DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Thames-Sydenham and Region Watershed Characterization Report

Thames Watershed & Region
(Upper Thames River & Lower Thames Valley Source Protection Areas)

Volume 2

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Prepared by --

LOWER THAMES VALLEY CONSERVATION AUTHORITY
UPPER THAMES RIVER CONSERVATION AUTHORITY

-- in cooperation with --

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Watershed Characterization Report
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3 Water Quality

This section of the Watershed Characterization Report provides a general assessment of surface water quality based on a review of information available for the Upper Thames River Conservation Authority (UTRCA) and Lower Thames Valley Conservation Authority (LTVCA).

Surface Water

It includes an assessment of water quality for inland watercourses and for raw surface water used as sources for treated drinking water.

The assessment of inland watercourse water quality is based on information that has been collected at sites that are part of the Provincial Water Quality Monitoring Network (PWQMN).

The examination of surface drinking water sources is based on raw water quality data for water treatment plants that supply water to communities in the Thames Watershed & Region. The water treatment plant water quality assessment uses information from the Drinking Water Surveillance Program (DWSP), Drinking Water Information System (DWIS), the Ontario Regulation 170/03 Drinking Water Systems (DWS) reports, and local plant records.

Groundwater

At this time, there is a brief synopsis of known groundwater quality issues and a detailed water quality assessment for microbial parameters based on available information for municipal drinking water wells. Microbiological sampling and data for Provincial Groundwater Monitoring Network wells are also summarized.

The report does not include a detailed assessment of groundwater quality. A comprehensive examination of groundwater quality is currently underway to consolidate and review historic information on ambient groundwater quality. It involves the review of data from the Drinking Water Surveillance Program (DWSP), Drinking Water Information System (DWIS), Provincial Groundwater Monitoring Network program (PGMN), Southern Ontario Water Quality (SOWAQ), and legacy information.

3.1 Selecting Indicator Parameters

The selection of parameters to assess water quality depends on many factors such as existing water quality problems, possible sources of contamination, and existing routine monitoring programs.

Water quality can be assessed by analyzing physical, chemical and microbial indicator parameters. Physical parameters include measurements such as temperature and turbidity. Chemical parameters include nutrients, metals, organic compounds, and many other substances. Microbiological parameters include coliform and other bacteria. In addition to these examples, other parameters such as radioactive and aesthetic qualities (odour and colour) may be analyzed as well.

Water quality may be influenced by point sources (i.e. discharge directly to a water body) and non-point sources (e.g. runoff) of pollution. The assessment of water quality involves monitoring the characteristics of the water body being studied at certain locations. There are numerous water characteristics and it is not feasible to monitor all contaminants all of the time. Hence indicator parameters are chosen to evaluate the water quality of a watershed.

The selection of parameters to assess inland surface water and intake raw surface water quality is described in the following sections.

3.1.1 Selecting Parameters for Inland Surface Water Quality

The inland surface water monitoring programs are outlined in the Interim Watershed Description Report (**Section 1.7.1.1: Existing Surface Water Monitoring Programs**). The Provincial Water Quality Monitoring Network (PWQMN) is the most extensive monitoring program for inland surface water quality in the Thames Watershed & Region. Samples taken as part of this program are analyzed for 37 parameters that are listed in **Table 3.1.1-1: PWQMN Parameters**.

In the past, microbiological levels (fecal coliform or *Escherichia coli*) were monitored at the PWQMN sites as an indicator of pathogens from human or animal waste. The microbiological testing was discontinued in 1996. In the LTVCA watershed, there is no PWQMN data from 1996 onwards for coliform bacteria. Some Conservation Authorities have made arrangements to monitor bacteria levels in their local watercourses. Since 2001, through a partnership between the UTRCA and the Middlesex-London Health Unit, surface water samples in the UTRCA watershed have been analyzed for *Escherichia coli (E. coli)*, a type of fecal coliform bacteria by the Ministry of Health laboratory in London.

Table 3.1.1-1: PWQMN Parameters

Alkalinity	Dissolved Solids	Phosphate
Aluminum	Dissolved Oxygen	Phosphorus
Ammonia	Hardness	Potassium
Barium	Iron	Suspended Solids
Beryllium	Kjeldahl Nitrogen	Sodium
Biochemical Oxygen Demand	Lead	Strontium
Cadmium	Magnesium	Temperature
Calcium	Manganese	Titanium
Chloride	Molybdenum	Turbidity
Chromium	Nickel	Vanadium
Cobalt	Nitrate	Zinc
Conductivity	Nitrite	
Copper	pH	

The Conservation Ontario February 2003 draft report ‘Water Sampling and Data Analysis Manual’ for PWQMN partners recommends the use of eight parameters as the indicator parameters for watershed management. These parameters were selected for conservation authority watershed planning based on extensive discussions between the Ministry of the Environment and Conservation Authorities.

The eight parameters are listed in **Table 3.1.1-2: Basic Parameters – Inland Surface Water.** These parameters reflect nutrient levels (phosphorus and nitrate), salt loading (chloride), solids, heavy metal pollution and fecal bacteria contamination. The importance of the selected parameters as indicators of water quality is described in **Section 3.1.3: Significance of the Parameters**.

Using data for these eight key parameters, the inland surface water quality in the Thames Watershed & Region is assessed at several Provincial Water Quality Monitoring Network (PWQMN) sites in **Section 3.2: Surface Water Quality Data Analysis and Reporting**.

Table 3.1.1-2: Basic Parameters – Inland Surface Water

Total Phosphorus
Nitrate
Chloride
Suspended solids
Copper
Zinc
Lead
Coliform bacteria (fecal coliform and *Escherichia coli*)

3.1.2 Selecting Parameters for Drinking Water Intake Quality

Drinking water is monitored extensively for a wide variety of parameters to assess the physical, chemical and microbiological water quality of both the raw (intake) water and the treated water that is distributed to the community.

In order to assess intake raw (surface) water quality, a 'multi-tier' parameter review was done based on:

- Basic parameters selected by the Ministry of the Environment and Conservation Ontario or routinely used as part of the water treatment process,
- Drinking Water Systems Regulation 170/03 parameters,
- Great Lakes parameters associated with international agreements, and
- Water treatment plant (WTP) or water supply system (WSS) specific parameters.

The parameter lists for each tier are described below. There are some parameter overlaps between various programs. The significance of the parameters is discussed in the **Section 3.1.3: Significance of the Parameters**.

In general, there was information and data available for almost all of the parameters identified as part of the 'multi-tier' review. The parameters that are part of the water quality review in Section 3 are summarized in **Table 3.1.4-1: Water Quality Standards, Objectives and Guidelines.** The table also provides the Drinking Water Standard and the Aquatic Protection Standard.

Some parameters were not reviewed as part of the raw water quality assessment and these are summarized in **Table 3.1.2-9: Parameters Not Reviewed**. The reasons why these parameters were not included in the intake water quality assessment are outlined in the discussion on each program where the parameter was identified.

1. Basic Parameters

Seven basic parameters have been selected for review. These parameters reflect nutrient levels, salt loading, solids, fecal bacteria contamination and routine monitoring at water treatment plants. The basic parameters are listed in **Table 3.1.2-1: Basic Parameters Raw Water.**

Four of the basic parameters (phosphorus, nitrate, chloride and fecal coliform bacteria) are among those selected for Conservation Authority watershed planning based on extensive discussions between the Ministry of the Environment and Conservation Ontario staff. The Conservation Ontario February 2003 draft report 'Water Sampling and Data Analysis Manual' for PWQMN partners recommends the use of these parameters as some of the indicator parameters for watershed management.

The other three parameters (turbidity, pH and temperature) are physical parameters measured as part of the treatment plant operation since their levels can affect the performance of the treatment processes.

Table 3.1.2-1: Basic Parameters – Raw Water

- Phosphorus
- Nitrate
- Chloride
- Turbidity
- pH
- Temperature
- Coliform bacteria (total coliform and *Escherichia coli*)

Information and data on the basic parameters are available in the Drinking Water Surveillance Program (DWSP) database.

2. Ontario Regulation 170/03 (Drinking Water Systems Regulation)

There are several inorganic elements and organic compounds that must be monitored by water treatment plant operators under the requirements of Ontario Regulation 170/03 (Drinking Water Systems Regulation) Safe Drinking Water Act, 2002[1]. Information and data on the inorganic and organic parameters are available in the Drinking Water Surveillance Program (DWSP) database.

Inorganic Parameters (Schedule 23 Ontario Regulation 170/03)

There are nine inorganics that must be tested in the treated drinking water according to Ontario Reg. 170/03 (Drinking Water Systems Regulation) Safe Drinking Water Act, 2002. They are listed in **Table 3.1.2-2: Schedule 23 (Ontario Reg. 170/03) Inorganic Parameters.**

Table 3.1.2-2: Schedule 23 (Ontario Reg. 170/03) Inorganic Parameters

- Antimony
- Arsenic
- Barium
- Boron
- Cadmium
- Chromium
- Mercury
- Selenium
- Uranium

Organic Parameters (Schedule 24 Ontario Regulation 170/03)

There are several organic chemicals that must be tested in the treated drinking water according to Ontario Reg. 170/03 (Drinking Water Systems Regulation) Safe Drinking Water Act, 2002. They are listed in **Table 3.1.2-3: Schedule 24 (Ontario Reg. 170/03) Organic Parameters.**

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[1] Ontario Ministry of the Environment. 2006. Ontario Safe Drinking Water Act: Drinking Water Systems under O. Reg. 170/03.
www.ontario.ca/ONT/portal51/drinkingwater/Combo?docId=STEL01_049278&breadcrumbLevel=1&lang=en

Table 3.1.2-3: Schedule 24 (Ontario Reg. 170/03) Organic Parameters

Pesticides (triazines & organochlorides)	
PCB (polychlorinated biphenyls)	Methoxychlor
Aldrin and dieldrin	Metolachlor
Alachlor	Metribuzin
Atrazine and N-dealkylated metabolites	Prometryne
Cyanazine	Simazine
Heptachlor and Heptachlor Epoxide	Trifluralin
Lindane (Total)	
Dichlorodiphenyltrichloroethane (DDT) and metabolites	
Specific Pesticides (other than triazines & organochlorides)	
Aldicarb	Dinoseb
Azinphos-methyl	Diquat
Bendiocarb	Diuron
Bromoxynil	Glyphosate
Carbaryl	Malathion
Carbofuran	Paraquat
Chlorpyrifos	Parathion
Diazinon	Phorate
Dicamba	Picloram
Diclofop-methyl	Temephos
Dimethoate	Terbufos
2,4-Dichlorophenoxy acetic acid (2,4-D)	Triallate
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	
Polynuclear aromatic hydrocarbons (PAH)	
Benzo(a)pyrene	
Chlordane (Total)	
Volatile organics	
Benzene	Dichloromethane
Carbon Tetrachloride	Monochlorobenzene
1,2-Dichlorobenzene	Tetrachloroethylene
1,4-Dichlorobenzene	Trichloroethylene
1,2-Dichloroethane	Vinyl Chloride
1,1-Dichloroethylene (vinylidene chloride)	
Chlorophenols	
2,4-Dichlorophenol	
2,3,4,6-Tetrachlorophenol	
Pentachlorophenol	
2,4,6-Trichlorophenol	
Dioxins and furans	
2,3,7,8 TCDD	
2,3,7,8 TCDF	

3. Great Lakes Parameters

There are several international agreements and plans that result in the monitoring of water quality in the Great Lakes, connecting channels and tributaries by various local, provincial, state and federal government agencies.

(A) SOLEC: As a reporting requirement of the Great Lakes Water Quality Agreement (GLWQA), the State of the Great Lakes Ecosystem Conference (SOLEC) is held every two years by the United States Environmental Protection Agency (USEPA) and Environment Canada. The conferences allow reporting on the state of the Great Lakes ecosystems and the impacting factors as well as a platform for information exchange[2]. Indicators of Great Lakes water quality[3] are listed in **Table 3.1.2-4: SOLEC Parameters** below.

Table 3.1.2-4: SOLEC Parameters

Chemical contaminants
Atrazine (organic herbicide)
Nitrate and nitrite nitrogen
Microbiological parameters
Total coliform
Escherichia coli
*Giardia**
*Cryptosporidium**
Treatment technique parameters
Turbidity
Total organic carbon*
Dissolved organic carbon
Taste and odour

*Not in DWSP or DWIS database

(B) IJC: The International Joint Commission (IJC) is an independent bi-national organization established by the Boundary Waters Treaty of 1909. Its purpose is to help prevent and resolve disputes relating to the use and quality of boundary waters and to advise Canada and the United States on related questions[4]. Pollutants of concern in the Great Lakes as per the IJC[5] are listed in **Table 3.1.2-5: International Joint Commission Parameters**.

Table 3.1.2-5: International Joint Commission Parameters

Pesticides (triazines & organochlorides)
PCB (polychlorinated biphenyls)
Toxaphene
Mirex
DDT
Aldrin and dieldrin
Polynuclear aromatic hydrocarbons (PAH)
Benzo(a)pyrene
Metals
Mercury
Alkylated lead*
Dioxins and furans
2,3,7,8 TCDD
2,3,7,8 TCDF
Chloroaromatics
Hexachlorobenzene

*Not in DWSP database, but lead data is available.

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[2] Binational.net website: State of the Lakes Ecosystem Conference. http://binational.net/solec/intro_e.html

[3] May, J.C. Drinking Water Quality Indicator #4175, SOLEC 2007 Draft. USEPA.

[4] International Joint Commission website. About Us: Commissioners. www.ijc.org/en/background/biogr_commiss.htm

[5] IJC. 1993. Virtual Elimination Task Force. A Strategy for Virtual Elimination of Persistent Toxic Substances. Vol.1.

(C) Lake Erie LaMP: The Lake Erie Lakewide Management Plan (LaMP)[6] is one of the Great Lake LaMPs. It was established by the governments of Canada and the United States and designed to address and eliminate bio-accumulative toxic chemicals. The Lake Erie LaMP also covers habitat loss, nutrient and sediment loadings, and the invasion of non-native species. The Lake Erie Lakewide Management Plan 2006 Report[7] provides a list of pollutants of concern in Lake Erie, shown in **Table 3.1.2-6: Lake Erie Lakewide Management Plan Parameters**.

Table 3.1.2-6: Lake Erie Lakewide Management Plan Parameters

Organochlorine insecticides and biocides	
DDT	Alpha-hexachlorocyclohexane
Chlordane	Beta-hexachlorocyclohexane
Dieldrin	Delta-hexachlorocyclohexane*
Toxaphene	Gamma-hexachlorocyclohexane
Mirex	
Industrial Organochlorine compounds or byproducts	
PCB	Hexachlorobenzene
Dioxin (2,3,7,8-TCDD)	3,3'-dichlorobenzidine*
1,4-dichlorobenzene	4,4'-methylenebis(2-chloroaniline)*
Pentachlorobenzene	
Polynuclear Aromatic Hydrocarbons (PAHs)	
Anthracene	Benzo(g,h,i)perylene
Benz(a)anthracene	Chrysene
Benzo(a)pyrene	Fluoranthene
Benzo(b)fluoranthene	Phenanthrene
Benzo(k)fluoranthene	Indeno(123-cd)pyrene
Current use herbicides	
Atrazine	Alachlor
Cyanazine	Metolachlor
Trace metals	
Alkyl lead**	Zinc
Cadmium	Mercury
Copper	Tributyl Tin*
Lead	
Other contaminants	
Total phosphorus	*Escherichia coli*
Nitrate-nitrogen	Total suspended sediments*
Fecal coliform	

*Not in DWSP database
**Not in DWSP database, but lead data is available.

(D) Lake Huron IAP: The Lake Huron Initiative Action Plan - 2002 was a precursor to the Lake Huron Binational Partnership[8]. It was led by the Michigan Office of the Great Lakes to begin discussions of issues of importance to Lake Huron and actions that need to be taken to protect and restore the Lake Huron ecosystem[9]. The parameters of concern are listed in **Table 3.1.2-7: Lake Huron Initiative Action Plan Parameters**.

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[6] Environment Canada. Lake Erie, A Lake in Flux. www.on.ec.gc.ca/laws/coa/2001/lake-erie-e.html

[7] Lake Erie LaMP Management Committee. April 2006. The Lake Erie Lakewide Management Plan 2006 Report.

[8] United States Environmental Protection Agency. Lake Huron. www.epa.gov/greatlakes/lakehuron/index.html

[9] Michigan Office of the Great Lakes Department of Environmental Quality. 2002. Lake Huron Initiative Action Plan. www.michigan.gov/deq/0,1607,7-135-3313_3677-30070--,00.html

Table 3.1.2-7: Lake Huron Initiative Action Plan Parameters

Pesticides (triazines & organochlorides)
PCB (polychlorinated biphenyls)
Toxaphene

Polynuclear aromatic hydrocarbons (PAH)
Chlordane

Metals
Mercury
Nickel
Copper
Zinc
Lead
Cadmium

Other
Suspended solids*
Phosphorus
Escherichia coli

Dioxins

*Not in DWSP database

As noted previously, turbidity is a parameter normally used to evaluate water quality at water treatment plants and data on suspended solids is not available in the DWSP databases.

4. Water Treatment Plant / Water Supply System Specific Parameters

These parameters are based on Drinking Water System (DWS) annual reports available from each WTP or WSS (or the related municipality) website. **Table 3.1.2-8: Drinking Water Systems Parameters** provides a list of parameters commonly tested as part of water treatment plant or water supply system operations. The annual reports identify (to the OMOE) parameters above drinking water standards or guidelines. Raw water parameters are not included in DWS reports from 2003 onwards.

Table 3.1.2-8: Drinking Water Systems Parameters

pH
Ammonia + Ammonium
Total Kjeldahl Nitrogen
Dissolved Organic Carbon
Conductivity
Sulphate
Alkalinity
Chloride
Colour
Turbidity
Calculated Hardness
Aluminum
Calcium
Copper
Iron
Magnesium
Manganese
Sodium
Zinc
Arsenic
Fluoride
Lead
Nitrate
Nitrite
Phosphorus
Bicarbonate
Carbonate

Of the raw water intakes that are characterized in this Report, only two parameters, hardness and aluminum, were reported as above relevant guidelines in the annual DWS reports of the Chatham WTP, Elgin PWSS and Wheatley WTP at various times during 2000 to 2003. The remaining parameters were consistently below the drinking water standards for all of the treatment plants.

Parameters Not Reviewed

The parameters not reviewed in the analysis of drinking water intake raw water quality are listed below in **Table 3.1.2-9: Parameters Not Reviewed**.

Table 3.1.2-9: Parameters Not Reviewed

Alkylated lead
Tributyl tin
Delta-hexachlorocyclohexane
3,3’-dichlorobenzidine
4,4’-methylenebis (2-chloroaniline)
Suspended solids
Total suspended sediments
Total organic carbon
Taste and Odour
Giardia
Cryptosporidium

The Lake Erie LaMP[10] parameters of alkylated lead, tributyl tin, delta-hexachlorocyclohexane, 3,3’-dichlorobenzidine and 4,4’-methylenebis (2-chloroaniline) are not included in the review. Ontario Ministry of the Environment (OMOE) laboratory staff indicate that these parameters are not monitored in drinking water since the primary source of ingestion is not through drinking water. These parameters are not found in the Drinking Water Surveillance Program (DWSP) database (which provided physical and chemical parameter concentrations). While information on alkylated lead is not available, data on lead is available for review.

As well, suspended solids, total suspended sediments and total organic carbon are not found in the DWSP database and, hence, are not analyzed. However turbidity is a parameter normally used to evaluate water quality at water treatment plants; turbidity and dissolved organic carbon data is found in the DWSP database. The ‘taste and odour’ parameter is in the DWSP database but as a group of chemicals that have no drinking water standards and hence not analyzed.

The microbial parameters not found in the Drinking Water Information System (DWIS) database (which provides microbial counts) and, therefore, not analyzed are *Giardia* and *Cryptosporidium*.

3.1.3 Groundwater Chemical Parameter Selection and Standards

Parameter selection to assess groundwater quality was influenced by:

- Conservation Ontario recommendations for water quality monitoring parameters
- Drinking Water Systems Ontario Regulation 170/03 parameters
- Additional water quality parameters available from several data sources (DWSP, DWIS, PGMN, annual DWS and OMOE reports)

Broad lists of parameters from the above sources are described below with summaries of the parameters that are reviewed. Some data is also available for several parameters that were not reviewed. These ‘parameters NOT reviewed’ are mentioned in the sections. In general, the laboratory detection limits were not available for these parameters at the time of data review or the primary mode of exposure of these chemicals is not through drinking water and these parameters do not have a drinking water standard.

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[10] Lake Erie LaMP Management Committee. April 2006. The Lake Erie Lakewide Management Plan 2006 Report.

1. Conservation Ontario Recommendations

A 2003 Conservation Ontario discussion paper provides recommendations for monitoring Ontario's water quality, for both surface water and groundwater sources. The water chemistry parameters suggested for groundwater quality monitoring are listed in **Table 3.1.3-1**.

Most of these water chemistry parameters are available in the Provincial Groundwater Monitoring Network (PGMN) data for Thames Watershed & Region wells.

Parameters NOT reviewed are dissolved oxygen (no data), carbonate, potassium and calcium (which do not have Ontario drinking water standards). Hardness and alkalinity have Ontario drinking water standards and were reviewed instead of carbonate.

Table 3.1.3-1: Conservation Ontario Recommended Water Chemistry Parameters

pH	Hardness
Dissolved oxygen	Nitrate
Temperature	Nitrite
Conductivity	Sodium
Chloride	Potassium
Fluoride	Calcium
Sulphate	Magnesium
Carbonate	Iron
Alkalinity	Dissolved solids

2. Ontario Regulation 170/03 (Drinking Water Systems Regulation)

There are inorganic and organic chemicals that must be tested in the treated drinking water according to Ontario Reg. 170/03 (Drinking Water Systems Regulation) Safe Drinking Water Act, 2002. Testing results are reported to the OMOE and the data is available in DWSP and DWIS databases as well as the annual DWS and OMOE reports. The Ontario Regulation 170/03 chemicals are listed in **Table 3.1.2-2** and **Table 3.1.2-3** in **Section 3.1.2: Selecting Parameters for Drinking Water Intake Quality**.

3. Additional Sources of Data

The data sources for groundwater quality in the Thames Watershed Region include:

- Drinking Water Surveillance Program (DWSP)
- Drinking Water Information System (DWIS)
- Provincial Groundwater Monitoring Network (PGMN)
- Annual DWS and OMOE Inspection reports

Drinking water is monitored for a variety of parameters to assess the physical and chemical water quality of both the raw water and the treated water that is distributed to the community.

In general, groundwater characteristics are considered to be relatively consistent and the chemical parameter monitoring is not as extensive as that of surface water sources in terms of monitoring frequency and long-term data collection. Thus, municipal water supply wells and PGMN monitoring wells offer limited water quality data compared to the data used to review surface water sources in **Section 3.2: Raw Water Characterization for Inland Surface Water** and **Section 3.4: Raw Water Characterization for Drinking Water Intakes**.

Drinking Water Surveillance Program (DWSP)

The OMOE DWSP database provides water chemistry data for some municipal well supply systems. DWSP is a voluntary program that was established in the 1990s and raw water quality data for only four well supply systems in the Thames watershed is available for review. Information is available (data years in brackets) for: Dorchester (1993-2005), Ingersoll (1995-2002), Stratford (1991-2005) and Woodstock (1994-2002) systems. Data is available as one raw water quality data set for each system and is not for each individual well within a system (for example, the Dorchester system has eight individual wells). The DWSP water quality parameters are listed in **Table 3.1.3-2: Parameters Available in the DWSP Database** and **Table 3.1.3-3: Parameters Available in the DWSP Database but Not Reviewed.**

Parameters NOT reviewed do not have Ontario Drinking Water standards or objectives or guidelines. However, some parameters such as Aldrin and Dieldrin are reviewed using combined parameter data for Aldrin + Dieldrin.

