various data sources	Requires update	Not all monitoring locations or data entered—continually being updated with various data sets. Database management is required. Multi-user access to be applied over a networked environment.
Water Quality/Benthic Database	Provincial OBBN Historical studies and reports	Requires update	Data, in general, has not been QC'd.

Knowledge Gaps

- Continued groundwater level and chemistry monitoring and analysis involving both PGMN wells and municipal partner monitoring wells (where data is provided).
- Low-flow streamflow surveys (quality and quantity) to characterize discharge zones and associated water quality. These surveys are also useful to delineate zones that may be impacted by human activities.
- Overland and streamflow travel time studies to be able to address possible spills response protocol and actions.
- Enhance the continuous streamflow gauge network and update data regarding discharge to streams.
- Update and verify outdated or missing water use data including Permit to Take Water (PTTW) information.
- Development of acceptable water use targets to protect both the resource and the aquatic ecosystem.
- Need for additional water quality monitoring sites.
- Need for additional climatic sites/data monitoring.

Development of the ESRI ArcHydro data model.

B1.7.2 Addressing Data

Future work will aim to develop and refine the overall database management system using the following methods:

- Preparing and refining land classification maps;
- Monitoring and analyzing groundwater level and chemistry involving both PGMN wells and municipal partner monitoring wells;
- Reviewing low-flow streamflow surveys (quality and quantity) to characterize discharge zones and associated water quality and to delineate zones that may be impacted by human activities;

- Reviewing overland and streamflow travel time studies to be able to address possible spills response protocol and actions;
- Enhancing the continuous streamflow gauge network and updating data regarding discharge to streams;
- Enhancing the coverage of climate data;
- Updating and verifying outdated or missing water using data including Permit to Take Water (PTTW) information; and
- Preparing a contaminant source database and associated risk to drinking water provided by each potential source.

Priority gaps that need to be addressed based on the analysis conducted include:

- Further development and promotion of its existing Clean Water Stewardship Program, which supports well upgrades and abandonment, nutrient management best management practices, and land restoration initiatives on private lands—all efforts that help remove potential pathways for contaminants;
- Need for additional water quality monitoring sites;
- Need for additional streamflow monitoring and climatic sites;
- Development of the ESRI ArcHydro data model; and
- Further estimates of water surplus (Thornwaite methodology).

B1.7.3 Assumptions

A number of statistical tests were performed on the surface water quality data for the study area. Tests were completed for all (PWQMN and CLOSPA) water quality sites that have a minimum of 40 samples (approximately five years of monitoring). Statistical tests were performed on chloride, nitrate, phosphorous, and copper.

Parametric and non-parametric statistical methods were used to describe the water data set and to determine if there are any temporal trends (i.e., the significance of a trend in water quality as it increases or decreases over time). Parametric statistical methods assume that observations are drawn from a normally distributed population. Since the distribution of surface water quality data are frequently skewed by extreme values, the assumptions of parametric statistical tests are often violated. Typically, non-parametric statistical methods are a more suitable choice for the analysis of surface water quality data. Non-parametric statistics do not assume a particular form of distribution, and they can handle outliers and non-detects that are common in water quality data.

The linear regression simply calculates a regression line on the time/value plot. A positive slope of the regression line indicates a trend towards increasing values, a negative slope indicates a trend to decreasing values. The results of this test should only be used qualitatively and should be confirmed by more sophisticated tests, such as Sen's and Mann-Kendall.

The Mann-Kendall test is a trend estimator that can be used to examine whether contaminant concentrations are diminishing or rising significantly over time. Unlike linear regression, there are no distributional assumptions. It is not greatly affected by gross data errors, outliers, or missing data (non-detects), and irregularly spaced measurement periods are allowed. Non-detects are assigned a value smaller than the smallest measured value.

The version of the Mann-Kendall Test used for this analysis comes from AquaChem and can be applied for virtually any surface water or groundwater parameter. The Mann Kendall test provides two values: S value and Z value. If the Mann-Kendall statistic (S) equals 0, then there is no increasing or decreasing trend in the data. If, however, S is less than 0, there is a decreasing trend, and if S is greater than 0, there is an increasing trend.

A two-sided test (for either increasing or decreasing trend) can also be obtained by using probability values. For monitoring stations with more than 10 samples, the normal approximation (Z) can be calculated. The quantity Z can be compared to standard normal cumulative distribution probabilities to test the null hypothesis of no trend.

B1.7.4 Method Limitations

Knowledge gaps relate to analysis and tool development to estimate and/or refine the water budget estimates and understand how the flow system operates. These tools enable us to predict the impact of potential future changes, such as increased municipal supply from groundwater due to climate change.

Priority knowledge gaps that need to be addressed include:

- Refinement of aquifer characterization and flow system understanding, including the orientation of bedrock valley systems and significant area recharge and discharge mapping;
- Development of surface water modelling capabilities;
- Refinement of a three-dimensional groundwater flow modelling tool;
- Refinement of the interaction of the surface water and groundwater flow models;
- Development of acceptable water use targets to protect both the resource and the aquatic ecosystem; and
- Development of methodology and tools to provide spills response analysis that will involve all pathways, including overland flow, stream travel, and groundwater flow, including the unsaturated zone transport.