Drinking Water Information System (DWIS)

The OMOE DWSP database provides microbiological data and water chemistry data for municipal well supply systems. The water chemistry data available is for treated water samples for most systems, with limited raw water data for a few systems. The years of data vary but are within the years 2002 to 2006. There is no DWIS chemical data available for the Mount Brydges and Mount Elgin well supply systems. The DWIS water chemistry parameters are listed in **Table 3.1.3-4: Parameters Available in the DWIS Database.**

Provincial Groundwater Monitoring Network (PGMN)

Under the PGMN program, monitoring wells spread across the Thames region are sampled and analyzed for various water chemistry parameters. The PGMN parameters are listed in **Table 3.1.3-5: Parameters Analyzed in the PGMN Program**.

Parameters NOT reviewed from the PGMN data set are: ammonia, phosphate, carbonate, bicarbonate, bismuth, calcium, magnesium, molybdenum, potassium, silicon dioxide, silver, strontium, titanium, total Kjeldahl nitrogen, tin, total suspended solids, and all provided saturation indices. These do not have Ontario Drinking Water standards or objectives or guidelines.

Annual Drinking Water System (DWS) Reports

Drinking Water System (DWS) annual reports are available from each WTP or WSS (or the related municipality) website. The annual reports identify parameters above drinking water standards or guidelines and are submitted to the OMOE. The parameters in the annual DWS reports are the Drinking Water System Ontario Regulation 170/03 parameters (shown in **Table 3.1.2-2** and **Table 3.1.2-3**), except for two chemicals that are not reported: TCDD and TCDF (dioxins and furans).

*Ministry of the Environment (*OMOE*) Annual Inspection Reports*

Ministry of the Environment Annual Inspection Reports are reports of findings of drinking water supply system inspections conducted by OMOE annually. These reports also identify parameters above drinking water standards or guidelines. However the number of parameters are less than those done for annual DWS reporting, and the type of parameters analyzed vary from year to year and between well supply systems. Below in **Table 3.1.3-6** is a list of parameters from the Ridgetown well supply system OMOE inspection report for 2006.

Parameters NOT reviewed are ammonia+ammonium, bromodichloromethane, chlorodibromomethane, chloroform, silver, titanium, strontium, xylene (m and p) and xylene (o). These do not have Ontario Drinking Water standards/objectives/guidelines. However, trihalomethanes are reviewed and these include the commonly detected bromodichloromethane, chlorodibromomethane, chloroform and bromoform[11] .

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[11] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

Table 3.1.3-2: Parameters Available in the DWSP Database

Antimony	Diclofop-methyl
Arsenic	Dimethoate
Barium	Dinoseb
Boron	Diquat
Cadmium	Diuron
Chromium	Glyphosate
Mercury	Heptachlor + Heptachlor Epoxide
Selenium	Lindane (Total)
Uranium	Malathion
Zinc	Methoxychlor
Alachlor	Metolachlor
Aldicarb	Metribuzin
Aldrin + Dieldrin	Monochlorobenzene
Atrazine + N-dealkylated metabolites	Paraquat
Azinphos-methyl	Parathion
Bendiocarb	Pentachlorophenol
Benzene	Phorate
Benzo(a)pyrene	Picloram
Bromoxynil	Polychlorinated Biphenyls (PCB)
Carbaryl	Prometryne
Carbofuran	Simazine
Carbon Tetrachloride	Temephos
Chlordane (Total)	Terbufos
Chlorpyrifos	Tetrachloroethylene (perchloroethylene)
Cyanazine	Triallate
Diazinon	Trichloroethylene
Dicamba	Trifluralin
Dichlorodiphenyltrichloroethane (DDT) + metabolites	Vinyl Chloride
Dichloromethane	1,1-dichloroethylene (vinylidene chloride)
Phosphorus	1,2-dichlorobenzene
Nitrate	1,2-dichloroethane
Nitrite	1,4-Dichlorobenzene
Nitrate + Nitrite	2,3,4,6-tetrachlorophenol
Alkalinity	2,3,7,8 TCDD (dioxin)
Aluminum	2,3,7,8 TCDF
Anthracene	2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)

Beryllium	2,4,6-trichlorophenol
Benzo(a)anthracene	2,4-dichlorophenol
Benzo(k) fluoranthene	2,4-dichlorophenoxyacetic acid (2,4-D)
Benzo(g,h,i)perylene	Sodium
Bromoform	Styrene
Chloride	Sulphate
Chrysene	Thallium
Cobalt	Toluene
Copper	Total Dissolved Solids
Dissolved Organic Carbon	Total Trihalomethanes
Ethyl Benzene	Toxaphene
Fluoride	Vanadium
Fluoranthene	
Hardness	
Hexachlorobenzene	
Iron	
Lead	
Manganese	
Mirex (dechlorane)	
Nickel	
Pentachlorobenzene	
pH	
Phenanthrene	

Table 3.1.3-3: Parameters Available in the DWSP Database but Not Reviewed

1,1,2 Trichloroethane	Aldrin
1,2,4 Trichlorobenzene	Dieldrin
1,2,3,5 - Tetrachlorobenzene	Titanium
1,1,1 - Trichloroethane	Strontium
1,1,2,2 - Tetrachloroethane	Silver
1,2 - Dichloropropane	Molybdenum
1,2,3 - Trichlorobenzene	Chlordane - Alpha
1,2,3,4 -Tetrachlorobenzene	Chlordane - Gamma
1,2,3,5 - Tetrachlorobenzene	Endosulfan I
1,3,5 - Trichlorobenzene	Endosulfan II
2,3,6 - Trichlorotoluene	Endosulfan,Sulphate
2,3,6-Trichloroanisole	Endrin
2,4,5 - Trichlorotoluene	Ethylene Dibromide
2,4,6-Trichloroanisole	Free Chlorine (Field)
2,6,A - Trichlorotoluene	Geosmin
2-Isobutyl-3-Methoxypyrazine	Gross Alpha-Hivols-Rpl
2-Isopropyl-3-Methoxypyrazine	Gross B-Hivols-Rpl
2-Methylisoborneol	Heptachlor
Cis - 1,2 - Dichloroethylene	Heptachlorepoxide
Ammonium	Hexachloro Cyclo Pentadiene
Anions	Hexachlorobutadiene
Cations	Hexachloroethane
Calcium	Xylene -m and p
Conductivity - Estimated	Xylene -o
Conductivity - Measured	
Dissolved Inorganic Carbon	

Table 3.1.3-4: Parameters Available in the DWIS Database

1,1-dichloroethylene (vinylidene chloride)
1,2-dichlorobenzene
1,2-dichloroethane
1,4-dichlorobenzene
2,3,4,6-tetrachlorophenol
2,4,5-trichlorophenoxyacetic acid (2,4,5-T)
2,4,6-trichlorophenol
2,4-dichlorophenol
2,4-dichlorophenoxyacetic acid (2,4-D)
Alachlor
Aldicarb
Aldrin + Dieldrin
Antimony
Arsenic
Atrazine + N-dealkylated metabolites
Azinphos-methyl
Barium
Bendiocarb
Benzene
Benzo(a)pyrene
Boron
Bromoxynil
Cadmium
Carbaryl
Carbofuran
Carbon tetrachloride
Chlordane (Total)
Chlorpyrifos
Chromium
Cyanazine
Diazinon
Dicamba
Dichlorodiphenyltrichloroethane (DDT) + Metabolites
Dichloromethane
Diclofop-methyl
Dimethoate
Dinoseb
Diquat
Diuron
Fluoride
Glyphosate
Heptachlor + Heptachlor Epoxide
Lindane (Total)
Malathion
Mercury
Methoxychlor
Metolachlor
Metribuzin
Monochlorobenzene
Nitrate + Nitrite (as nitrogen)
Nitrates
Nitrite
Paraquat
Parathion
Pentachlorophenol
Phorate
Picloram
Polychlorinated Biphenyls (PCBs)
Prometryne
Selenium
Simazine
Sodium
Sodium
Temephos
Terbufos
Tetrachloroethylene (perchloroethylene)
Triallate
Trichloroethylene
Trifluralin
Uranium
Vinyl Chloride

Table 3.1.3-5: Parameters Analyzed in the PGMN Program

Aluminum	Molybdenum	SI (Albite)
Ammonium	Nickel	SI (Anhydrite)
Antimony	Nitrate + Nitrite as N	SI (Aragonite)
Arsenic	Nitrite	SI (Barite)
Barium	pH	SI (Calcite)
Benzene	Phosphorus	SI (Chalcedony)
Beryllium	Phosphate	SI (Dolomite)
Bicarbonate	Potassium	SI (Fluorite)
Bismuth	Selenium	SI (Goethite)
Boron	Silicon di oxide	SI (Gypsum)
Bromoform	Silver	SI (Halite)
Cadmium	Sodium	SI (Hematite)
Calcium	Srontium	SI (Pyrite)
Carbonate	Styrene	SI (Quartz)
Chloride	Sulphate	SI (Siderite)
Chloroform	Thallium	SI (Talc)
Chromium	Tin	SI (Willemite)
Cobalt	Titanium	SI (Witherite)
Copper	Toluene	
Ethylbenzene	Total Dissolved Solids	
Fluoride	Total Kjeldahl Nitrogen	
Iron	Total Organic Carbon	
Lead	Total Suspended Solids	
Magnesium	Total Trihalomethanes	
Manganese	Uranium	
Measured Alkalinity	Vanadium	
Measured Hardness	Zinc	

Note: SI is saturation index

Table 3.1.3-6: Parameters Available in Annual OMOE Inspection Report
(Parameters shown are from Ridgetown Well Supply System Inspection Report for 2006)

Antimony	Benzene
Arsenic	Chloroethane
Barium	Carbon tetrachloride
Boron	1,2-dichlorobenzene
Cadmium	1,3-dichlorobenzene
Chromium	1,4-dichlorobenzene
Mercury	1,2-dichloroethane
Selenium	trans-1,2-dichloroethane
Uranium	cis-1,2-dichloroethane
Nitrogen; nitrite	1,1 dichloroethane
Nitrogen; nitrate+nitrite	Dichloromethane
Nitrogen; ammonia+ammonium	Chlorobenzene
Sodium	Tetrachloroethene
Fluoride	1,1,1-Trichloroethane
Phosphorus; phosphate	Trichloroethene
Copper	Bromodichloromethane
Nickel	Toluene
Zinc	1,2-dichloropropane
Lead	1,2-dibromoethane
Iron	Trihalomethane
Manganese	1,1,2-trichloroethane
Aluminum	dibromochloromethane
Vanadium	ethylbenzene
Molybdenum	m- and p-xylene
Silver	bromoform
Beryllium	styrene
Strontium	o-xylene
Titanium	1,1,2,2-tetrachloroethane
Thallium	Tert-butyl methyl ether
Cobalt	Chloroform

3.1.4 Significance of the Parameters

Phosphorus and nitrate are essential plant growth nutrients. However nutrients in water bodies may result in algal growth, giving rise to taste and odour problems that may have an aesthetic effect on drinking water quality. Excessive algal blooms cause a condition called eutrophication, choking the water body by depleting oxygen and thereby harming aquatic life. Certain *cyanobacteria*, or blue-green algae, produce toxic substances of which *microcystins* are the most common found in water and are most often responsible for poisoning animals and humans who come into contact with it[12]. Phosphorus itself is not considered harmful to human health; however, high concentrations of nitrate may cause "blue baby syndrome" (methaemoglobinaemia). This is a condition in which enough oxygen cannot be released to body tissues, mostly affecting infants under three months of age[13].

Chlorides are conservative chemicals, moving with the water. Chloride can be toxic to aquatic organisms at high concentrations, and affects growth and reproduction at lower concentrations.

Suspended solids consist of silt, clay, and fine particles of organic and inorganic matter. These particles are significant carriers of phosphorus, metals, and other hazardous contaminants. Suspended solids can be detrimental to aquatic organisms including fish (spawning beds, damage gills, etc.). Oxygen levels in the stream can be impaired by decaying organic solids from sources such as wastewater treatment plants and storm sewers.

Turbidity is a measure of water's clarity and is often analyzed instead of suspended solids since turbidity has a drinking water standard. The substances and particles that cause turbidity can significantly interfere with disinfection, can be a source of disease-causing organisms, and can shield pathogenic organisms from the disinfection treatment process.

Metals such as copper, zinc, lead, chromium, arsenic and mercury may cause chronic or acute poisoning when higher than drinking water standard levels, affecting various parts of the human body, and some are carcinogenic.

Coliform are a type of bacteria. Fecal coliform are a subgroup of total coliform. *Escherichia coli* (*E. coli*) are a subgroup of fecal coliform. Total coliform are bacteria present in the intestines and feces of animals including humans, livestock, poultry, and wildlife. They are also present in soil. The presence of total coliform in water indicates environmental or possibly fecal contamination. Fecal coliform are found in the fecal matter of warm blooded animals. The presence of fecal coliform in water may indicate fecal contamination and, hence, indicates the potential presence of pathogens (disease causing organisms). Fecal contamination of drinking water can result in gastrointestinal sicknesses owing to pathogens found in fecal matter. *Escherichia coli* also indicate the possible presence of pathogens in water. Certain strains of *E. coli*, such as *E. coli* O157:H7, are disease-causing.

pH is defined as the negative logarithm of hydrogen ion concentration. In a water sample, it provides a measure of the activity of the hydrogen ion, and is reported on a scale of 0 to 14. Typically, pH levels of 0, 7 and 14 are considered to be acidic, neutral, and basic, respectively.

Temperature is a physical characteristic in drinking water that may have an effect on or could be associated with other aesthetic parameters. Temperature affects taste and odour perceptions and the rate of growth of micro-organisms.

Pesticides and herbicides at high levels in drinking water can affect various organs of the human body as well as be carcinogenic. The presence of atrazine and other pesticides or herbicides (such as alachlor or methoxychlor) even at trace levels indicates that the raw water source is affected by activities that use pesticides including agriculture, landscaping (public places, domestic use) and golf courses; atrazine is the pesticide most commonly detected in Ontario's municipal drinking water[14].

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[12] Health Canada. Blue-Green Algae (Cyanobacteria) and their Toxins. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/cyanobacter-eng.php

[13] Health Canada. What's In Your Well? A Guide to Well Water Treatment and Maintenance. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/well-puits-eng.php

[14] OMOE. Drinking Water Surveillance Program Summary Report for 2000, 2001 and 2002. DWSP Parameter Groups. www.ene.gov.on.ca/envision/water/dwsp/0002/index.htm#pargroups

The presence of polynuclear aromatic hydrocarbons (PAHs) such as anthracene in the environment is principally associated with the combustion of organic matter, including fossil fuels[15]. Long-term exposure to PAHs can cause cancer[16].

Polychlorinated biphenyls (PCBs), in the past, have been marketed extensively for a wide variety of purposes but are no longer manufactured or used[15]. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioural and immunological changes in children. PCBs are known to cause cancer in animals[17].

Volatile organic carbon compounds such as benzene are generally present in source water as a result of recreational or industrial activity[15]. The effects on human health include damage to organs, nervous systems, paralysis, bone marrow toxicity and cancer[18].

Dioxins and furans are chlorinated hydrocarbons that occur as by-products and are formed in very small amounts in combustion processes, particularly of chlorinated materials, and in some poorly controlled industrial processes such as bleached paper manufacturing[15]. Human exposure to dioxins can cause severe skin disease, rashes, discolouration, excessive body hair, liver damage, alterations to glucose metabolism, and small changes in hormone levels[19].

3.1.5 Water Quality Standards, Objectives and Guidelines

Water quality standards, objectives and guidelines have been developed by federal and provincial governments to protect both aquatic life and human water uses. Human uses include drinking water, crop irrigation, animal watering, and recreation uses such as fishing, boating, swimming and aesthetic value.

Drinking water standards are established for treated drinking water supplied to communities. In this report, the data for raw (untreated) water are compared to the treated water standards (there are none specifically for raw water). The comparison with these standards is only intended to provide a means of quality assessment using a reference number (the standard) and not to judge conformance of raw water to the standards. The current (most recent) standards, objectives and guidelines are summarized below.

The Ontario Ministry of the Environment (OMOE) published standards for drinking water, referred to as the Ontario Drinking Water Standards (ODWS), in 2003[20]. The ODWS are further categorized into Maximum Acceptable Concentration (MAC), Interim MAC (IMAC), Aesthetic Objective (AO), and Operational Guidelines (OG).

The **Maximum Acceptable Concentration (MAC)** is established for parameters that, when present above a certain concentration, have known or suspected adverse health effects.

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[15] OMOE. Drinking Water Surveillance Program Summary Report for 2000, 2001 and 2002. DWSP Parameter Groups. www.ene.gov.on.ca/envision/water/dwsp/0002/index.htm#pargroups

[16] Agency for Toxic Substances & Disease Registry. September 1996. ToxFAQs for Polycyclic Aromatic Hydrocarbons (PAHs) - How can polycyclic aromatic hydrocarbons (PAHs) affect my health? www.atsdr.cdc.gov/tfacts69.html#bookmark05

[17] ATSDR. February 2001. ToxFAQs for Polychlorinated Biphenyls (PCBs). www.atsdr.cdc.gov/tfacts17.html

[18] USEPA. Drinking Water Contaminants – Volatile Organic Chemicals. www.epa.gov/safewater/dwh/t-voc.html

[19] ATSDR. February 1999. ToxFAQs for Chlorinated Dibenzo-p-dioxins (CDDs). www.atsdr.cdc.gov/tfacts104.html

[20] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf

The **Interim Maximum Acceptable Concentration (IMAC)** is established for parameters either when there is insufficient toxicological data to establish a MAC with reasonable certainty, or when it is not feasible, for practical reasons, to establish a MAC at the desired level.

The **Aesthetic Objective (AO)** is established for parameters that may impair the taste, odour or colour of water or that may interfere with good water quality control practices. For certain parameters, both aesthetic objectives and health-related MACs have been derived.

The **Operational Guideline (OG)** is established for parameters that, if not controlled, may negatively affect the efficient and effective treatment, disinfection and distribution of the water.

An additional source of drinking water standards is the 'Guidelines for Canadian Drinking Water Quality' published by Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water[21] (CDW). This document provides guidelines on drinking water quality for physical, chemical, microbial and radiological parameters. Most guidelines correspond to ODWS values.

The OMOE published a document in 1994 stipulating updated Provincial Water Quality Objectives[22] (PWQO) that provides general guidelines for sustenance of healthy aquatic life.

"The **Provincial Water Quality Objective (PWQO)** is established when a defined minimum information base representing the following effects is available: aquatic toxicity; bioaccumulation; and mutagenicity. The final PWQO is based on the lowest effect concentration reported for any of the above endpoints with an added safety factor."[22]

An **Interim Provincial Water Quality Objective (IPWQO)** is established when there is insufficient toxicological information to prepare a PWQO. It is based on lowest effect concentration and uncertainty factor (quality and quantity of data, and bioaccumulation potential of the substance).

An **Emergency Interim Provincial Water Quality Objective** is a numerical criterion assigned to a substance that does not have a PWQO or IPWQO to meet emergency needs.

The Canadian Council of Ministries of the Environment (CCME) has also published the Canadian Environmental Quality Guidelines (CEQG) in 1996 (updated in 2006) which provides guidelines for the protection of aquatic life.

For some parameters, the drinking water standards can be very different from the healthy aquatic life levels. For example, the Provincial Water Quality Objective (PWQO) for copper is 5 µg/L or 0.005 mg/L because copper can have serious effects on aquatic life at that level. However, the Ontario Drinking Water Standard (ODWS) Aesthetic Objective (AO) is 1 mg/L because drinking water standards do not consider copper to be of concern until the concentration reaches 1 mg/L which will affect the aesthetic taste of the water.

The Ontario Drinking Water Standards are used to assess the quality of the inland and intake source water. However, not all parameters selected, for example phosphorus, have an ODWS. Where the ODWS is not available, the Guidelines for Canadian Drinking Water Quality[21] (published by Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water (CDW)), was checked to see if drinking water standards were available. It was found that for all chemicals without an ODWS, there are no Canadian Drinking Water Quality guidelines either, or the guidelines were 'archived', meaning they

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[21] Health Canada. 2008. Guidelines for Canadian Drinking Water Quality Summary Table. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index_e.html

[22] OMOE. 1994. Water Management: Policies, Guidelines, Provincial Water Quality Objectives. www.ene.gov.on.ca/envision/gp/3303e.pdf

are no longer needed[23]. Hence, for those chemicals without ODWS, the United States Environmental Protection Agency (USEPA) Maximum Concentration Level (MCL) from the USEPA National Primary Drinking Water Regulations[24] are used. In the USA, National Primary Drinking Water Regulations (NPDWRs or primary standards) are legally enforceable standards that apply to public water systems. Where the USEPA MCLs are not available, Provincial Water Quality Objectives (for healthy aquatic life) are used.

Table 3.1.5-1: Water Quality Standards, Objectives and Guidelines summarizes drinking water standards for the water quality parameters that will be considered in this report. To provide comparison, water quality objectives for the protection of aquatic life or for recreational purposes are also provided.

Table 3.1.5-1: Water Quality Standards, Objectives and Guidelines

Parameter	Drinking Water Standard	Aquatic Life Protection Standard
Basic Parameters		
Phosphorus	None	0.03 mg/L (IPWQO - rivers & steams)[b] 0.02 mg/L (IPWQO – lakes)[b]
Nitrate	10 mg/L (ODWS MAC)[a]	13 mg/L as mg $NO_3^{-}\cdot L^{-1}$ (as per CCME)[c]
Turbidity	5 NTU (ODWS AO)[a]	No change in natural Secchi disc reading by more than 10 percent due to addition of suspended matter (PWQO)[b]
Chloride	250 mg/L (ODWS AO)[a]	210 mg/L (median lethal concentration)[d]
pH	6.5 to 8.5 (ODWS OG)[a]	6.5 to 8.5 (PWQO)[b]
Temperature	15^{0}C (ODWS AO)[a]	Diversity, distribution and abundance of plant and animal life shall not be significantly changed (PWQO)[b]
Total coliform	Not detectable (ODWS MAC)[a]	Before May 1994, was 1000 counts/100 mL based on a geometric mean density of a series of samples[e]
Escherichia coli	Not detectable (ODWS MAC)[a]	100 counts/100 mL recreational health guideline based on geometric mean of at least five samples taken from one swimming area within a one month period[e]
Ontario Regulation 170/03 Schedule 23 Inorganic Parameters		
Antimony	0.006 mg/L (ODWS IMAC)[a]	20 µg/L (IPWQO)[f]
Arsenic	0.025 mg/L (ODWS IMAC)[a]	100 µg/L (PWQO)[b]
Barium	1 mg/L (ODWS MAC)[a]	None
Boron	5 mg/L (ODWS IMAC)[a]	200 µg/L (IPWQO)[e]
Cadmium	0.005 mg/L (ODWS MAC)[a]	0.2 µg/L (PWQO)[e]
Chromium	0.05 mg/L (ODWS MAC)[a]	1 µg/L (PWQO)[c] for hexavalent chromium 8.9 µg/L (PWQO)[c] for trivalent chromium
Mercury	0.001 mg/L (ODWS MAC)[a]	0.2 µg/L (PWQO)[b] (in a filtered sample)
Selenium	0.01 mg/L (ODWS MAC)[a]	100 µg/L (PWQO)[b]
Uranium	0.02 mg/L (ODWS MAC)[a]	5 µg/L (IPWQO)[e]
Parameter	Drinking Water Standard	Aquatic Life Protection Standard

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[23] Health Canada. 2008. Guidelines for Canadian Drinking Water Quality Summary Table. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index_e.html

[24] USEPA. Drinking Water Contaminants – Volatile Organic Chemicals. www.epa.gov/safewater/dwh/t-voc.html

Parameter	**Drinking Water Standard**	**Aquatic Life Protection Standard**
Ontario Regulation 170/03 Schedule 24 Organic Parameters		
Alachlor	0.005 mg/L (ODWS IMAC)[a]	None
Aldicarb	0.009 mg/L (ODWS MAC)[a]	None
Aldrin + Dieldrin	0.0007 mg/L (ODWS MAC)[a]	0.001 µg/L (PWQO)[b]
Atrazine + N-dealkylated metabolites	0.005 mg/L (ODWS IMAC)[a]	None
Azinphos-methyl	0.02 mg/L (ODWS MAC)[a]	None
Bendiocarb	0.04 mg/L (ODWS MAC)[a]	None
Benzene	0.005 mg/L (ODWS MAC)[a]	100 µg/L (IPWQO)[e]
Benzo(a)pyrene	0.00001 mg/L (ODWS MAC)[a]	None
Bromoxynil	0.005 mg/L (ODWS IMAC)[a]	None
Carbaryl	0.09 mg/L (ODWS MAC)[a]	0.2 µg/L (PWQO)[c]
Carbofuran	0.09 mg/L (ODWS MAC)[a]	None
Carbon Tetrachloride	0.005 mg/L (ODWS MAC)[a]	None
Chlordane (Total)	0.007 mg/L (ODWS MAC)[a]	0.06 µg/L (PWQO)[b]
Chlorpyrifos	0.09 mg/L (ODWS MAC)[a]	0.001 µg/L (PWQO)[b]
Cyanazine	0.01 mg/L (ODWS IMAC)[a]	None
Diazinon	0.02 mg/L (ODWS MAC)[a]	0.08 µg/L (PWQO)[b]
Dicamba	0.12 mg/L (ODWS MAC)[a]	200 µg/L (PWQO)[b]
1,2-Dichlorobenzene	0.2 mg/L (ODWS MAC)[a]	2.5 µg/L (PWQO)[g]
1,4-Dichlorobenzene	0.005 mg/L (ODWS MAC)[a]	4.0 µg/L (PWQO)[g]
Dichlorodiphenyltrichloroethane (DDT) + metabolites	0.03 mg/L (ODWS MAC)[a]	None
1,2-dichloroethane	0.005 mg/L (ODWS IMAC)[a]	100 µg/L (IPWQO)[h]
1,1-Dichloroethylene	0.014 mg/L (ODWS MAC)[a]	40 µg/L (IPWQO)[h]
Dichloromethane	0.05 mg/L (ODWS MAC)[a]	None
2,4-Dichlorophenol	0.9 mg/L (ODWS MAC)[a]	0.2 µg/L (PWQO)[i]
2,4-Dichlorophenoxy acetic acid (2,4-D)	0.1 mg/L (ODWS IMAC)[a]	None
Diclofop-methyl	0.009 mg/L (ODWS MAC)[a]	None
Dimethoate	0.02 mg/L (ODWS IMAC)[a]	None
Dinoseb	0.01 mg/L (ODWS MAC)[a]	None
Diquat	0.07 mg/L (ODWS MAC)[a]	0.5 µg/L (PWQO)[b]
Ontario Regulation 170/03 Schedule 24 Organic Parameters		
Diuron	0.15 mg/L (ODWS MAC)[a]	1.6 µg/L (PWQO)[b]
Glyphosate	0.28 mg/L (ODWS IMAC)[a]	None
Heptachlor + Heptachlor Epoxide	0.003 mg/L (ODWS MAC)[a]	0.001 µg/L (PWQO)[b]
Lindane (Total)	0.004 mg/L (ODWS MAC)[a]	0.01 µg/L (PWQO)[b]
Malathion	0.19 mg/L (ODWS MAC)[a]	0.1 µg/L (PWQO)[b]
Methoxychlor	0.9 mg/L (ODWS MAC)[a]	0.04 µg/L (PWQO)[b]
Metolachlor	0.05 mg/L (ODWS IMAC)[a]	3 µg/L (IPWQO)[e]
Metribuzin	0.08 mg/L (ODWS MAC)[a]	None
Monochlorobenzene	0.08 mg/L (ODWS MAC)[a]	None
Paraquat	0.01 mg/L (ODWS IMAC)[a]	None
Parathion	0.05 mg/L (ODWS MAC)[a]	0.008 µg/L (PWQO)[b]

Parameter	Drinking Water Standard	Aquatic Life Protection Standard
Pentachlorophenol	0.06 mg/L (ODWS MAC)[a]	0.5 µg/L (PWQO)[i]
Phorate	0.002 mg/L (ODWS IMAC)[a]	None
Picloram	0.19 mg/L (ODWS IMAC)[a]	None
Polychlorinated Biphenyls (PCB)	0.003 mg/L (ODWS IMAC)[a]	0.001 µg/L (PWQO)[b]
Prometryne	0.001 mg/L (ODWS IMAC)[a]	None
Simazine	0.01 mg/L (ODWS IMAC)[a]	10 µg/L (PWQO)[b]
Temephos	0.28 mg/L (ODWS IMAC)[a]	None
Terbufos	0.001 mg/L (ODWS IMAC)[a]	None
Tetrachloroethylene (perchloroethylene)	0.03 mg/L (ODWS MAC)[a]	50 µg/L (IPWQO)[h]
2,3,4,6-Tetrachlorophenol	0.1 mg/L (ODWS MAC)[a]	1 µg/L (PWQO)[i]
Triallate	0.23 mg/L (ODWS MAC)[a]	None
Trichloroethylene	0.005 mg/L (ODWS MAC)[a]	20 µg/L (IPWQO)[h]
2,4,6-Trichlorophenol	0.005 mg/L (ODWS MAC)[a]	18 µg/L (PWQO)[i]
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	0.28 mg/L (ODWS MAC)[a]	None
Trifluralin	0.045 mg/L (ODWS IMAC)[a]	None
Vinyl Chloride	0.002 mg/L (ODWS MAC)[a]	600 µg/L (IPWQO)[e]
SOLEC 2007 Parameters		
Nitrite	1.0 mg/L (ODWS MAC)[a]	None
Dissolved Organic Carbon	5 mg/L (ODWS AO)[a]	None
IJC 1993, Lake Erie LaMP 2006 Parameters		
Toxaphene	0.003 mg/L (USEPA MCL)[j]	0.008 µg/L (PWQO)[b]
2,3,7,8 TCDD (dioxin)	0.000000015 mg/L (ODWS IMAC)[a]	None
2,3,7,8 TCDF	0.000000015 mg/L (ODWS IMAC)[a]	None
Mirex (dechlorane)	None	0.001 ug/L (PWQO)[b]
Hexachlorobenzene	0.001 mg/L (USEPA MCL)[j]	0.0065 µg/L (PWQO)[g]
Lake Huron IAP 2002		
Nickel	None	25 ug/L (PWQO)[b]
Lake Erie LaMP 2006, Lake Huron IAP 2002		
Lead	10 µg/L (ODWS MAC)[a]	(PWQO)[b] based on alkalinity: 5 µg/L for <20 mg/L 10 to 20 µg/L for 20 to 80 mg/L 25 µg/L for >80 mg/L
Copper	1000 µg/L (ODWS AO)[a]	5 µg/L (PWQO)[b]
Zinc	5 mg/L (ODWS AO)[a]	30 µg/L (PWQO)[b]
Lake Erie LaMP 2006		
Alpha-hexachlorocyclohexane	None	None
Beta-hexachlorocyclohexane	None	None
Pentachlorobenzene	None	0.03 µg/L (PWQO)[g]
Anthracene	None	0.0008 µg/L (Emergency IPWQO)[e]
benzo(a)anthracene	None	0.0004 µg/L (Emergency IPWQO)[e]

Parameter	Drinking Water Standard	Aquatic Life Protection Standard
benzo(b)fluoranthene	None	None
Benzo(k) fluoranthene	None	0.0002 µg/L (Emergency IPWQO)[e]
Benzo(g,h,i)perylene	None	0.00002 µg/L (Emergency IPWQO)[e]
Chrysene	None	0.0001 µg/L (Emergency IPWQO)[e]
Fluoranthene	None	0.0008 µg/L (Emergency IPWQO)[e]
Phenanthrene	None	0.03 µg/L (Emergency IPWQO)[e]
Indeno(123-cd)pyrene	None	None
Parameters from DWS Reports - Chatham WTP		
Hardness	80-100 mg/L (ODWS OG)[a]	None
Aluminum	0.1 mg/L (ODWS OG)[a]	At pH > 6.5 to 9.0, is 75 µg/L based on total aluminum measured in clay-free samples; where natural background concentration is above this level, no more than 10% above the background concentration is allowed[k]

ODWS: Ontario Drinking Water Standard
MAC: Maximum Acceptable Concentration
IMAC: Interim Maximum Acceptable Concentration
AO: Aesthetic Objective
OG: Operational Guidelines
PWQO: Provincial Water Quality Objective
IPQWO: Interim Provincial Water Quality Objective
Emergency IPWQO: Emergency Interim Provincial Water Quality Objective
USEPA: United States Environmental Protection Agency
MCL: Maximum Concentration Level

Source of Water Standard, Guideline or Objective in Table 3.1.4-1:

[a] Ministry of the Environment. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

[b] OMOE. 1979. Rationale for the establishment of Ontario's Water Quality Objectives. 236 pp.

[c] Canadian Council of Ministers of the Environment (CCME). 1998. Canadian Environmental Quality Guidelines, Chapter 4: Canadian Water Quality Guidelines for the protection of aquatic life. CCME, Winnipeg, MB.

[d] Environment Canada. 2001. Assessment Report - Road Salts. www.ec.gc.ca/substances/ese/eng/psap/final/roadsalts.cfm

[e] Ministry of the Environment. 1994. Water Management: Policies, Guidelines, Provincial Water Quality Objectives. www.ene.gov.on.ca/envision/gp/3303e.pdf.

[f] OMOEE. 1996. Scientific Criteria Document for the Development of Provincial Water Quality Objectives and Guidelines - Antimony. PIBS 3348e02, 32 pp.

[g] OMOE. 1984. Scientific Criteria Document for Standard Development - Chlorinated Benzenes in the Aquatic Environment. 197 pp.

[h] OMOEE. 1993. Scientific Criteria Document for the Development of Provincial Water Quality Objectives and Guidelines – Chlorinated Ethanes and Chlorinated Ethylenes. PIBS 2603. 111 pp.

[i] OMOE. 1984. Scientific Criteria Document for Standard Development - Chlorinated Phenols in the Aquatic Environment. 180 pp.

[j] USEPA National Primary Drinking Water Regulations. www.epa.gov/safewater/contaminants/index.html#organic

[k] OMOE. 1988. Scientific Criteria Document for the Development of Provincial Water Quality Objectives and Guidelines - Aluminum. 81 pp.

3.2 Raw Water Characterization for Inland Surface Water

This section of the Watershed Characterization Report provides an overview of water quality for inland watercourses and a brief summary of monitoring programs in the Lower Thames Valley Conservation Authority (LTVCA) and Upper Thames River Conservation Authority (UTRCA) watersheds.

Inland surface water quality is examined by using several key parameters including: total phosphorus, nitrates, suspended solids, chloride, bacteria, copper, zinc and lead. The results of the review are summarized in **Section 3.2.4: Water Quality Monitoring, Results and Analysis**.

Water quality has been examined in the UTRCA and LTVCA watersheds since the 1960s when the Provincial Water Quality Monitoring Network (PWQMN) was first established. This report reviews inland surface water quality based on 'current conditions' and 'historic changes'.

'Current conditions' are based on recent data collected since 2002 and are represented by plots that show a range of values for each sampling station.

'Historic changes' span thirty to forty years depending on the data available for each site and are shown by graphing the 75th percentile value per five year data block. These graphs of historic information do not necessarily indicate a trend over time but do help to provide an overview of long-term water quality.

3.2.1 Inland Watercourses and Drainage Areas

The Thames Watershed & Region is made up of the combined watersheds of the Lower Thames Valley Conservation Authority (LTVCA) and the Upper Thames River Conservation Authority (UTRCA). The combined watersheds have a collective drainage area of approximately 6,700 sq. km. The Thames River is the major watercourse with a drainage basin of approximately 5,800 sq. km that drains over 85% of the combined watershed.

The LTVCA watershed is comprised of the lower Thames River (below Delaware), Lake St. Clair and Lake Erie subwatersheds, totalling approximately 3,270 sq. km.

The UTRCA area is about 3,440 sq. km. It is comprised of the North, Middle and South Thames Branch watersheds and several tributaries that discharge into the main Thames River between London and Delaware.

The major subwatersheds are shown in **Map 2: Major Subwatershed Delineations**. An overview of land uses in the region is shown in **Map 30: Generalized Land Cover.** The most significant land use is agriculture, which comprises approximately 82% of the watershed. Urban/industrial land use is over 9% in the UTRCA watershed but is less than 3% in the LTVCA watershed. Overall, urban/industrial is about 6% of the land use. Other land uses in the region shown on the map include woodlands (8.7%), recreational (0.6%) and water/wetlands (0.8%). About 2.1% of the region is not mapped.

The total population in the Thames Watershed & Region is approximately 579,500 with 107,000 in the LTVCA area and 472,500 in the UTRCA area. The higher population in the UTRCA watershed reflects the large urban population in the City of London.

Human activities have significantly influenced surface water quality in the region. Land use activities are linked to changes in surface water quality over the past decades.

Both urban and rural land uses contribute to the deterioration of surface water quality. In the 1970s, sediment delivery to the Great Lakes was of prime concern and extensive monitoring of sediment and nutrients was completed as part of studies to understand pollution from land use in agricultural watersheds. In the 1980s, recreational beach closures due to elevated fecal coliform levels led to studies that included fecal coliform monitoring in watersheds across the province.

3.2.2 Existing Inland Surface Water Monitoring Programs

Since 2001, the UTRCA has used a system that involves water monitoring and reporting on each of the 28 subwatersheds that make up the UTRCA watershed. These subwatersheds average 150 sq. km, which is a manageable size for monitoring, subwatershed planning, and targeting remedial work. It also facilitates involving local groups in the planning and remediation.

LTVCA has developed a monitoring and reporting program in both the lower Thames River subwatersheds and Lake Erie subwatersheds. Eight sites are currently monitored in consideration of both the provincial network and the Great Lakes water quality concerns.

Currently, water quality monitoring in the UTRCA watershed follows the recommendations developed for conservation authorities to support watershed management.[25] This includes a format for sampling, data analyses, and reporting for four areas of water quality assessment:

- Water chemistry
- Biotic community (benthic invertebrates)
- Pathogens
- Toxic contaminants

The water quality monitoring in the LTVCA watershed does not have pathogen or toxic contaminant monitoring.

Water chemistry and benthic invertebrate monitoring are well established programs while pathogens and toxic contaminant monitoring are currently quite limited. Past monitoring programs have tended to focus on aquatic ecology issues. Today, with watershed source protection a priority, water quality monitoring programs will need to address information gaps related to drinking water sources and human health.

Inland surface water quality will be reviewed using several key parameters including: total phosphorus, nitrates, suspended solids, chloride, bacteria, copper, zinc and lead. The result from the benthic invertebrate monitoring program has been summarized in **Section 1.4: Aquatic Ecology**, in the **Interim Watershed Description Report**.

A wide variety of surface water monitoring programs are carried out by provincial, municipal, and other organizations. The following outlines monitoring programs in the Thames Watershed & Region.

(A) Long-term Monitoring Programs

(1) The Provincial Water Quality Monitoring Network (PWQMN)

The LTVCA and the UTRCA have been partners in the OMOE's Provincial Water Quality Monitoring Network (PWQMN) since the 1960s. The objectives of this monitoring program are to assess long-term ambient water quality trends; to determine the general location and causes of water quality problems; and to measure the effectiveness of broad pollution control and watershed management programs. **Map 37: Surface Water Quality Sampling Sites** shows the active and discontinued PWQMN stations across the UTRCA and LTVCA areas.

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[25] Jones, C., and I. Wilcox. 2003. Conservation Ontario Discussion Paper: Recommendations for Monitoring Ontario's Water Quality. Conservation Ontario and Nottawasaga Valley Conservation Authority.

Samples are taken by Conservation Authority staff and analyzed at the OMOE laboratory in Etobicoke. Samples are analyzed for 37 parameters listed below in **Table 3.2.2-1: Provincial Water Quality Monitoring Network List of Parameters**.

Fecal coliform bacteria were monitored in river samples as part of the PWQMN program until 1996 at which time the Province discontinued this part of the program. In the LTVCA watershed, there is no data from 1996 onwards for coliform bacteria at the PWQMN monitoring sites.

In 2001, UTRCA formed a partnership with the local health units (Middlesex, Perth, and Oxford) to continue to monitor *Escherichia coli*, a type of fecal coliform at the PWQMN locations. Samples are analyzed at the Ministry of Health laboratory in London.

Table 3.2.2-1: Provincial Water Quality Monitoring Network List of Parameters

Alkalinity
Aluminum
Ammonia
Barium
Beryllium
Biochemical Oxygen Demand
Cadmium
Calcium
Chloride
Chromium
Cobalt
Conductivity
Copper
Dissolved Solids
Dissolved Oxygen
Hardness
Iron
Kjeldahl Nitrogen
Lead
Magnesium
Manganese
Molybdenum
Nickel
Nitrate
Nitrite
pH
Phosphate
Phosphorus
Potassium
Suspended Solids
Sodium
Strontium
Temperature
Titanium
Turbidity
Vanadium
Zinc

In the UTRCA watershed, the PWQMN is the most extensive monitoring program. Historically, this monitoring program consisted of up to 23 stations monitored monthly up to 12 times per year. In the mid-1990s, changes in provincial funding reduced the program to 15 sites.

In 2002, UTRCA and OMOE redesigned the monitoring program for the upper Thames to better reflect the UTRCA's subwatershed management approach to monitor, report, and implement work on the 28 subwatershed units. Currently there are 24 sample locations with nine sites monitored eight times per year, and 15 sites monitored four times per year.

In the LTVCA watershed, the PWQMN program involved monitoring up to 10 stations until 1996 when changes in provincial funding reduced the program to one site on the Thames River at Jacob Road.

In 2002, the monitoring program was re-designed by LTVCA and OMOE, resulting in eight PWQMN sites monitored eight times per year. Sampling sites for current monitoring programs were selected to reflect conditions in each of the main subwatersheds (Thames River, Lake St. Clair and Lake Erie) in the LTVCA watershed.

The location, description and years sampled for both the active and inactive PWQMN sites are listed in **Table 3.2.2-2: PWQMN and City of London Monitoring Stations in the UTRCA** and **Table 3.2.2-3: PWQMN Monitoring Stations in the LTVCA**.

Table 3.2.2-2: PWQMN and City of London Monitoring Stations in the UTRCA

Subwatershed	Name	Status	Active Years
N. Mitchell, Glengowan, Whirl Creek	Thames Mitchell	Active	1970-2004
Avon River	Avon River	Active	1967-2004
Middle Thames, Mud Creek	Thames Thamesford	Active	1967-2004
North Woodstock	Thames Innerkip	Active	1967-2004
North Woodstock	Thames Tavistock	Inactive	1976-2002
Reynolds Creek	Reynolds Creek	Active	1979-2004
Cedar Creek	Cedar Creek	Active	1965-2004
Cedar Creek	Cedar Creek	Inactive	1982-2003
Dingman Creek	Dingman Creek	Active	1972-2004
Dingman Creek	Dingman Creek London	Inactive	1975-1996
Dorchester	Thames Dorchester*	Active	1978-2004
Dorchester	Thames Hamilton Rd	Inactive	1975-1995
Dorchester	Dorchester Swamp Creek	Inactive	1976-2002
The Forks	Thames Byron*	Active	1978-2004
Medway Creek	Medway Creek*	Active	1978-2004
Plover Mills	Thames Thorndale	Active	1975-2004
Plover Mills	Thames Clarke	Active	1972-2003
Plover Mills	Thames d/s St. Marys	Inactive	1975-2003
Plover Mills	Thames Hwy 7	Inactive	1975-1996
Plover Mills	Thames St. Marys	Inactive	1965-1996
River Bend	Thames Komoka	Active	1975-2004
Pottersburg Creek	Pottersburg Creek*	Active	1993-2004
South Thames	Thames Woodstock	Active	1965-2004
South Thames	Thames d/s Ingersoll	Active	1975-2004
South Thames	Foldens Creek	Inactive	1981-2002
South Thames	Thames Ingersoll	Inactive	1975-1996
South Thames	Thames Vansittart	Inactive	1975-2002
Trout Creek	Trout Creek d/s	Active	1979-2004
Trout Creek	Trout Creek u/s	Active	1979-2004
Glengowan	Thames Rd 133	Inactive	1979-1995
Black Creek	Black Creek	Active	2003-2004
Flat Creek	Flat Creek	Active	2003-2004
Otter Creek	Otter Creek	Active	2003-2004
Fish Creek	Fish Creek	Active	2003-2004
Gregory Creek	Gregory Creek	Active	2003-2004
Wye Creek	Wye Creek	Active	2003-2004
Stoney Creek	Stoney Creek	Active	2003-2004

Subwatershed	Name	Status	Active Years
Waubuno Creek	Waubuno Creek	Active	2003-2004
Oxbow Creek	Oxbow Creek	Active	2003-2004
Komoka Creek	Komoka Creek	Active	2003-2004
Dingman Creek	at Longwoods Rd	Inactive	1965-1971
Dorchester	200 m u/s of Dorchester Rd	Inactive	1978-1983
Komoka Creek	Oxbow Drive	Inactive	1983, 1989
Dorchester	Dorchester Road	Inactive	1978-1983
Middle Thames	Nissouri Creek	Inactive	1975-1976
Mud Creek	North Branch Creek	Inactive	1975-1978
Plover Mills	D/s Campbells Soup outfall	Inactive	1976-1979
Plover Mills	Fanshawe Lake dam	Inactive	1965-1971
Oxbow Creek	Ten Mile Rd, SW of Ilderton	Inactive	1975-1979
Reynolds Creek	Pigram Rd	Inactive	1982-1987
Reynolds Creek	Hwy 19, N of Mt. Elgin	Inactive	1982-1987
	Line 37, E of Brocksden	Inactive	1983
Avon River	U/s of Lorne Ave, Stratford	Inactive	1976-1978
The Forks	Sanatorium Rd, London	Inactive	1967-1971
River Bend	Glendon Dr, Kilworth	Inactive	1972-1977
Dorchester	Meadowlily Rd, London	Inactive	1976-1978

* City of London stations.

Table 3.2.2-3: PWQMN Monitoring Stations in the LTVCA

Subwatershed	Name	Status	Active Years
Thames River	Currie Rd	Active	2002-2004
Thames River	Newbiggin Creek	Active	1982-1996,2003-2004
Thames River	Kent Bridge	Active	1976-1996,2002-2004
Thames River	McGregor Creek	Active	2002-2004
Thames River	Jacob Rd	Active	2002-2004
Thames River	Big Creek	Active	1974-1996,2003-2004
Thames River	Sharon Creek	Inactive	1979-1996
Thames River	Turkey Creek	Inactive	1977-1996
Thames River	Newbiggen Creek	Inactive	1965-1972,1981-1982
Thames River	Newbiggen Creek	Inactive	1972-1975
Thames River	Simpson Rd	Inactive	1983-1996
Thames River	Graham Rd	Inactive	1973-1982
Thames River	White Ash Creek	Inactive	1976-1977
Thames River	McGregor Creek	Inactive	1975-1996
Thames River	Lock Drain	Inactive	1972-1975,1981-1996

Subwatershed	Name	Status	Active Years
Thames River	Kiel Dr	Inactive	1964-1971
Thames River	Kiel Dr	Inactive	1964-1971
Thames River	Kiel Dr	Inactive	1964-1966
Thames River	Kiel Dr	Inactive	1964-1966
Thames River	Kiel Dr	Inactive	1972-1975
Thames River	Riverview Dr	Inactive	1975-1979
Thames River	Jacob Rd	Inactive	1966-1971,1981,1984
Thames River	Jacob Rd	Inactive	1972-1975,1979-2002
Thames River	Jacob Rd	Inactive	1966-1971
Thames River	Baptiste Creek	Inactive	1964-1971
Thames River	Tilbury Creek	Inactive	1964-1971
Thames River	Tilbury Creek	Inactive	1972-1996
Thames River	Tilbury Creek	Inactive	1975-1996
Thames River	Lake St. Clair	Inactive	1964-1970
Thames River	Lake St. Clair	Inactive	1964-1970
Thames River	Lake St. Clair	Inactive	1964-1970
Thames River	Lake St. Clair	Inactive	1964-1971
Lake Erie	Dutton Drain	Active	1968-1996,2002-2004
Lake Erie	Sixteen Mile Creek	Active	2002-2004
Lake Erie	Talbot Creek	Inactive	1964-1971
Lake Erie	Talbot Creek	Inactive	1972-1975
Lake Erie	Brock Creek	Inactive	1968-1975,1981-1996
Lake Erie	Sixteen Mile Creek	Inactive	1964-1975,1981-1996
Lake Erie	Coleman Drain	Inactive	1983-1996
Lake Erie	Indian Creek	Inactive	1983-1983
Lake Erie	Indian Creek	Inactive	1983-1996
Lake Erie	John Clark Drain	Inactive	1983-1996
Lake Erie	Erieau Canal	Inactive	1970-1971

(2) Health Unit Bacteria (Pathogen) Monitoring

Recreational beaches used for swimming have been monitored since the 1970s by the county Health Units. Samples are currently analyzed for *Escherichia coli*, an indicator fecal coliform bacteria.

In the UTRCA watershed, this monitoring is done at three swimming area beaches: Fanshawe Lake, Wildwood Lake, and Pittock Lake. Since 2001, the rowing course on Fanshawe Lake has also been sampled. Samples are taken weekly through the summer months and more frequently when bacteria levels are elevated.

In the LTVCA watershed, Chatham-Kent Public Health monitors 10 public swimming areas[26] throughout the municipality. Testing for bacteriological levels is conducted on a weekly basis from mid June to the beginning of September. The Thames River in Chatham is also tested by Chatham-Kent Public Health for fecal coliform bacteria every year from mid June to the beginning of September. The Elgin-St. Thomas Health Unit monitors the beach at Port Glasgow on Lake Erie during the swimming season.

(3) City of London – Thames River Monitoring Program

The City of London routinely monitors the water quality of the Thames River and its tributaries at 10 locations in the city. This monitoring program was initiated in 1963 with the objective of assessing impacts to the Thames River from pollution control plant discharge.

Samples are analyzed at the Pollution Control Operation Division Laboratory Services in London. The locations of the sites are listed in **Table 3.2.2-2: PWQMN and City of London Monitoring Stations in UTRCA**. Samples are analyzed for the parameters listed in **Table 3.2.2-4: City of London Monitoring Parameters**.

Table 3.2.2-4: City of London Monitoring Parameters

Biochemical Oxygen Demand	Dissolved Oxygen	Conductivity
pH	Total Phosphorus	Nitrates
Suspended Solids	Ammonia	Nitrites
Temperature	Fecal coliform and *E. coli*	

(4) Benthic Invertebrate Monitoring Program

Benthic invertebrate sampling has been conducted throughout the UTRCA watershed at over 250 sites in the past 10 years. The program is a partnership of the UTRCA and University of Western Ontario. This information relates to water quality and aquatic health. Starting in 2003, 33 sites have been monitored in the LTVCA. Information on the Benthic Invertebrate Monitoring Program and the assessment of aquatic water quality is outlined in Section 1.4.3: Aquatic Ecology in the interim Watershed Description Report.

(5) Municipal and Industrial Point Source Monitoring[27]

Industrial direct discharges are regulated under the mandate of the Ontario Monitoring and Compliance Regulations also known as the Municipal Industrial Strategy for Abatement (MISA). Under MISA Regulations, industrial direct discharges are required to monitor specified pollutants (persistent toxic contaminants) at daily, weekly, monthly or other defined frequency. The information is reported by industries as monthly average flows and pollutant loads and concentrations.

Municipal waste water treatment plants (WWTPs) are controlled through Certificates of Approval and the Policy objectives of the OMOE. WWTPs report monthly average flows and concentrations of ammonia, biochemical oxygen demand (BOD), total phosphorus, and total suspended solids. Some WWTPs monitor additional parameters including microbial indicators.

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[26] Municipality of Chatham-Kent website. www.chatham-kent.ca/default.htm

[27] OMOE. Municipal/ Industrial Strategy for Abatement. www.ene.gov.on.ca/envision/water/misa/index.htm

(B) Other Watershed Monitoring Studies and Programs

In addition to the programs outlined above, there are several studies and programs that can provide information on water quality.

(1) Pesticide Monitoring Study

The OMOE, Grand River Conservation Authority and UTRCA initiated a study in 2004 to better understand the presence of in-use pesticides in our river systems. Samples have been taken at 12 subwatershed sites in the UTRCA twice a year for 2004 and 2005. **Table 3.2.2-5: Pesticide Monitoring Study List** is a list of herbicides and insecticides monitored for the Pesticide Monitoring Study.

Table 3.2.2-5: Pesticide Monitoring Study List

Triazines (herbicides):	Phenoxys (herbicides):	Organophosphates (insecticides):
Desethyl atrazine	Dicamba	Mevinphos
Desethyl simazine (atrazine Desisopropyl)	2,4-D	Diazinon
Atrazine	2,4-DB	Dimethoate
Simazine	2,4-DP	Malathion
Metribuzin	MCPP	Parathion
Alachlor	MCPA	Methidathion
Metolachlor	MCPB	Ethion
Cyanazine		Phosmet
		Azinphosmethyl
		Chlorpyrifos
		Phosalone

(2) Sport Fish Contaminant Monitoring Program

The Ministry of Natural Resources (MNR) and the OMOE monitor contaminants in fish. This information is reported in the Guide to Eating Ontario Sport Fish, published every other year (there are currently 23 editions of the guide and the most recent is the 2005-2006 edition). Contaminants monitored include mercury and other metals, polychlorinated biphenyls (PCBs), mirex/photomirex, pesticides (DDT, toxaphene), other pesticides, dioxins and furans, and other contaminants. The report includes information on fish from Lake Huron, Lake St. Clair, Lake Erie and sections of the Thames River.

(3) Monitoring through Previous Studies

Many past watershed studies and research projects have involved water quality monitoring at stream locations in the Thames River watershed. Some of these include:

- **City of London Subwatershed Studies:** A monitoring program was conducted in 1993 and 1994 to assess water quality and quantity at 15 subwatersheds (27 sample locations) in the City of London. Water samples were monitored for bacteria, nutrients and metals[28]. This information was collected as part of the City of London Subwatershed Studies, a component of a comprehensive planning exercise (Vision '96) to provide guidance for future development[29].
- **Clean Up Rural Beaches Plan (CURB)[30]:** Extensive water quality monitoring of targeted agricultural subwatersheds was completed through the mid 1980s and early 1990s as part of CURB studies to 1) identify sources of bacteria and phosphorus pollution; 2) study the fate and transport of bacteria in watersheds; and 3) assess the effectiveness of agricultural best management practices.

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[28] Upper Thames River Conservation Authority. 1994. Water Quality and Quantity Monitoring Program Results. City of London Subwatershed Studies.

[29] Marshall Macklin Monaghan Limited, Paragon Engineering Limited, Aquafor Beech Limited. 1995. City of London Subwatershed Studies Implementation Plan.

[30] UTRCA. 1990. A Clean Up Rural Beaches Plan (CURB) for Fanshawe, Pittock and Wildwood Reservoirs in the Upper Thames River Conservation Authority Watershed.

- **Pollution from Land Use Activities Reference Group (PLUARG) Studies:** Between 1972 and 1978, landmark studies on non-point source pollution in the Great Lakes basin were undertaken as part of the PLUARG, under the auspices of the International Joint Commission[31]. Numerous studies were conducted, identifying Great Lakes pollution related to land use including phosphorus, sediments, industrial compounds, previously used pesticides, and heavy metals.
- **Stratford-Avon River Environmental Management Project:** A multi-agency team of researchers conducted extensive studies from 1980 to 1982 in the Avon River watershed to develop a comprehensive water quality management plan addressing both urban and rural sources of pollution[32].
- **Thames River Basin Water Management Study[33]:** An extensive Thames River basin-wide study was undertaken by the Ontario Ministries of Environment and Natural Resources in the 1970s to address water quality and quantity issues.

3.2.3 Parameter Selection, Standards and Special Cases

Parameter Selection

Eight parameters were selected for conservation authority watershed planning based on extensive discussions between the OMOE and Conservation Ontario staff. The parameters are total phosphorus, nitrates, suspended solids, chloride, coliform (fecal coliform and *Escherichia coli*), copper, zinc and lead. These parameters reflect nutrient levels, salt loading, solids, fecal bacteria contamination and heavy metal pollution.

As well, the Conservation Ontario February 2003 report ‘Water Sampling and Data Analysis Manual’ for PWQMN partners recommends the use of the selected eight parameters as the indicator parameters for watershed management.

Standards, Objectives and Guidelines

The effects of various land use activities on water quality in the Thames Watershed & Region are considered by assessing data for the eight selected parameters. The following provides background information on the standards for each of the parameters.

Water quality standards, objectives and guidelines have been developed by federal and provincial governments to protect both aquatic life and human water uses. Human uses include drinking water, crop irrigation, animal watering, and recreation uses such as fishing, boating, swimming and aesthetic value. The current (most recent) standards, objectives and guidelines are summarized in **Table 3.2.3.1: Water Quality Standards, Objectives and Guidelines**.

The OMOE published a document in 1994 stipulating updated Provincial Water Quality Objectives (PWQO). The document indicates that “PWQO are established when a defined minimum information base representing the following effects is available: aquatic toxicity; bioaccumulation; and mutagenicity. The final PWQO is based on the lowest effect concentration reported for any of the above endpoints with an added safety factor.” The PWQO provide general guidelines for sustenance of healthy aquatic life.

The OMOE published standards for drinking water, referred to as the Ontario Drinking Water Standards (ODWS), in 2003. For some parameters, these standards differ from the PWQO levels. For example, the PWQO for copper is 5 µg/L because copper can have serious effects on aquatic life at that level.

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[31] Great Lakes Commission website. www.glc.org

[32] Ministry of the Environment, Ministry of Natural Resources, Ministry of Agriculture and Food, Upper Thames River Conservation Authority, City of Stratford, Lands Directorate Environment Canada. 1984. Stratford-Avon River Environmental Management Project, Final Report.

[33] OMOE and Ontario Ministry of Natural Resources. 1975. Thames River Basin Water Management Study.

However, the ODWS is 1 mg/L (1,000 µg/L) because drinking water standards do not consider copper to be of concern until they reach 1 mg/L and affect the aesthetic taste of the drinking water.

The Canadian Council of Ministries of the Environment (CCME) published the Canadian Environmental Quality Guidelines (CEQG) in 1996 (updated in 2006) which provides guidelines for the protection of aquatic life.

Table 3.2.3-1: Water Quality Standards, Objectives and Guidelines provides a summary of values for the seven of the eight water quality parameters that will be considered in the Watershed Description Report. There are no established standards for the eighth parameter, suspended solids. However, turbid water is undesirable for water supplies, healthy aquatic life, recreation and aesthetics. Suspended solids can also transport significant quantities of trace contaminants.

Table 3.2.3-1: Water Quality Standards, Objectives and Guidelines

Parameter	Aquatic Life		Drinking Water	
Phosphorus	0.03 mg/L (IPWQO) to avoid excessive plant growth in rivers and streams	OMOE[34]	–	–
Nitrate	2.93 mg/L*	*	10 mg/L (MAC)	OMOE[35]
Chloride	210 mg/L	EC[36]	250 mg/L (AO)	OMOE[35]
Escherichia coli	100 counts/100 mL** Based on a geometric mean*** of at least 5 samples per site	MOH[37]	Not detectable (MAC)	OMOE[35]
Copper	5 µg/L	OMOE[34]	1000 µg/L (AO)	OMOE[35]
Zinc	20 µg/L	OMOE[34]	5000 µg/L (AO)	OMOE[35]
Lead	5 µg/L	OMOE[34]	10 µg/L (MAC)	OMOE[35]

IPWQO = Interim Provincial Water Quality Objective, AO=Aesthetic Objective
MAC = Maximum Acceptable Concentration
* To obtain a guideline for nitrate in the same units as the PWQMN nitrate data, the CCME[38] guideline was converted of 13 mg/L $NO_3^{-}\cdot L^{-1}$ by dividing it by 4.43 to get 2.93 mg/L $NO_3^{-}\text{-N}\cdot L^{-1}$.
** Recreational Water Use
*** Geometric mean is the nth root of the product of n numbers

Current guidelines provide a benchmark for interpreting surface water data. However, until guidelines or recommendations for source protection have been developed, it is difficult to assess the state of surface water as it relates specifically to source protection.

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[34] OMOE. 1994. Water Management: Policies, Guidelines, Provincial Water Quality Objectives. www.ene.gov.on.ca/envision/gp/3303e.pdf.

[35] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

[36] Environment Canada. 2001. Existing Substances Evaluation: Assessment Report - Road Salts. www.ec.gc.ca/substances/ese/eng/psap/final/roadsalts.cfm.

[37] Ministry of Health. 1992. Recreational Water Quality Guideline. www.ene.gov.on.ca/envision/gp/3303e.htm#Tab2.

[38] Canadian Council of Ministers of the Environment. 1999, updated 2006. Canadian Environmental Quality Guidelines. www.ccme.ca/assets/pdf/e1_o62.pdf.

Special Cases

Certain ‘special’ cases are described here in order to better understand the underlying conditions of monitoring for various forms of a parameter, or changes in laboratory analysis methods that may affect results. The grouping of station data to facilitate analysis is also described here.

(A) Parameters

(1) Phosphorus

The IPWQO for streams and smaller rivers is 0.03 mg/L and is used in **Section 3.2: Raw Water Characterization for Inland Surface Water** when evaluating the local streams and rivers. The Interim Provincial Water Quality Objective for phosphorus in lakes recommends that the average total phosphorus concentration for the ice-free period should not exceed 0.02 mg/L to avoid nuisance concentrations of algae. This level has been used in Section 3.4 to evaluate water quality for sources using the Great Lakes and the Lake St. Clair.

(2) Nitrates

From 1997 to 2001, there is no nitrate data due to lack of monitoring in this period. This is explained in greater detail in the section on data gaps.

The methods of analysis for nitrates by OMOE have changed over the past 40 years as follows:

- Filtered Reactive Nitrate from 1965 to 1984,
- Unfiltered Reactive Nitrate from 1984 to 1996,
- Total Unfiltered Reactive Nitrates from 2002 to 2004.

From the mid 1980s, the OMOE laboratory stopped filtering samples and analyzed supernatant (top liquid) from samples that had been allowed to settle. They found no significant difference between filtered and unfiltered samples[39]. In 2002, the analysis was switched to total unfiltered nitrates, which is the sum of nitrites and nitrates. Nitrites are considered to contribute negligibly to the total nitrate values.

Nitrate data collected from different analysis method periods were pooled together for analyses. Limitations include the possible influence of analysis method changes on nitrate values.

In this report, the CCME guideline for nitrates has been converted from units of mg $NO_3^-\cdot L^{-1}$to units of mg $NO_3^-\text{-}N\cdot L^{-1}$ in order to compare with the PWQMN nitrate data which have mg $NO_3^-\text{-}N\cdot L^{-1}$ units. The limitation in doing this is that PWQMN data is not compared with the actual CCME guideline, but the advantage is that the PWQMN data is presented in the original form and not converted.

(3) Heavy Metals

Analysis of low levels of metals is difficult and reporting methods have changed over the years. The current analytical instrument used to quantify metals is inductively coupled plasma atomic emission spectroscopy (ICP-AES) using ultrasonic nebulization. The method detection limits (MDL) for lead, copper and zinc are 10, 1.6 and 0.6 µg/L, respectively.

Since the method detection limit for lead is so high, low concentration lead values are considered to be of ‘poor quality,’ At present, values reported are exactly as read by the instrument with a precision factored in. To determine the precision, the analyzing laboratory runs a number of tests for metals in surface water. The mean and the 95% confidence intervals of the results from these tests are calculated. The confidence intervals are reported as a precision (+/-). The precision for lead measurements in surface water is typically +/- 11 µg/L which is a high value and is above the MDL of 10 µg/L. Thus, due to the

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[39] Crowther, J., and S. Brencis. 1983. The Effect of Filtration Pretreatment on Automated Analyses for Soluble Nutrients. MOE Laboratory Services Report.

imprecision of the measurements, water containing low concentrations of lead can result in negative values being reported. Historically, these negative results might have been reported as the MDL, thus possibly over-estimating the lead value.

More than half of the lead values from recent testing (2002 to 2004) were reported to be negative. As recommended by the Conservation Ontario February 2003 report 'Water Sampling and Data Analysis Manual' for PWQMN partners, lead data was not graphed. Instead, the number and percent of samples above the relevant lead guidelines are provided.

Graphs were made for zinc and copper since the lower method detection levels for these metals reduce the problem. However, some negative values can still be reported.

It should also be noted that a considerably higher number of samples were monitored for lead throughout the historic monitoring period at the LTVCA station of Thames River at Jacob Road. The highest number of samples was 416 in the 1980-84 time block.

(4) Bacteria

Historically, fecal coliform, a type of bacteria, was monitored as an indicator of pathogens present in human and animal (domestic and wildlife) waste. OMOE changed this indicator in 1994 to *Escherichia coli* (*E. coli*), a type of fecal coliform bacteria. Since the data is comparable[40], the data can be pooled together to form longer time series to look for historic changes.

In 1996, fecal coliform testing was eliminated from the Provincial Water Quality Monitoring Network. In the LTVCA watershed, there is no PWQMN data from 1996 onwards for coliform bacteria. Hence, there is no analysis of 'Bacteria Current Conditions' for the LTVCA watersheds at PWQMN stations.

For the UTRCA watershed, there is *E. coli* data from Health Units for the years 2002 to 2004. All three time periods of bacterial information (before 1994, 1994-1996, and 2002-2004) are used to graph the historic changes percentile line graphs for the UTRCA watersheds.

(B) Sampling

(1) Bias

The majority of the samples are collected during the ice-free seasons and most sampling has occurred only eight times per year at any monitoring station. Consequently, there will be a bias toward dry weather sampling.

(2) Number of Samples

For the time block 2000-2004, seven of the eight stations monitored in the LTVCA watershed have only four to five samples per parameter. It is not possible to derive meaningful statistics from small sample sizes[41]. Hence, the current conditions of the LTVCA watershed at the seven stations with four to five samples are presented in this report as graphs depicting average, minimum and maximum values per parameter.

Only the Thames at Jacob Road station has above 50 samples per parameter for 2000-2004. The data for the Thames at Jacob Road station is presented with the box plots for UTRCA stations. Historic changes are plotted for the LTVCA stations but only the Thames at Jacob Road has a data point for the 2000-2004 time block.

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[40] Palmer, Merv, and D.W. Draper. March 1991. Support Document for Recreational Water Quality Objectives. BEAK Consultants Limited and Environmental Consulting. BEAK Reference: 4233.1.

For statistical analysis, sample sizes of at least 30 are preferred, according to the Conservation Ontario February 2003 report ‘Water Sampling and Data Analysis Manual’ for PWQMN partners. However, this many samples have not been collected in a single year at most stations.

To help with the analysis of historic changes, the data has been pooled in five-year blocks. These larger temporal blocks provide significant sample size to cover the range of flow that occurs in the watershed. At certain stations, there can still be time blocks that have low sample sizes when the sample started or was interrupted. The sample sizes for the analysis of active stations are listed in **Table 3.2.3-2a** to **Table 3.2.3-2c: Sample Size in the UTRCA Watershed**, and **Table 3.2.3-3a** to **Table 3.2.3-3c: Sample Size in the LTVCA Watershed**.

Table 3.2.3-2a: **Sample Size in the UTRCA Watershed**

Parameter	Station															
	Thames Mitchell	n	Avon River	n	Thames Thamesford	n	Thames Innerkip	n	Thames Tavistock	n	Reynolds Creek	n	Cedar Creek	n	Dingman Creek	n
Phosphorus	1975-79	52	1967-69	31	1975-79	51	1967-69	36	1976-79	34	1979	8	1965-69	51	1972-74	33
	1980-84	56	1970-74	58	1980-84	56	1970-74	61	1980-84	54	1980-84	58	1970-74	60	1975-79	56
	1985-89	55	1975-79	42	1985-89	55	1975-79	57	1985-89	57	1985-89	57	1982-84	36	1980-84	59
	1990-94	55	1980-84	59	1990-94	51	1980-84	55	1990-94	52	1990-94	53	1985-89	56	1985-89	58
	1995-99	31	1985-89	57	1995-99	30	1985-89	59	1995-99	30	1995-96	12	1990-94	54	1990-94	53
	2000-04	43	1990-94	55	2000-04	40	1990-94	54	2000-02	27	2003-04	8	1995-96	12	1995-99	32
			1995-99	32			1995	11					2002-04	23	2000-04	43
			2000-04	44			2002-04	18								
Nitrates	1975-79	52	1967-69	31	1975-79	51	1967-69	36	1976-79	34	1979	8	1965-69	51	1972-74	33
	1980-84	56	1970-74	58	1980-84	56	1970-74	61	1980-84	54	1980-84	58	1970-74	59	1975-79	55
	1985-89	55	1975-79	42	1985-89	55	1975-79	57	1985-89	57	1985-89	57	1982-84	36	1980-84	59
	1990-94	55	1980-84	59	1990-94	51	1980-84	55	1990-94	52	1990-94	53	1985-89	57	1985-89	58
	1995-99	32	1985-89	57	1995-99	30	1985-89	59	1995-99	30	1995-96	13	1990-94	54	1990-94	53
	2000-04	42	1990-94	55	2000-04	40	1990-94	54	2000-02	27	2003-04	8	1995-96	13	1995-99	33
			1995-99	33			1995	11					2002-04	23	2000-04	43
			2000-04	44			2002-04	17								
Copper	1983-84	22	1976-79	33	1983-84	23	2002-04	17	1998-99	19	2003-04	8	2003-04	16	1983-84	23
	1985-89	52	1980-84	56	1985-89	54			2000-02	25					1985-89	56
	1990-94	55	1985-89	56	1990-94	53									1990-94	54
	1995-99	30	1990-94	55	1995-99	29									1995-99	32
	2000-04	42	1995-99	32	2000-04	39									2000-04	42
			2000-04	43												

Parameter	Station															
	Thames Mitchell	**n**	**Avon River**	**n**	**Thames Thamesford**	**n**	**Thames Innerkip**	**n**	**Thames Tavistock**	**n**	**Reynolds Creek**	**n**	**Cedar Creek**	**n**	**Dingman Creek**	**n**
Zinc	1983-84	22	1976-79	34	1983-84	23	2002-04	17	1998-99	19	2003-04	8	2003-04	16	1983-84	23
	1985-89	52	1980-84	56	1985-89	54			2000-02	25					1985-89	56
	1990-94	55	1985-89	56	1990-94	53									1990-94	54
	1995-99	29	1990-94	55	1995-99	29									1995-99	32
	2000-04	42	1995-99	32	2000-04	39									2000-04	42
			2000-04	43												
Lead	1983-84	22	1980-84	45	1983-84	23	2002-04	17	1998-99	19	2003-04	8	2003-04	16	1983-84	23
	1985-89	52	1985-89	56	1985-89	54			2000-02	25					1985-89	56
	1990-94	55	1990-94	55	1990-94	53									1990-94	54
	1995-99	30	1995-99	32	1995-99	29									1995-99	32
	2000-04	42	2000-04	43	2000-04	39									2000-04	42
Suspended Solids	1978-79	22	1967-69	31	1977-79	23	1967-69	38	1976-79	35	1979	8	1964-69	55	1976-79	24
	1980-84	55	1970-72	26	1980-84	56	1970-72	31	1980-84	53	1980-84	58	1970-72	29	1982-84	59
	1985-89	55	1976-79	39	1985-89	55	1978-79	23	1985-89	57	1985-89	57	1982-84	36	1985-89	58
	1990-94	55	1980-84	59	1990-94	51	1980-84	55	1990-94	52	1990-94	53	1985-89	57	1990-94	53
	1995-99	32	1985-89	56	1995-99	30	1985-89	58	1995-99	31	1995-96	13	1990-94	54	1995-99	33
	2000-04	43	1990-94	54	2000-04	40	1990-94	54	2000-02	27	2003-04	8	1995-96	13	2000-04	43
			1995-99	33			1995	11					2002-04	23		
			2000-04	44			2002-04	18								

Parameter	Station															
	Thames Mitchell	n	Avon River	n	Thames Thamesford	n	Thames Innerkip	n	Thames Tavistock	n	Reynolds Creek	n	Cedar Creek	n	Dingman Creek	n
Chloride	1975-79	52	1967-69	29	1975-79	51	1967-69	38	1976-79	34	1979	8	1965-69	53	1972-74	28
	1980-84	56	1970-74	54	1980-84	56	1970-74	55	1980-84	54	1980-84	58	1970-74	55	1975-79	55
	1985-89	55	1975-79	41	1985-89	55	1975-79	57	1985-89	57	1985-89	56	1982-84	36	1980-84	59
	1990-94	55	1980-84	58	1990-94	51	1980-84	55	1990-94	52	1990-94	53	1985-89	57	1985-89	58
	1995-99	32	1985-89	57	1995-99	30	1985-89	59	1995-99	31	1995-96	13	1990-94	54	1990-94	53
	2000-04	43	1990-94	55	2000-04	40	1990-94	54	2000-02	27	2003-04	8	1995-96	13	1995-99	33
			1995-99	33			1995	11					2002-04	23	2000-04	42
			2000-04	44			2002-04	18								
Bacteria	1975-79	52	1972-74	32	1975-79	51	1972-74	32	1976-79	34	1979	7	1972-74	32	1972-74	33
	1980-84	53	1975-79	42	1980-84	53	1975-79	55	1980-84	50	1980-84	52	1982-84	33	1975-79	54
	1985-89	52	1980-84	56	1985-89	53	1980-84	52	1985-89	53	1985-89	54	1985-89	55	1980-84	56
	1990-94	54	1985-89	54	1990-94	52	1985-89	54	1990-94	52	1990-94	53	1990-94	53	1985-89	54
	1995	11	1990-94	55	1995-99	11	1990-94	52	1995-96	12	1995-96	13	1995-96	12	1990-94	47
	2002-04	19	1995-96	12	2000-04	19	1995	11			2003-04	8	2002-04	19	1995	11
			2002-04	20			2002-04	13							2002-04	20

Table 3.2.3-2b: Sample Size in the UTRCA Watershed

Parameter	Station													
	Thames Dorchester	**n**	**Dorchester Swamp Creek**	**n**	**Thames Byron**	**n**	**Thames Clarke**	**n**	**Thames Komoka**	**n**	**Pottersburg Creek**	**n**	**Thames Woodstock**	**n**
Phosphorus	1978	36	1976-77	19	1978-79	76	1972-74	35	1975-79	52	1993-94	16	1965-69	50
	1980-84	178	1983-84	22	1980-84	187	1975-79	58	1980-84	60	1995-99	49	1970-74	61
	1985-89	162	1985-89	58	1985-89	191	1980-84	59	1985-89	57	2000-04	47	1975-79	56
	1990-94	154	1990-94	52	1990-94	182	1985-89	58	1990-94	52			1980-84	59
	1995-99	184	1995-99	31	1995-99	209	1990-94	52	1995-96	12			1985-89	57
	2000-04	171	2000-02	28	2000-04	199	1995-99	31	2002-04	24			1990-94	54
							2000-03	29					1995-96	12
													2003-04	16
Nitrates	1998-99	71	1976-77	19	1998-99	73	1972-74	35	1975-79	50	2000-04	21	1965-69	49
	2000-04	170	1983-84	22	2000-04	192	1975-79	58	1980-84	60			1970-74	60
			1985-89	58			1980-84	59	1985-89	58			1975-79	56
			1990-94	53			1985-89	58	1990-94	52			1980-84	59
			1995-99	33			1990-94	52	1995-96	13			1985-89	56
			2000-02	28			1995-99	32	2002-04	24			1990-94	54
							2000-03	28					1995-96	13
													2003-04	16

Parameter	Station													
	Thames Dorchester	**n**	**Dorchester Swamp Creek**	**n**	**Thames Byron**	**n**	**Thames Clarke**	**n**	**Thames Komoka**	**n**	**Pottersburg Creek**	**n**	**Thames Woodstock**	**n**
Copper			1983-84	20			1998-99	20	1980-84	47			1983-84	22
			1985-89	53			2000-03	27	1985-89	55			1985-89	57
			1990-94	53					1990-94	51			1990-94	55
			1995-99	32					1995-96	12			1995-96	12
			2000-02	27					2002-04	23			2003-04	16
Zinc			1983-84	20			1998-99	20	1980-84	46			1983-84	22
			1985-89	53			2000-03	27	1985-89	55			1985-89	57
			1990-94	53					1990-94	52			1990-94	54
			1995-99	32					1995-96	12			1995-96	12
			2000-02	27					2002-04	23			2003-04	16
Lead			1983-84	20			1998-99	20	1980-84	47			1983-84	22
			1985-89	53			2000-03	27	1985-89	55			1985-89	57
			1990-94	53					1990-94	52			1990-94	55
			1995-99	32					1995-96	12			1995-96	12
			2000-02	27					2002-04	23			2003-04	16

Parameter	Station													
	Thames Dorchester	**n**	**Dorchester Swamp Creek**	**n**	**Thames Byron**	**n**	**Thames Clarke**	**n**	**Thames Komoka**	**n**	**Pottersburg Creek**	**n**	**Thames Woodstock**	**n**
Suspended Solids	1993-94	39	1976-77	20	1993-94	43	1978-79	23	1975-79	51	1993-94	14	1964-69	54
	1995-99	192	1983-84	22	1995-99	214	1980-84	28	1980-84	60	1995-99	51	1970-72	30
	2000-04	175	1985-89	58	2000-04	203	1985-89	58	1985-89	58	2000-04	49	1976-79	46
			1990-94	53			1990-94	52	1990-94	52			1980-84	59
			1995-99	33			1995-99	33	1995-96	13			1985-89	57
			2000-02	28			2000-03	29	2002-04	24			1990-94	54
													1995-96	13
													2002-04	16
Chloride			1976-77	19			1972-74	31	1975-79	51			1965-69	53
			1983-84	22			1975-79	58	1980-84	59			1970-74	56
			1985-89	58			1980-84	59	1985-89	58			1975-79	55
			1990-94	53			1985-89	58	1990-94	52			1980-84	59
			1995-99	33			1990-94	52	1995-96	13			1985-89	57
			2000-02	28			1995-99	32	2002-04	24			1990-94	54
							2000-03	29					1995-96	13
													2003-04	16

Parameter	Station													
	Thames Dorchester	n	Dorchester Swamp Creek	n	Thames Byron	n	Thames Clarke	n	Thames Komoka	n	Pottersburg Creek	n	Thames Woodstock	n
Bacteria	1978	36	1976-77	20	1978-79	77	1972-74	34	1975-79	49	1993-94	15	1972-74	32
	1980-84	166	1983-84	18	1980-84	160	1975-79	58	1980-84	54	1995-99	45	1975-79	56
	1985-89	141	1985-89	55	1985-89	165	1980-84	56	1985-89	54	2000-04	49	1980-84	55
	1990-94	138	1990-94	54	1990-94	136	1985-89	57	1990-94	52			1985-89	54
	1995-99	179	1995-96	12	1995-99	196	1990-94	52	1995-96	13			1990-94	53
	2000-04	175			2000-04	203	1995-96	13	2002-04	20			1995-96	12
													2003-04	17

Table 3.2.3-2c: Sample Size in the UTRCA Watershed

Parameter	Station													
	Thames d/s Ingersoll	n	Thames Thorndale	n	Thames Medway	n	Foldens Creek	n	Trout Creek d/s	n	Trout Creek u/s	n	Fish Creek	n
Phosphorus	1975-79	53	1975-79	53	1978-79	18	1981-84	47	1979	10	1979	9	2003-04	8
	1980-84	56	1980-84	58	1980-84	44	1985-89	58	1980-84	59	1980-84	57		
	1985-89	57	1985-89	57	1985-89	35	1990-94	54	1985-89	58	1985-89	58		
	1990-94	54	1990-94	50	1990-94	48	1995-99	33	1990-94	53	1990-94	54		
	1995	11	1995-96	11	1995-99	50	2000-02	28	1995-99	32	1995-99	31		
	2003-04	9	2003-04	9	2000-04	44			2000-04	44	2000-04	36		
Nitrates	1975-79	52	1975-79	53	2000-04	21	1981-84	47	1979	10	1979	9	2003-04	8
	1980-84	56	1980-84	58			1985-89	58	1980-84	59	1980-84	57		
	1985-89	57	1985-89	57			1990-94	54	1985-89	58	1985-89	58		
	1990-94	54	1990-94	50			1995-99	34	1990-94	53	1990-94	54		
	1995-96	12	1995-96	11			2000-02	28	1995-99	33	1995-99	32		
	2003-04	9	2003-04	9					2000-04	44	2000-04	36		
Copper	1975-79	45	2003-04	9			1998-99	21	1998-99	20	1998-99	19	2003-04	8
	1980-84	53					2000-02	27	2000-04	43	2000-04	35		
	1985-89	56												
	1990-94	54												
	1995-96	12												
	2003-04	9												

Parameter	Station													
	Thames d/s Ingersoll	**n**	**Thames Thorndale**	**n**	**Thames Medway**	**n**	**Foldens Creek**	**n**	**Trout Creek d/s**	**n**	**Trout Creek u/s**	**n**	**Fish Creek**	**n**
Zinc	1975-79	45	2003-04	9			1998-99	21	1998-99	20	1998-99	19	2003-04	8
	1980-84	53					2000-02	27	2000-04	43	2000-04	35		
	1985-89	56												
	1990-94	54												
	1995-96	12												
	2003-04	9												
Lead	1981-84	36	2003-04	9			1998-99	21	1998-99	20	1998-99	21	2003-04	8
	1985-89	56					2000-02	27	2000-04	43	2000-04	26		
	1990-94	54												
	1995-96	12												
	2003-04	9												
Suspended Solids	1975-79	53	1978-79	24	1993-94	13	1981-84	47	1979	10	1975-79	9	2003-04	8
	1980-84	56	1980-84	57	1995-99	51	1985-89	58	1980-84	59	1980-84	57		
	1985-89	57	1985-89	57	2000-04	47	1990-94	54	1985-89	58	1985-89	58		
	1990-94	54	1990-94	50			1995-99	34	1990-94	53	1990-94	54		
	1995	12	1995-96	12			2000-02	28	1995-99	33	1995-99	32		
	2003-04	9	2003-04	9					2000-04	43	2000-04	36		

Parameter	Station													
	Thames d/s Ingersoll	**n**	**Thames Thorndale**	**n**	**Thames Medway**	**n**	**Foldens Creek**	**n**	**Trout Creek d/s**	**n**	**Trout Creek u/s**	**n**	**Fish Creek**	**n**
Chloride	1975-79	51	1975-79	53			1981-84	47	1979	10	1975-79	9	2003-04	8
	1980-84	57	1980-84	58			1985-89	57	1980-84	59	1980-84	57		
	1985-89	57	1985-89	57			1990-94	54	1985-89	58	1985-89	58		
	1990-94	53	1990-94	50			1995-99	34	1990-94	53	1990-94	54		
	1995	12	1995-96	11			2000-02	28	1995-99	33	1995-99	32		
	2003-04	9	2003-04	9					2000-04	44	2000-04	36		
Bacteria	1975-79	53	1975-79	52	1978-79	19	1981-84	44	1979	10	1979	9	2003-04	7
	1980-84	56	1980-84	55	1980-84	47	1985-89	53	1980-84	56	1980-84	53		
	1985-89	53	1985-89	55	1985-89	29	1990-94	52	1985-89	56	1985-89	55		
	1990-94	53	1990-94	50	1990-94	45	1995-96	12	1990-94	53	1990-94	54		
	1995-96	12	1995-96	12	1995-99	43			1995-96	13	1995-96	13		
	2003-04	9	2003-04	8	2000-04	47			2002-04	19	2002-04	12		

Note: The rest of the stations Black Creek, Otter Creek, Fish Creek, Gregory Creek, Wye Creek, Stoney Creek, Waubuno Creek, Oxbow Creek and Komoka Creek have sample sizes (n) of 8 for all parameters for only 2003-2004.

Table 3.2.3-3a: Sample Size in the LTVCA Thames River and Lake St. Clair Subwatershed

Parameter	Station															
	Sharon Creek	**n**	**Turkey Creek**	**n**	**Newbiggen Creek**	**n**	**Simpson Rd Thames**	**n**	**Graham Rd Thames**	**n**	**Kent Bridge Thames**	**n**	**McGregor Creek**	**n**	**Lock Drain**	**n**
Phosphorus	1979	10	1977-79	16	1965-69	48	1983-84	21	1973-74	15	1976-79	35	1975-79	50	1972-74	21
	1980-84	55	1980-84	49	1970-74	52	1985-89	50	1975-79	49	1980-84	52	1980-84	53	1975-75	4
	1985-89	52	1985-89	36	1975-75	5	1990-94	50	1980-82	30	1985-89	52	1985-89	55	1981-84	40
	1990-94	51	1990-94	43	1981-84	39	1995-96	10			1990-94	51	1990-94	53	1985-89	42
	1995-96	14	1995-96	13	1985-89	41					1995-96	11	1995-96	15	1990-94	46
					1990-94	40					2002-04	5			1995-96	14
					1995-96	9										
					2003-04	4										
Nitrates	1979	10	1977-79	16	1965-69	45	1983-84	21	1973-74	15	1976-79	35	1975-79	50	1972-74	21
	1980-84	55	1980-84	47	1970-74	52	1985-89	50	1975-79	49	1980-84	52	1980-84	53	1975-75	4
	1985-89	52	1985-89	37	1975-75	5	1990-94	50	1980-82	30	1985-89	52	1985-89	55	1981-84	40
	1990-94	51	1990-94	43	1981-84	39	1995-96	13			1990-94	51	1990-94	51	1985-89	43
	1995-96	14	1995-96	13	1985-89	40					1995-96	12	1995-96	15	1990-94	46
					1990-94	41					2002-04	5			1995-96	14
					1995-96	9										
					2003-04	4										

Parameter	Station															
	Sharon Creek	**n**	**Turkey Creek**	**n**	**Newbiggen Creek**	**n**	**Simpson Rd Thames**	**n**	**Graham Rd Thames**	**n**	**Kent Bridge Thames**	**n**	**McGregor Creek**	**n**	**Lock Drain**	**n**
Copper					1983-84	17					1983-84	21	1983-84	20	1983-84	16
					1985-89	40					1985-89	51	1985-89	51	1985-89	41
					1990-94	39					1990-94	51	1990-94	54	1990-94	48
					1995-96	9					1995-96	11	1995-96	13	1995-96	13
					2003-04	4					2002-04	5				
Zinc					1983-84	17					1983-84	21	1983-84	20	1983-84	16
					1985-89	40					1985-89	52	1985-89	51	1985-89	41
					1990-94	39					1990-94	51	1990-94	54	1990-94	48
					1995-96	9					1995-96	11	1995-96	13	1995-96	13
					2003-04	4					2002-04	5				
Lead					1983-84	17					1983-84	21	1983-84	20	1983-84	16
					1985-89	40					1985-89	52	1985-89	51	1985-89	41
					1990-94	39					1990-94	51	1990-94	54	1990-94	48
					1995-96	9					1995-96	11	1995-96	13	1995-96	13
					2003-04	4					2002-04	5				

Parameter	Station															
	Sharon Creek	n	Turkey Creek	n	Newbiggen Creek	n	Simpson Rd Thames	n	Graham Rd Thames	n	Kent Bridge Thames	n	McGregor Creek	n	Lock Drain	n
Suspended Solids	1979	10	1977-79	16	1965-69	50	1983-84	21	1973-74	15	1976-79	35	1978-79	20	1972-74	21
	1980-84	55	1980-84	49	1970-72	23	1985-89	49	1975-79	49	1980-84	52	1980-84	53	1975-75	4
	1985-89	51	1985-89	37	1975-75	3	1990-94	45	1980-82	30	1985-89	52	1985-89	54	1981-84	40
	1990-94	50	1990-94	42	1981-84	39	1995-96	12			1990-94	49	1990-94	50	1985-89	43
	1995-96	14	1995-96	13	1985-89	41					1995-96	12	1995-96	15	1990-94	42
					1990-94	39					2002-04	5			1995-96	13
					1995-96	9										
					2003-04	4										
Chloride	1979	10	1977-79	16	1965-69	50	1983-84	21	1973-74	15	1976-79	34	1975-79	50	1972-74	21
	1980-84	55	1980-84	49	1970-72	50	1985-89	49	1975-79	49	1980-84	52	1980-84	53	1975-75	4
	1985-89	52	1985-89	37	1975-75	5	1990-94	51	1980-82	30	1985-89	52	1985-89	55	1981-84	40
	1990-94	51	1990-94	43	1981-84	39	1995-96	13			1990-94	50	1990-94	49	1985-89	43
	1995-96	14	1995-96	13	1985-89	41					1995-96	12	1995-96	15	1990-94	47
					1990-94	41					2002-04	5			1995-96	14
					1995-96	6										
					2003-04	4										

Parameter	Station															
	Sharon Creek	**n**	**Turkey Creek**	**n**	**Newbiggen Creek**	**n**	**Simpson Rd Thames**	**n**	**Graham Rd Thames**	**n**	**Kent Bridge Thames**	**n**	**McGregor Creek**	**n**	**Lock Drain**	**n**
Bacteria	1979	9	1977-79	13	1972-74	31	1983-84	29	1973-74	14	1976-79	34	1975-79	48	4972-75	21
	1980-84	51	1980-84	45	1975-75	5	1985-89	36	1975-79	47	1980-84	49	1980-84	49	1975-75	4
	1985-89	51	1985-89	35	1981-84	36	1990-94	49	1980-82	28	1985-89	50	1985-89	51	1981-84	35
	1990-94	48	1990-94	39	1985-86	18	1995-96	11			1990-94	47	1990-94	46	1985-89	41
	1995-96	11	1995-96	9							1995-96	10	1995-96	13	1990-94	41
															1995-96	12

Table 3.2.3-3b: Sample Size in the LTVCA Thames River and Lake St. Clair Subwatershed

Parameter	Station													
	Kiel Dr Thames	n	Riverview Dr Thames	n	Jacob Rd Thames	n	Baptiste Creek	n	Tilbury Creek	n	Big Creek	n	Lake St. Clair Thames	n
Phosphorus	1965-69	122	1975-79	53	1966-69	89	1965-69	56	1965-69	57	1974-74	18	1964-64	6
	1970-74	82			1970-74	85	1970-71	26	1970-74	58	1975-79	815	1965-69	142
	1975	5			1975-79	17			1975-79	106	1980-84	54	1970-71	38
					1980-84	467			1980-84	106	1985-89	53		
					1985-89	222			1985-89	110	1990-94	54		
					1990-94	192			1990-94	110	1995-96	13		
					1995-99	143			1995-96	29	2003-04	4		
					2000-04	57								
Nitrates	1965-69	104	1975-79	49	1966-69	88	1966-69	50	1965-69	53	1974-74	17	1964-64	4
	1970-74	82			1970-74	85	1970-71	26	1970-74	57	1975-79	402	1965-69	111
	1975	5			1975-79	17			1975-79	106	1980-84	54	1970-71	37
					1980-84	718			1980-84	106	1985-89	52		
					1985-89	224			1985-89	109	1990-94	54		
					1990-94	193			1990-94	109	1995-96	13		
					1995-99	145			1995-96	29	2003-04	4		
					2000-04	57								

Parameter	Station													
	Kiel Dr Thames	**n**	**Riverview Dr Thames**	**n**	**Jacob Rd Thames**	**n**	**Baptiste Creek**	**n**	**Tilbury Creek**	**n**	**Big Creek**	**n**	**Lake St. Clair Thames**	**n**
Copper	1971-74	32	1976-78	23	1979-79	9			1983-84	21	1974-74	8		
	1975	5			1980-84	408			1985-89	53	1975-77	150		
					1985-89	212			1990-94	54	2003-04	4		
					1990-94	191			1995-96	14				
					1995-99	145								
					2000-04	58								
Zinc	1970-74	37	1976-78	27	1980-84	24			1983-84	21	1974-74	8		
	1975	5			1985-89	54			1985-89	53	1975-77	150		
					1990-94	71			1990-94	54	2003-04	4		
					1995-99	145			1995-96	14				
					2000-04	58								
Lead			1976-78	27	1979-79	9			1983-84	21	1974-74	8		
					1980-84	415			1985-89	53	1975-77	150		
					1985-89	212			1990-94	54	2003-04	4		
					1990-94	188			1995-96	14				

Parameter	Station													
	Kiel Dr Thames	n	Riverview Dr Thames	n	Jacob Rd Thames	n	Baptiste Creek	n	Tilbury Creek	n	Big Creek	n	Lake St. Clair Thames	n
Suspended Solids	1964	8	1976-79	46	1966-69	94	1964-64	2	1964-69	61	1974-74	2	1964-64	6
	1965-69	130			1970-74	84	1965-69	59	1970-72	28	1975-79	416	1965-69	153
	1970-74	86			1975-79	17	1970-71	26	1978-79	39	1980-84	54	1970-71	38
	1975	5			1980-84	474			1980-84	106	1985-89	53		
					1985-89	223			1985-89	110	1990-94	54		
					1990-94	173			1990-94	107	1995-96	13		
					1995-99	141			1995-96	29	2003-04	4		
					2000-04	57								
Chloride	1965-69	124	1975-78	40	1966-69	92	1965-69	57	1964-69	58	1974-74	17	1964-64	2
	1970-74	80			1970-74	81	1970-71	26	1970-72	56	1975-79	365	1965-69	148
	1975	5			1975-75	5			1978-79	104	1980-84	54	1970-71	38
					1980-84	57			1980-84	106	1985-89	52		
					1985-89	56			1985-89	110	1990-94	53		
					1990-94	53			1990-94	110	1995-96	13		
					1995-99	143			1995-96	30	2003-04	4		
					2000-04	58								

Parameter	Station													
	Kiel Dr Thames	**n**	**Riverview Dr Thames**	**n**	**Jacob Rd Thames**	**n**	**Baptiste Creek**	**n**	**Tilbury Creek**	**n**	**Big Creek**	**n**	**Lake St. Clair Thames**	**n**
Bacteria	1972-74	33	1975-79	49	1972-74	34	1964-64	2	1972-74	33	1975-79	61		
	1975	5			1975-79	14	1965-69	59	1975-79	97	1980-84	50		
					1980-84	59	1970-71	24	1980-84	97	1985-89	46		
					1985-89	51			1985-86	41	1990-94	53		
					1990-94	46					1995-96	12		
					1995-96	13								

Table 3.2.3-3c: Sample Size in the LTVCA Lake Erie Subwatershed

Parameter	Station													
	Talbot Creek	**n**	**Dutton Drain**	**n**	**Brock Creek**	**n**	**Sixteen Mile Creek**	**n**	**Coleman Drain**	**n**	**Indian Creek**	**n**	**John Clark Drain**	**n**
Phosphorus	1965-69	57	1968-69	26	1968-69	27	1965-69	56	1983-84	29	1983-84	29	1983-84	29
	1970-74	56	1970-74	55	1970-74	58	1970-74	60	1985-89	49	1985-89	51	1985-89	48
	1975	5	1975-79	47	1975-75	5	1975-75	5	1990-94	44	1990-94	46	1990-94	42
			1980-84	50	1981-85	38	1981-85	40	1995-96	9	1995-96	8	1995-96	8
			1985-89	53	1986-89	51	1986-89	51						
			1990-94	43	1990-94	43	1990-94	42						
			1995-96	14	1995-96	14	1995-96	14						
			2002-04	5										
Nitrates	1966-69	48	1968-69	26	1968-69	27	1965-69	55	1983-84	29	1983-84	29	1983-84	29
	1970-74	55	1970-74	56	1970-74	58	1970-74	60	1985-89	48	1985-89	50	1985-89	47
	1975	5	1975-79	47	1975-75	5	1975-75	5	1990-94	44	1990-94	45	1990-94	42
			1980-84	50	1981-85	38	1981-85	40	1995-96	10	1995-96	9	1995-96	9
			1985-89	53	1986-89	50	1986-89	50						
			1990-94	43	1990-94	43	1990-94	41						
			1995-96	14	1995-96	14	1995-96	13						
			2002-04	5										

Parameter	**Station**													
	Talbot Creek	**n**	**Dutton Drain**	**n**	**Brock Creek**	**n**	**Sixteen Mile Creek**	**n**	**Coleman Drain**	**n**	**Indian Creek**	**n**	**John Clark Drain**	**n**
Copper			1983-84	22	1983-84	22	1983-84	22						
			1985-89	50	1985-89	50	1985-89	50						
			1990-94	42	1990-94	44	1990-94	43						
			1995-96	13	1995-96	13	1995-96	13						
			2002-04	5										
Zinc			1983-84	22	1983-84	22	1983-84	22						
			1985-89	50	1985-89	50	1985-89	50						
			1990-94	42	1990-94	44	1990-94	43						
			1995-96	13	1995-96	13	1995-96	13						
			2002-04	5										
Lead			1983-84	22	1983-84	22	1983-84	22						
			1985-89	50	1985-89	50	1985-89	50						
			1990-94	42	1990-94	44	1990-94	43						
			1995-96	13	1995-96	13	1995-96	13						
			2002-04	5										

Parameter	Station													
	Talbot Creek	n	Dutton Drain	n	Brock Creek	n	Sixteen Mile Creek	n	Coleman Drain	n	Indian Creek	n	John Clark Drain	n
Suspended Solids	1965-69	58	1968-69	26	1968-69	26	1965-69	57	1983-84	29	1983-84	29	1983-84	29
	1970-74	54	1970-74	55	1970-74	62	1970-74	59	1985-89	49	1985-89	50	1985-89	48
	1975	5	1975-79	47	1975-75	5	1975-75	5	1990-94	43	1990-94	45	1990-94	41
			1980-84	50	1981-85	38	1981-85	40	1995-96	11	1995-96	8	1995-96	9
			1985-89	53	1986-89	51	1986-89	51						
			1990-94	39	1990-94	41	1990-94	41						
			1995-96	14	1995-96	14	1995-96	14						
			2002-04	5										
Chloride	1965-69	59	1968-69	26	1968-69	27	1965-69	57	1983-84	21	1983-84	21	1983-84	21
	1970-74	52	1970-74	52	1970-74	55	1970-74	56	1985-89	49	1985-89	51	1985-89	48
	1975	5	1975-79	47	1975-75	5	1975-75	5	1990-94	43	1990-94	44	1990-94	41
			1980-84	50	1981-85	38	1981-85	40	1995-96	11	1995-96	10	1995-96	9
			1985-89	53	1986-89	51	1986-89	51						
			1990-94	43	1990-94	43	1990-94	42						
			1995-96	14	1995-96	14	1995-96	14						
			2002-04	5										

Parameter	**Station**													
	Talbot Creek	**n**	**Dutton Drain**	**n**	**Brock Creek**	**n**	**Sixteen Mile Creek**	**n**	**Coleman Drain**	**n**	**Indian Creek**	**n**	**John Clark Drain**	**n**
Bacteria	1972-74	31	1972-74	31	1972-74	34	1972-74	35	1983-84	25	1983-84	25	1983-84	25
	1975	5	1975-79	42	1975-75	5	1975-75	4	1985-89	46	1985-89	47	1985-89	46
			1980-84	45	1981-84	35	1981-85	37	1990-94	34	1990-94	41	1990-94	37
			1985-89	49	1985-89	47	1985-89	49	1995-96	9	1995-96	9	1995-96	9
			1990-94	40	1990-94	42	1990-94	38						
			1995-96	11	1995-96	11	1995-96	11						

(3) Sample Location

The locations of some stations have changed over the time. In cases where sites under the same name were very close and the data are comparable, the data are pooled together to increase the sample size and appropriately represent the full range of water quality conditions at the station.

3.2.4 Inland Water Quality Monitoring Results and Analysis

Water quality will be examined for both 'current conditions' and 'historic changes'. The key parameters considered include: total phosphorus, nitrates, suspended solids, chloride, coliform, copper, zinc and lead.

The location, description and years sampled for both the active and inactive PWQMN sites are listed in **Table 3.2.2-2: PWQMN and City of London Monitoring Stations in UTRCA** and **Table 3.2.2-3: PWQMN Monitoring Stations in LTVCA**.

For statistical analysis, data sets with at least 30 samples[41] are preferred. However, this many samples have not been collected at all the stations in the last five years. In the UTRCA watersheds, each station has eight to 203 samples per parameter.

In the LTVCA watersheds, most stations have only four to five samples per parameter for current conditions, with the exception of the Jacob Road station which has 57 to 59 samples per parameter. Most LTVCA stations have a larger number of samples prior to 1996 to allow statistical analysis of historic changes.

Information from the LTVCA stations with limited data will be presented in graphs depicting average, minimum and maximum values per parameter. Information from the other LTVCA and UTRCA stations will be analyzed using the following methods for 'current conditions' and 'historic conditions.'

Current Conditions

For the LTVCA watersheds, the analysis of 'Current Conditions' is based on the analysis of data collected within the period from 2000-2004 at one site (Thames River at Jacob Road) and from 2002 to 2004 at seven sites.

For the UTRCA watersheds, depending on the parameter, data sets from 24 to 28 stations are available to analyze 'current conditions'. At a few stations, all five years (2000 to 2004) data is available but at most, the data available was for 2003-2004.

Current conditions for all parameters except lead are visually represented by means of box and whisker plots that indicate the distribution and provide general statistical analysis. As discussed in special cases, lead data is presented in a table.

In addition to a box and whisker plot, the analysis of current conditions of fecal coliform bacteria is done by means of horizontal bar charts of geometric means at each station in order to compare to the relevant guidelines. Geometric mean is the n^{th} root of the product of n numbers and helps reduce bias due to high or low values[42].

Due to the limited current data for most LTVCA stations, current information from the LTVCA stations is presented in graphs depicting average, minimum and maximum values per parameter.

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[41] Conservation Ontario and OMOE. February 2003. Water Sampling and Data Analysis Manual.

[42] Buzzards Bay National Estuary Program website. www.buzzardsbay.org/geomean.htm.

Figure 3.2.4-1: Box and Whisker Plot depicts an example of how a set of data is plotted. The box ends represent the 25th and 75th percentiles (or lower and upper quartiles), the line in the box depicts the 50th percentile (median), the whiskers represent the 10th and 90th percentiles, and the dots represent the 5th and 95th percentiles. Explanations of these terms are given below.

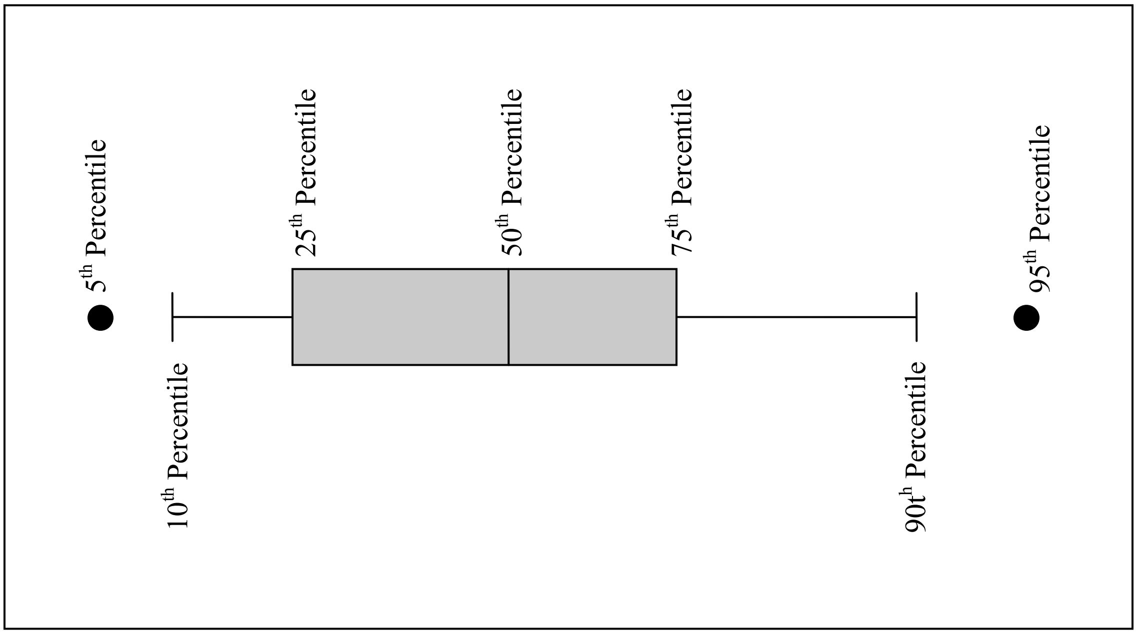

Figure 3.2.4-1: Box and Whisker Plot

When the data values are sorted in increasing order:
- 25th percentile ('lower quartile') is the value below which 25% of the values fall.
- 50th percentile ('median') is the value above which half of the values fall; it indicates the central tendency of the data set.
- 75th percentile ('upper quartile') is the value below which 75% of the values fall.

Other important points to note are:
- Values that lie between the 25th and 75th percentile, or the 'inter quartile range', are 50% of the total data set.
- The 10th and 90th percentile values (whiskers) are calculated to depict a large range of the data.
- Boxes without whiskers represent stations with eight samples or less and thus have too few data points to calculate the 10th and 90th percentile values to show the whiskers.
- The 5th and 95th percentiles dots typically indicate 'low' and 'high' values respectively. These values may also be considered as outliers in a data set depending on the underlying causes of such values.
- Boxes without 5th and 95th percentiles represent stations that have too few data points to calculate these percentiles.

Historic Changes

'Historic Changes' have been plotted as line-and-symbol graphs of the 75th percentile values only for each five-year time block for active and historic sites. The 75th percentiles are used to reflect pollutants more appropriately than by using average values and to reduce potential sampling bias. The graphs do not necessarily indicate long-term trends but do help compare past and current information. As discussed in special cases, lead data was not graphed but is presented in a table.

Analysis of historic changes is based on data from the sites for which there is historic information. Analysis for the watersheds spans from 20 to 40 years, depending on the information available for each station.

The information has been analyzed in five-year blocks. The goal in analyzing the data in larger temporal blocks was to obtain a significant sample size[43] to cover the range of flow and climactic conditions.

Some stations have different station numbers because their locations switched over the time or the stations had been monitored at different sites. In cases where sites under the same name were very close and the data are comparable, the data are pooled together to increase the sample size and appropriately represent the full range of water quality conditions at the station.

The LTVCA watershed has been delineated into two subwatersheds: (a) Thames River and Lake St. Clair and, (b) Lake Erie for the analysis on historic changes. This is to accommodate for the larger number of historic sites. Data for up to six sites on creeks draining into Lake Erie and up to 11 sites from the Thames River and Lake St. Clair area is considered. Since sample sizes at all LTVCA stations except Thames River at Jacob Road are small (only four or five samples) for the 2000-2004 time block, 75th percentile values for this time block are not presented except for Thames River at Jacob Road.

For the Upper Thames River Conservation Authority watersheds, data from up to 13 sites are used.

(1) Total Phosphorus

Fate and Behaviour: Phosphorus is generally the limiting nutrient in aquatic ecosystems. While phosphorus is an essential nutrient for plant and animal life, excess phosphorus levels can result in significant increases in unwanted plant growth. Phosphorus is not directly toxic to aquatic life but elevated concentrations can lead to excessive plant growth, resulting in undesirable changes including taste and odour problems in drinking water, reduced oxygen levels, reduced biodiversity, and toxic algae blooms.

Sources: Phosphorus sources include commercial fertilizers, animal waste, domestic and industrial wastewater, including soaps and cleaning products. Phosphorus binds to soil and is readily transported to streams with eroding soil.

Standards: Ontario has an Interim Provincial Water Quality Objective (IPWQO) of 30 µg/L or 0.03 mg/L of total phosphorus to prevent the nuisance growth of algae. There is no Ontario Drinking Water Standard.

(a) Current Conditions

With the exception of Komoka Creek, the 75th percentile levels of total phosphorus at all stations in the UTRCA and LTVCA watersheds are above the IPWQO of 0.03 mg/L.

UTRCA: Figure 3.2.4-2: Current Total Phosphorus Conditions in the Thames River Watershed shows the current total phosphorus conditions in the UTRCA. The highest current 75th percentile levels of phosphorus are at the following sites: Thames River at Mitchell, Thames River at Woodstock, and Thames River at Byron. The Wildwood Reservoir seems to act as a sediment and nutrient settling basin since phosphorus concentrations decrease from upstream (u/s) Trout Creek to downstream (d/s) Trout Creek. The lowest phosphorus level is at Komoka Creek which has a 75th percentile level of 0.029 mg/L. However, some samples at this location are still higher than the IPWQO of 0.03 mg/L.

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[43] Cooke, S. March 2006. Water Quality in the Grand River: A Summary of Current Conditions (2000-2004) and Long-term Trends. Grand River Conservation Authority.

LTVCA: In **Figure 3.2.4-2,** the box plot shows that the 75th percentile level at Thames River Jacob Road is above the PWQO. **Figure 3.2.4-3: Current Total Phosphorus Conditions in the LTVCA Watershed** shows that the average phosphorus levels at all stations are above the IPWQO of 0.03 mg/L and that the average phosphorus levels are three to six times the IPWQO. Newbiggen Creek has the highest average (0.18 mg/L), while the lowest average (0.091 mg/L) is at McGregor Creek. The highest maximum (0.99 mg/L) phosphorus level is at Thames River at Jacob Road.

(b) Historic Changes

The 75th percentile concentrations of total phosphorus at all stations in the UTRCA and LTVCA watersheds are higher than the IPWQO throughout the study period.

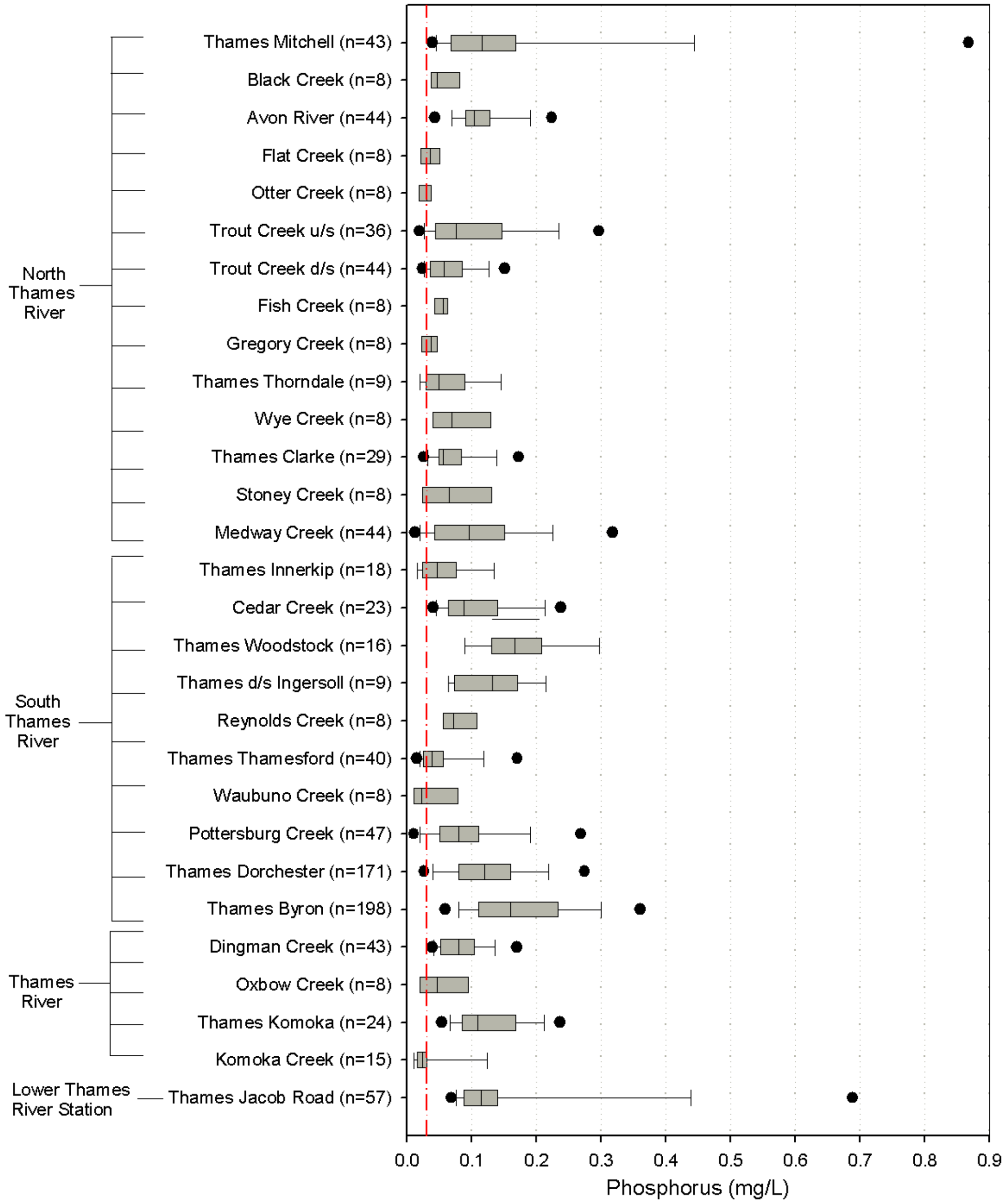
Figure 3.2.4-4: Historic Changes: Phosphorus 75th Percentiles in the UTRCA Watershed, **Figure 3.2.4-5: Historic Changes: Phosphorus 75th Percentiles in the LTVCA Thames River and Lake St. Clair**, and **Figure 3.2.4-6: Historic Changes: Phosphorus 75th Percentiles in the LTVCA Lake Erie Watershed** provide graphs of phosphorus levels over the past 40 years.

UTRCA: In general**, t**he historic values range between two and eight times the IPWQO at all the stations. In 1965-1969, the Avon River and Thames River at Woodstock had very high concentrations that were 40 to 80 times the IPWQO and had significant decreases in 75th percentile levels by 1975-1979. Since the late 1970s, the 75th percentile phosphorus levels at all stations have been below 0.25 mg/L.

LTVCA - Thames River and Lake St. Clair Subwatersheds: The highest 75th percentile concentrations of phosphorus were observed in Newbiggin in the 1960s and 1970s with values over 1.0 mg/L (33 times the IPWQO). There was a major decrease by the early 1980s to below 16 times the IPWQO (0.5 mg/L). Tilbury Creek also had a steady decrease from over 16 times the IPWQO (0.5 mg/L) to less than 0.5 mg/L in 1990-94. For most other stations, the 75th percentile phosphorus levels have been above the Interim Provincial Water Quality Objective of 0.03 mg/L but below 0.5 mg/L.

LTVCA - Lake Erie Subwatershed: The 75th percentile phosphorus concentrations at all stations have been over the IPWQO throughout the historic monitoring. In general, at most stations, the levels have decreased from over seven times the IPWQO (0.2 mg/L) in 1965-69 to below 0.2 mg/L since 1990-04. The most significant decreases occurred between 1965-69 and 1975-79 at Brock Creek, Dutton Drain, and Sixteen Mile Creek. The Talbot Creek station has had levels above the IPWQO but below 0.2 mg/L for all of the historic records.

Figure 3.2.4-2 Current Total Phosphorus Conditions in the Thames River Watershed



Total Phosphorus concentrations (2000-2004) for monitoring stations in the Upper and Lower Thames River watersheds. Sample size at each station is indicated in brackets. The red line is the Interim Provincial Water Quality Objective of 0.03 mg/L.

Figure 3.2.4-2: **Current Total Phosphorus Conditions in the Thames River Watershed**

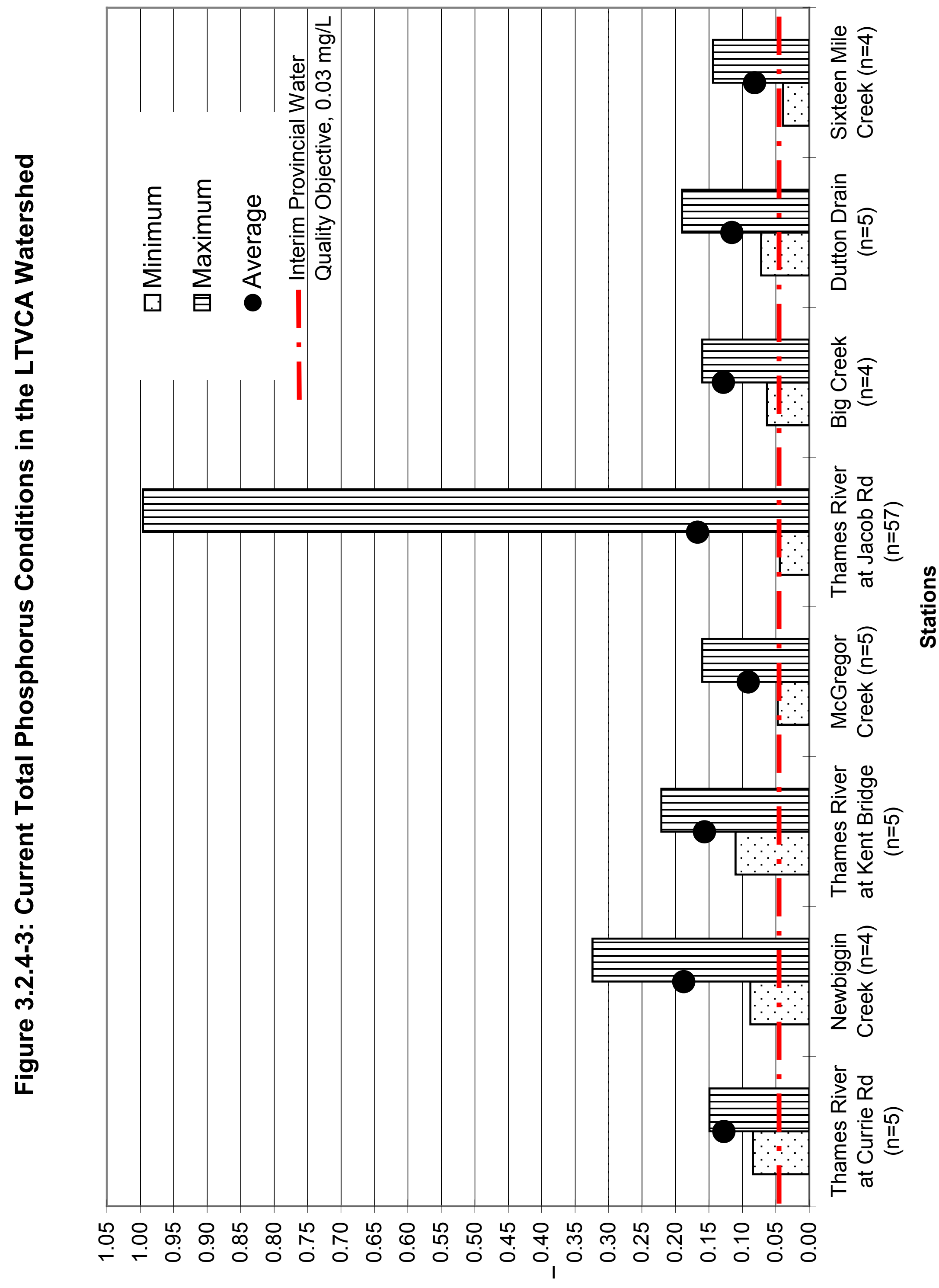


Figure 3.2.4-3: **Current Total Phosphorus Conditions in the LTVCA Watershed**

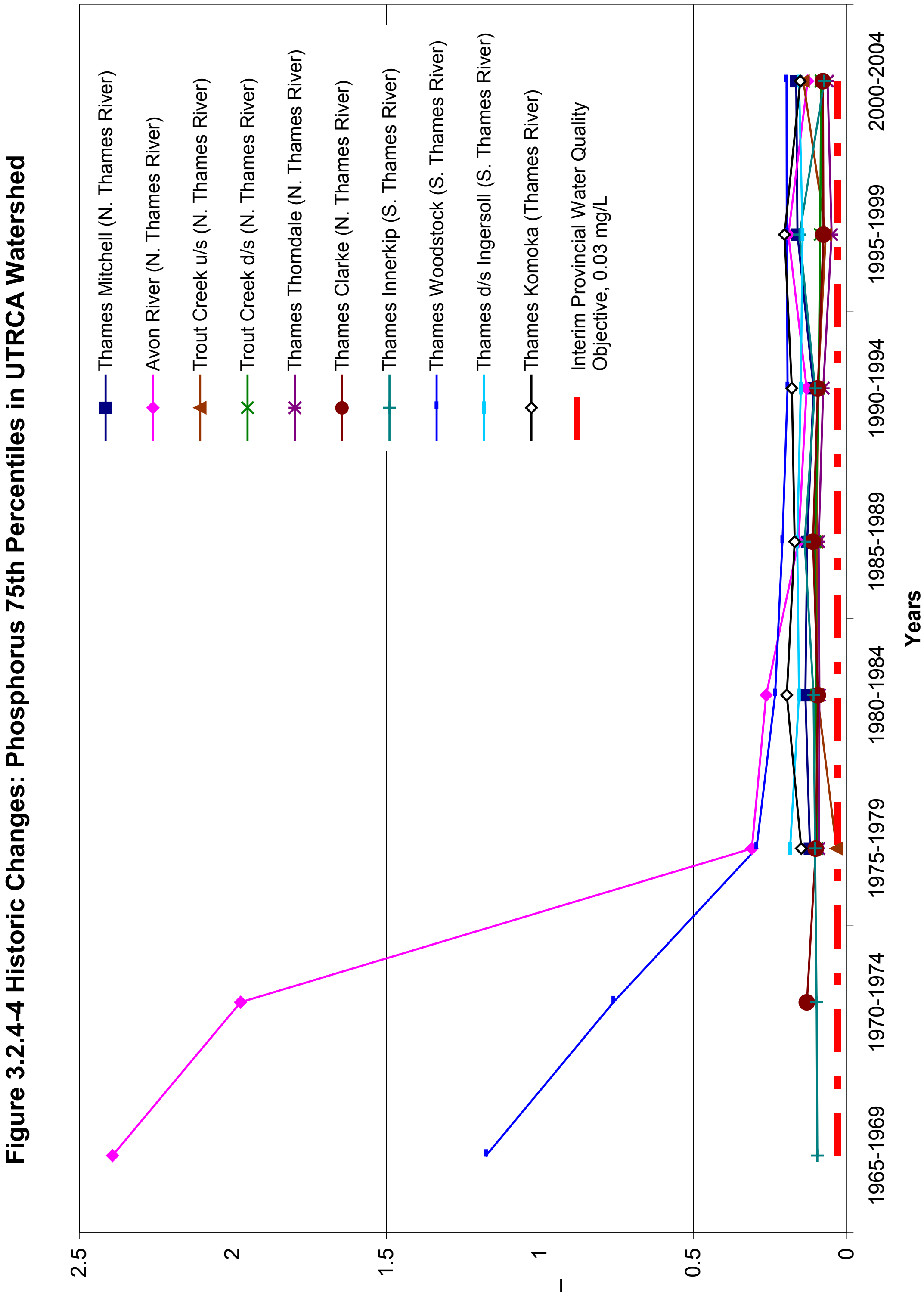


Figure 3.2.4-4: **Historic Changes: Phosphorus 75th Percentiles in UTRCA Watershed**

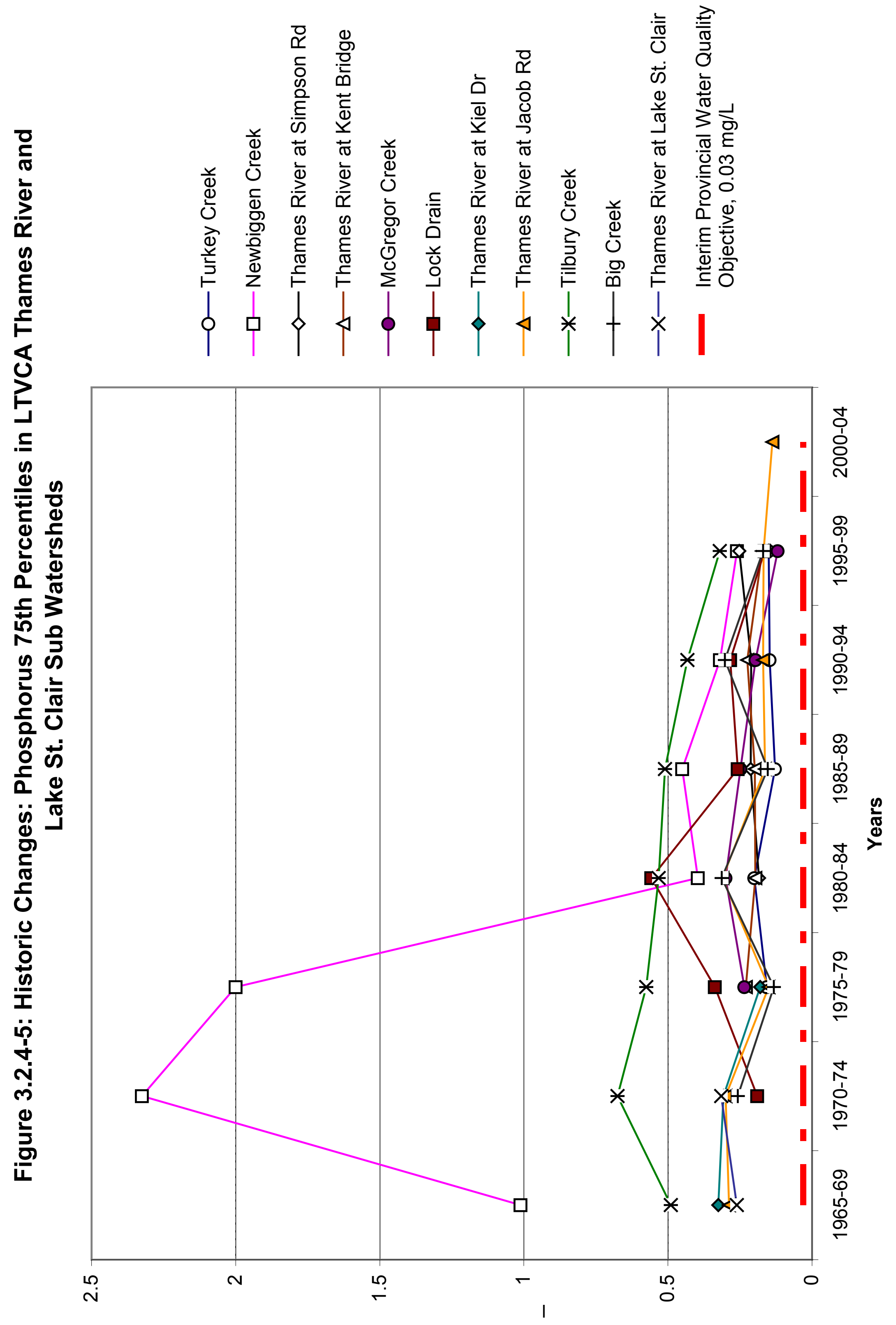


Figure 3.2.4-5: **Historic Changes: Phosphorus 75th Percentiles in LTVCA Thames River and Lake St. Clair Subwatersheds**

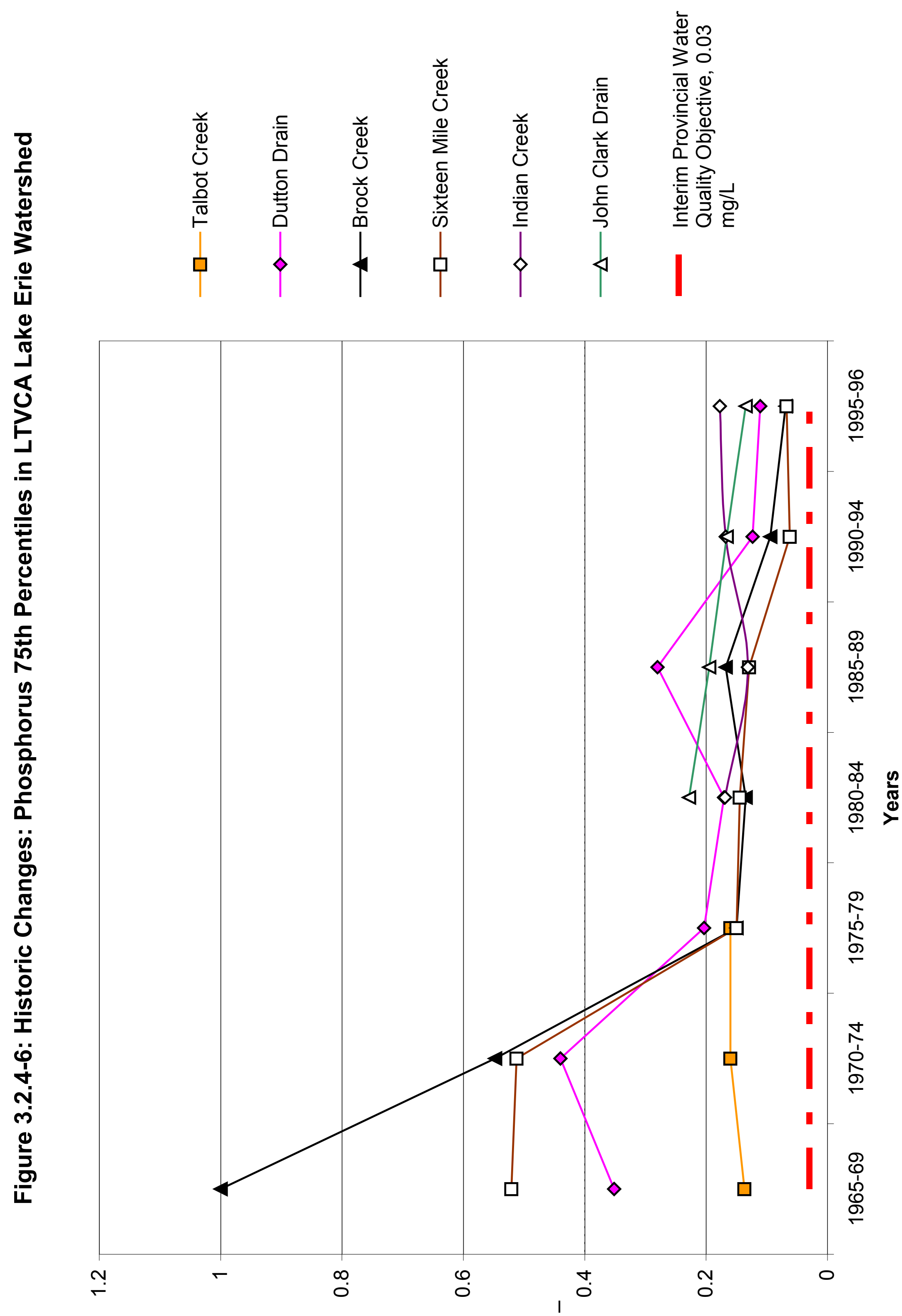


Figure 3.2.4-6: **Historic Changes: Phosphorus 75th Percentiles in LTVCA Lake Erie Watershed**

(2) Nitrate

Fate and Behaviour: The nitrate ion is soluble and does not adsorb to sediment or organic matter. Therefore, nitrate has a high potential for mobility through surface runoff and by leaching into groundwater. Due to its solubility in water, nitrates can readily reach streams by infiltration through soil and percolation via shallow groundwater or through tile drains. Elevated levels in a watercourse can be toxic to aquatic organisms, especially amphibians. A condition called blue baby syndrome can result from young children drinking water with elevated nitrates.

Sources: Nitrate sources include animal waste, commercial fertilizers, municipal wastewater, septic systems, and atmospheric deposition. Nitrate sources are usually found to be the highest in intensively farmed areas and downstream of municipal wastewater discharges.

Standards: The Ontario Drinking Water Standard (ODWS) for nitrate is a maximum acceptable concentration of 10 mg/L. The Province does not have an objective for aquatic life but there is a Canadian Environmental Quality Guideline to protect aquatic life from direct toxicity. As discussed in the section on Water Quality Standards and Guidelines, a value of 2.93 mg/L will be used to evaluate water quality for aquatic life, and is called the modified CCME guideline. This value is obtained by dividing the CCME guideline of 13 mg/L by 4.43 since the PWQMN nitrate is recorded as mg NO_3^--N·L^{-1} whereas the CCME guideline reports nitrate as mg NO_3^-·L^{-1}.

(a) Current Conditions

UTRCA: Figure 3.2.4-7: Current Total Nitrate Conditions in the Thames River Watershed shows the current nitrate conditions in the UTRCA. Komoka Creek and Dorchester Swamp Creek are the only stations at which 75th percentile values are below both the modified CCME guideline. The 75th percentile nitrate levels at all other stations are above the modified CCME guideline of 2.93 mg/L. At several stations, the levels are higher than the ODWS of 10 mg/L.

The highest current 75th percentile levels of nitrate are at the following sites: Thames River at Mitchell, Avon River, Fish Creek, Wye Creek, Thames at Thamesford, Thames at Tavistock and Waubuno Creek. The 75th percentile nitrate levels at these stations are higher than the Ontario Drinking Water Standard of 10 mg/L.

There is a noticeable decrease in nitrate levels between the upstream Trout Creek and downstream Trout Creek sites. Wildwood Reservoir lies between the two stations.

LTVCA: Figure 3.2.4-7 also shows that 75th percentile nitrate level at Thames River at Jacob Road is above the modified CCME guideline but below the ODWS. From **Figure 3.2.4-8: Current Total Nitrate Conditions in the LTVCA Watershed**, the minimum nitrate levels at all stations are below the modified CCME guideline of 2.93 mg/L for aquatic life. However, only Big Creek has an average value below the modified CCME guideline. The averages all other stations are between the modified CCME guideline and the ODWS value of 10 mg/L. The highest average nitrate value is 7.7 mg/L at Dutton Drain. At two stations, Newbiggen Creek and Dutton Drain, the maximum nitrate levels are above the ODWS at 10.4 and 17 mg/L, respectively.

(b) Historic Changes

As discussed in the section on special cases, the different analytical tests used over the last 40 years may make it difficult to determine if a change in total nitrates over time is due to an absolute change in total nitrates or due to changing test methods.

UTRCA: Figure 3.2.4-9 Historic Changes: Nitrate 75th Percentiles shows graphs of the nitrate levels at UTRCA stations over the past 40 years. Since 1965, the 75th percentile values of nitrate at all long-term monitoring sites have increased including at the outlet of the UTRCA watershed (Thames at Komoka).

Sites with particularly significant increases in recent years include Avon River, Thames at Mitchell, Dorchester Swamp Creek, Thames at Tavistock and Foldens Creek.

Since the early 1980s, nitrate levels at all stations, except Dorchester Swamp Creek, are higher than the modified CCME guideline of 2.93 mg/L. Levels at Dorchester Swamp Creek have shown a steady increase since 1985-89 and are approaching the modified CCME guideline.

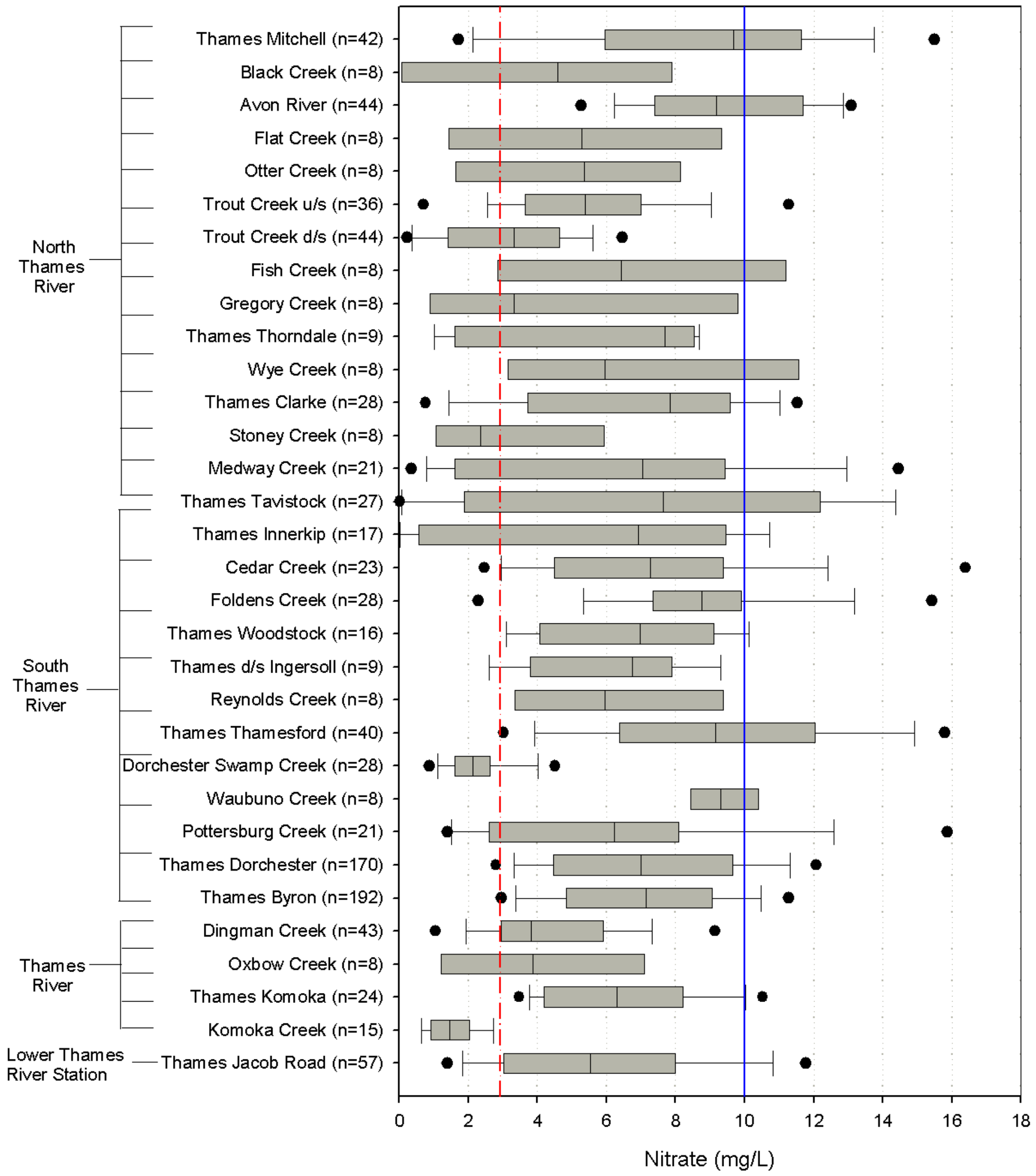
During the 1995-1999 data block, the Avon River and Thames at Innerkip stations had nitrate levels above the ODWS (10mg/L). In the period 2000-04, stations at Thames River at Mitchell, Thames River at Tavistock and Avon River have 75th percentile nitrate levels above the ODWS.

LTVCA - Thames River and Lake St. Clair Subwatersheds: Figure 3.2.4-10 Historic Changes: Nitrate 75th Percentiles shows that the 75th percentile nitrate concentrations at almost all stations increased over the years. In general, the historic values were above the modified CCME guideline but remained below the Ontario Drinking Water Standard. However, in 1995-1999, the 75th percentile nitrate at Big Creek was higher than the ODWS. Some variations from these general observations are discussed below.

Turkey Creek had relatively consistent nitrate levels over the 20 years it was sampled from the 1970s to the 1990s and the value in the last time block (1995-99) was similar to the 1975-79 level. Several stations including Newbiggen Creek, Big Creek and Tilbury Creek had high nitrate levels in the 1970-74 time block with lower values for the 1975-79 time block after which they begin to increase. The Lock Drain had a steady decrease in nitrate levels to a low in the 1985-89 time block and then had a large increase in the 1990-94 time block.

LTVCA - Lake Erie Subwatershed: Figure 3.2.4-11 Historic Changes: Nitrate 75th Percentiles shows the historic information available for this area. At the Indian Creek and John Clark Drain stations, the 75th percentile nitrate concentrations were above both the modified CCME guideline for the protection of aquatic life and the Ontario Drinking Water Standard for all years (1980 to 1996) that data is available. Nitrate levels at the other stations show historic increases to levels above the modified CCME guideline but below the ODWS.

Figure 3.2.4-7: Current Total Nitrate Conditions in the Thames River Watershed



Total Nitrates concentrations (2000-2004) for monitoring stations in the Upper and Lower Thames River watersheds. Sample size per station is indicated in the brackets. The red line represents the 2.93 mg/L modified CCME guideline for aquatic life and the blue line, the Ontario Drinking Water Standard of 10 mg/L (maximum acceptable concentration).

Figure 3.2.4-7: Current Total Nitrate Conditions in the Thames River Watershed

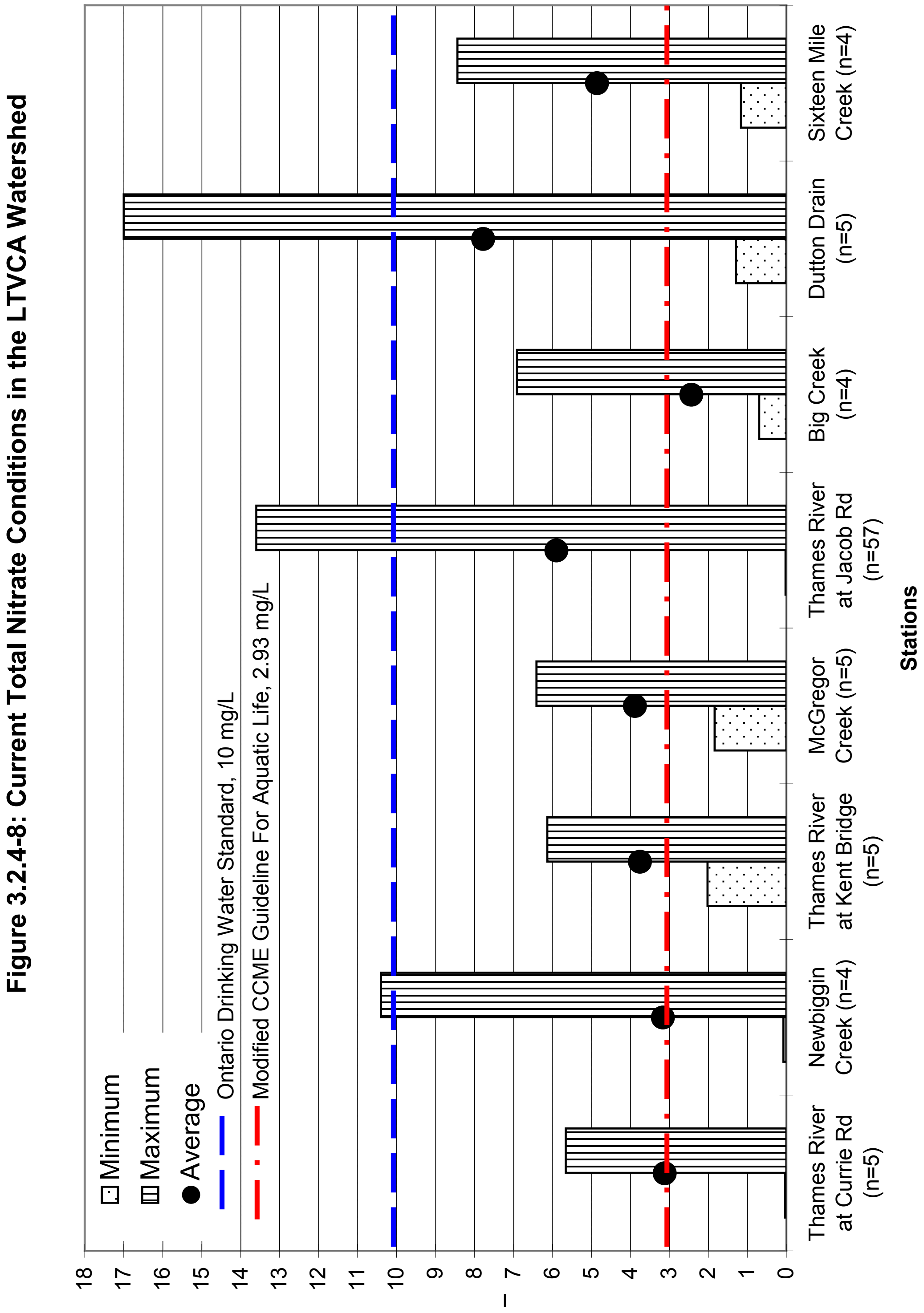
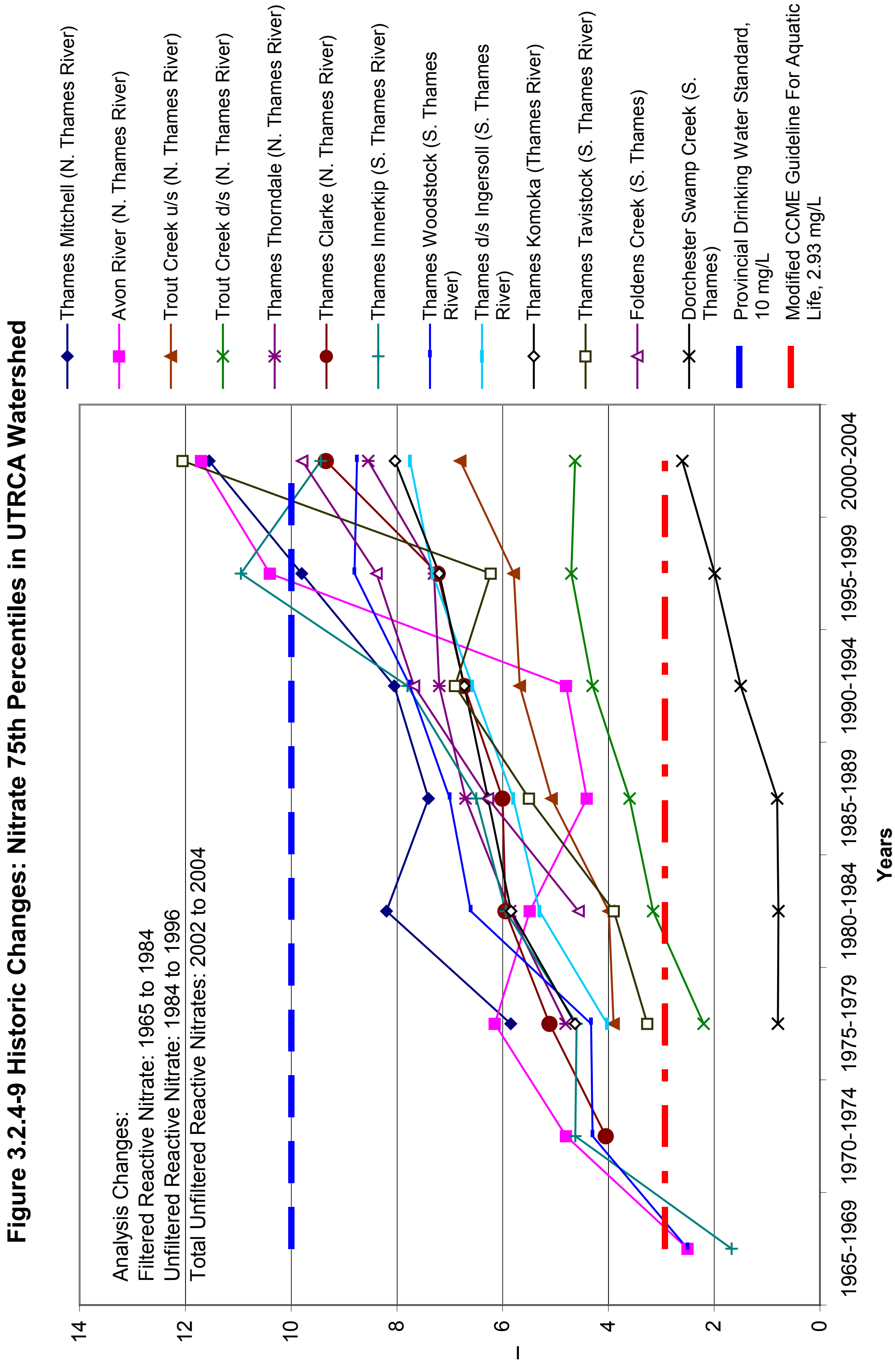


Figure 3.2.4-8: Current Total Nitrate Conditions in the LTVCA Watershed



Analysis Changes:
Filtered Reactive Nitrate: 1965 to 1984
Unfiltered Reactive Nitrate: 1984 to 1996
Total Unfiltered Reactive Nitrates: 2002 to 2004

Figure 3.2.4-9: Historic Changes: Nitrate 75th Percentiles in UTRCA Watershed

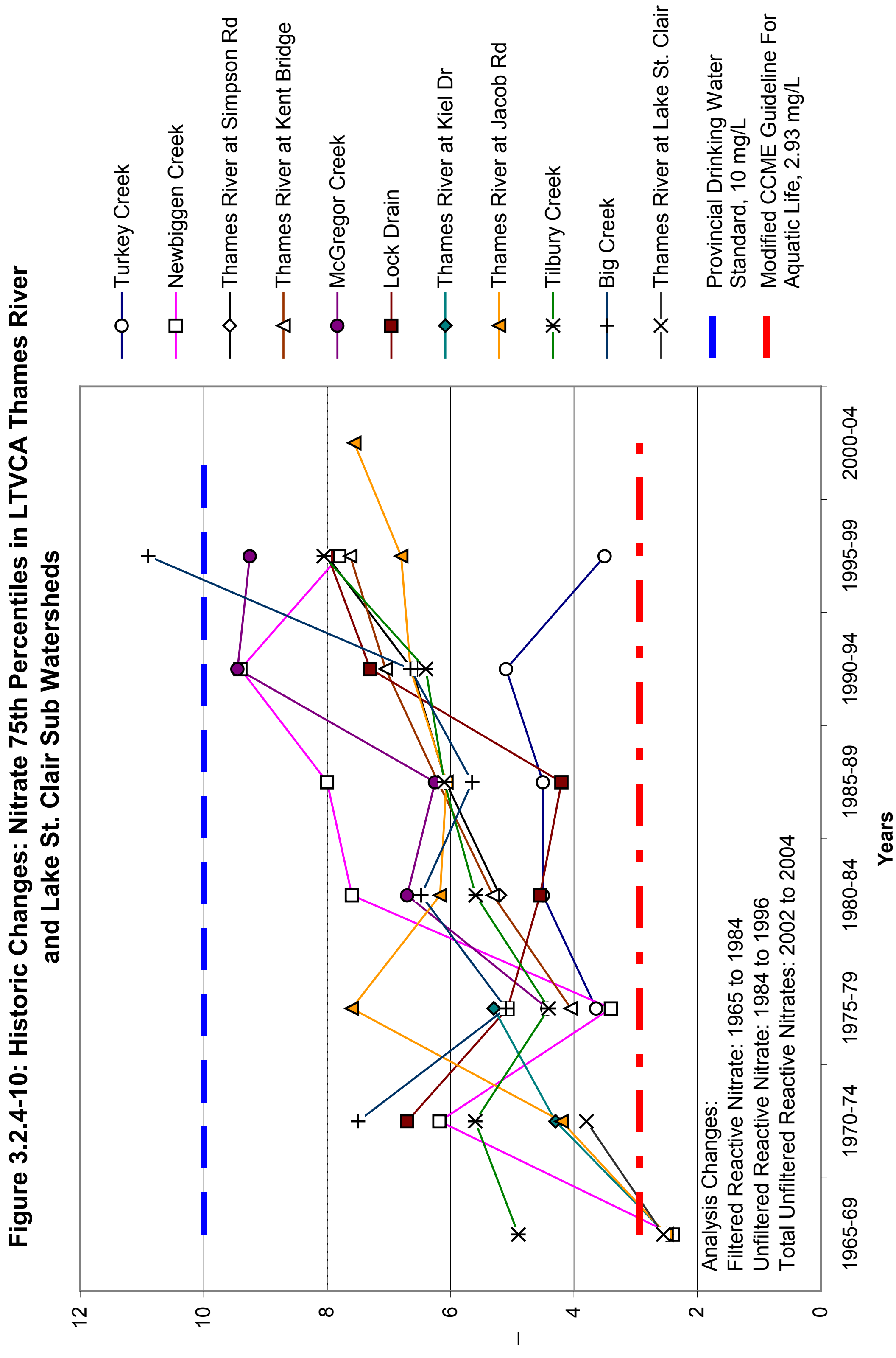


Figure 3.2.4-10: **Historic Changes: Nitrate 75th Percentiles in LTVCA Thames River and Lake St. Clair Subwatersheds**

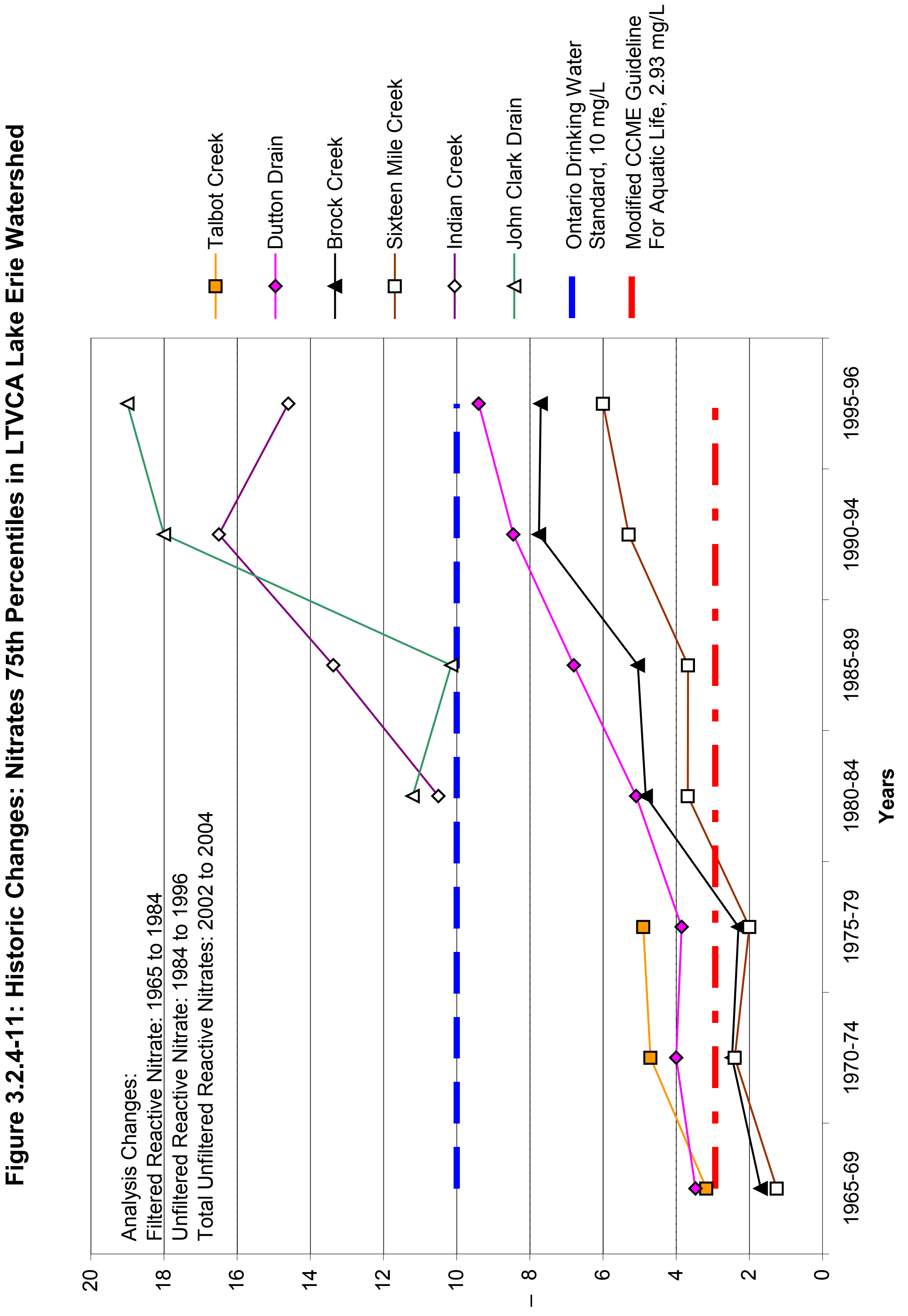


Figure 3.2.4-11: **Historic Changes: Nitrate 75th Percentiles in LTVCA Lake Erie Watershed**

(3) Chloride

Fate and Behaviour: Chloride ions are conservative, moving with water without being lost. Nearly all chloride added to the environment will eventually migrate to surface water or groundwater. Chloride can be toxic to aquatic organisms at high concentrations, and affects growth and reproduction at lower concentrations.

Sources: The highest loadings of chloride are typically associated with the application and storage of road salt (calcium chloride). Therefore, urban streams tend to have the highest chloride concentrations.

Standards: The Ontario Drinking Water Standard (ODWS) is 250 mg/L for aesthetic objectives. Ontario does not have a Provincial Water Quality Objective for aquatic life. An Environment Canada/Health Canada assessment report[44] documents toxicity for sensitive aquatic species at 210 mg/L. In this report, it is called the Environment Canada guideline (toxicity to aquatic species). To protect sensitive aquatic species, British Columbia recommends a guideline of 600 mg/L for acute exposure and 150 mg/L (30 day average) for chronic exposure.

(a) Current Conditions

UTRCA: Figure 3.2.4-12: Current Chloride Conditions in the Thames River Watershed shows current chloride conditions in the UTRCA. The 75th percentile concentrations of chloride at all stations fall below the Ontario Drinking Water Aesthetic Objective of 250 mg/L and most of the stations have values less than 0.6 times 150 mg/L the ODWS.

The highest current levels of chloride are at the Avon River and Dingman Creek. The Avon River has 25% of samples above 210 mg/L, the toxicity level for sensitive aquatic species documented by Environment Canada. Dingman Creek has a current 75th percentile slightly over 0.6 times 150 mg/L the ODWS.

LTVCA: Figure: 3.2.4-12 shows that the chloride concentrations for the Thames River at Jacob Road are below both the Environment Canada and ODWS (Aesthetic Objective) criteria. From **Figure 3.2.4-13: Current Chloride Conditions in the LTVCA Watershed**, all average chloride values are below the ODWS (aesthetic objective) of 250 mg/L. Only the maximum values at two stations, Big Creek and Dutton Drain, were above the Environment Canada guideline (toxicity to aquatic species) of 210 mg/L. The highest average chloride level is 166 mg/L at Dutton Drain and the lowest is 56 mg/L at Sixteen Mile Creek.

(b) Historic changes

UTRCA: Since 1965, the 75th percentile chloride levels at all long-term monitoring sites in the watershed have increased as shown in **Figure 3.2.4-14: Historic Changes Chloride 75th Percentiles for the UTRCA**.

At the Avon River station, the chloride 75th percentile value has increased significantly from approximately 100 mg/L in 1990-1994 to be near the Environment Canada toxicity to species limit of 210 mg/L in 2000-2004.

Most sites have also doubled their 75th percentile chloride levels over the studied 40 year period. Most of the initial levels were below 50 mg/L and current levels are under 100 mg/L which is below both the Ontario Drinking Water Aesthetic Objective and the Environment Canada aquatic health toxicity levels.

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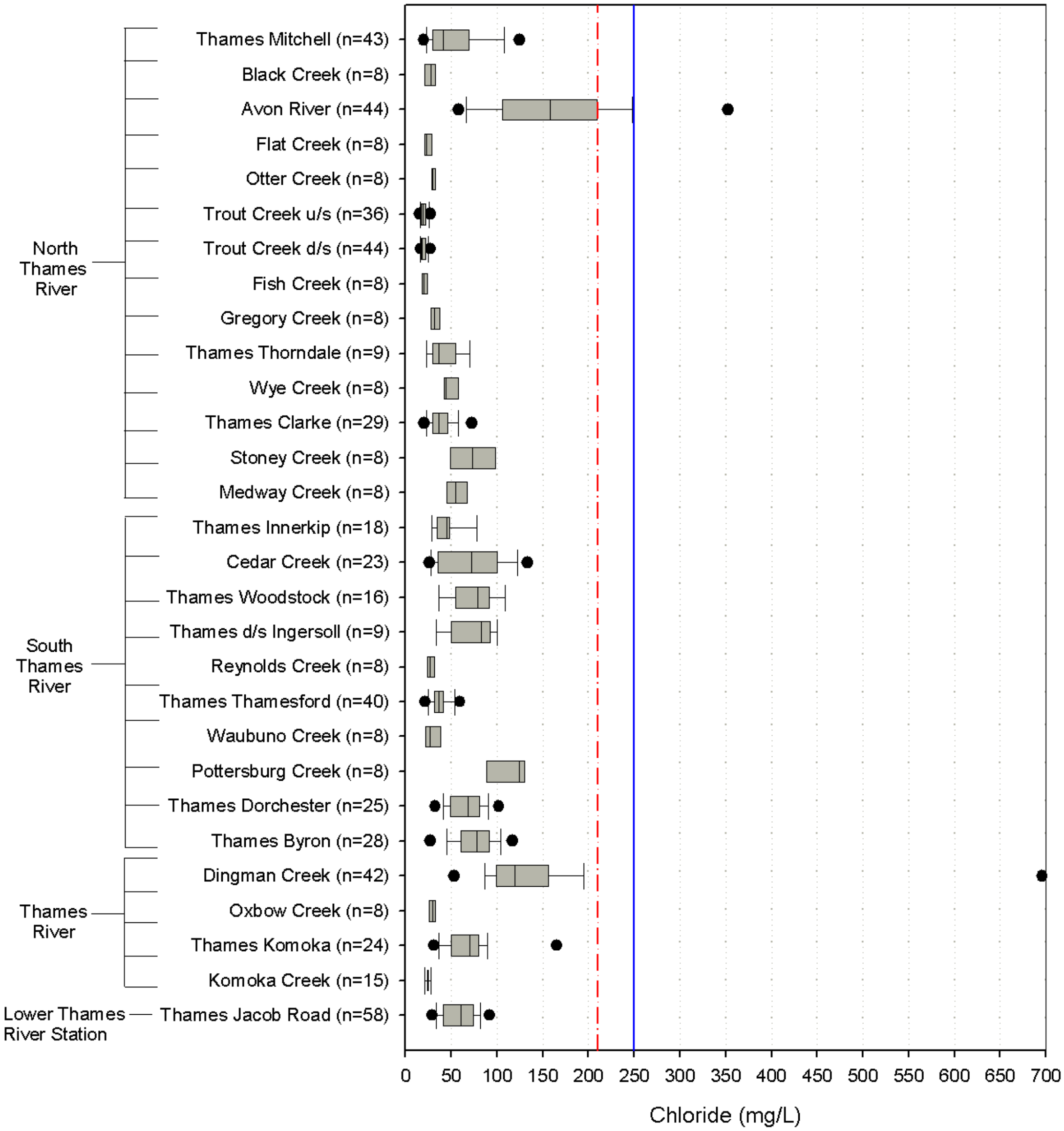
[44] Environment Canada. 2001. Existing Substances Evaluation: Assessment Report - Road Salts. www.ec.gc.ca/substances/ese/eng/psap/final/roadsalts.cfm

LTVCA - Thames River and Lake St. Clair Subwatersheds: As shown in **Figure 3.2.4-15: Historic Changes: Chloride 75th Percentiles**, Newbiggen Creek had high 75th percentile chloride concentrations in 1970-74 that were above both the Ontario Drinking Water Aesthetic Objective and the Environment Canada aquatic species toxicity criteria. However, levels decreased rapidly after that and by 1990-94 were below 100 mg/L. At all other stations, 75th percentile chloride levels are below the limits over the study period. Only the Thames River at Jacob Rd has a value plotted for the 2000-04 time block.

In general, the 75th percentile chloride concentrations increase slightly over the study period. Levels in Big Creek appear to have increased more rapidly than most other stations.

LTVCA - Lake Erie Subwatershed: As shown in **Figure 3.2.4-16: Historic Changes: Chloride 75th Percentiles**, the 75th percentile chloride levels at all stations are below both drinking water and aquatic species toxicity limits over the historic study period. These watersheds show slight increases in 75th percentile chloride concentrations between 1965-69 and 1995-96 when monitoring stopped. Talbot Creek had higher levels (approximately 100 mg/L) than the other stations which were between 50 and 75 mg/L.

Figure 3.2.4-12: Current Chloride Conditions in the Thames River Watershed



Chloride concentrations (2000-2004) for monitoring stations in the Upper and Lower Thames River watersheds. Sample size is shown in the brackets at each station. The red line depicts the Environment Canada guideline (toxicity to sensitive species) of 210 mg/L and the blue line is the Ontario Drinking Water Aesthetic Objective of 250 mg/L.

Figure 3.2.4-12: Current Chloride Conditions in the Thames River Watershed

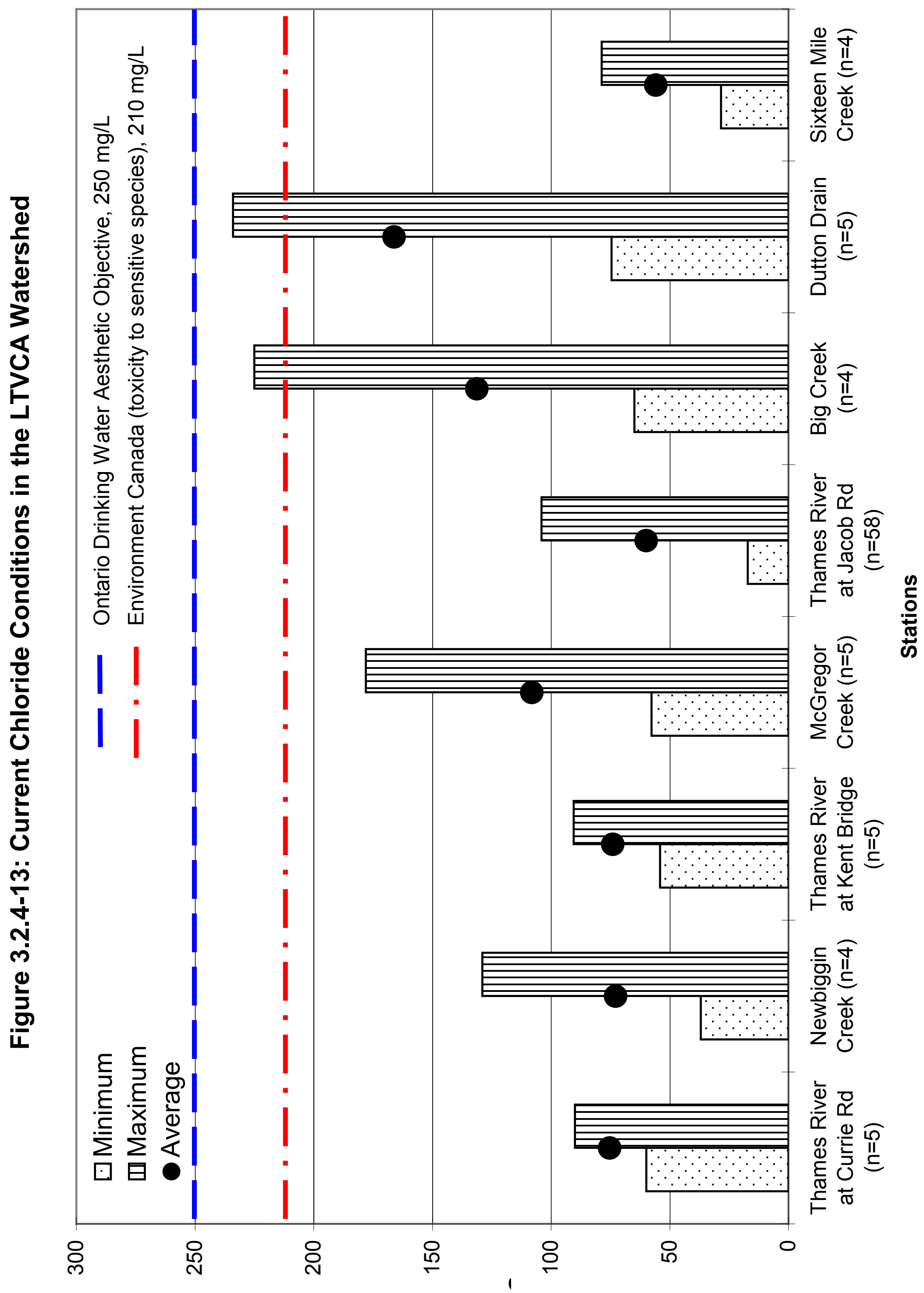


Figure 3.2.4-13: **Current Chloride Conditions in the LTVCA Watershed**

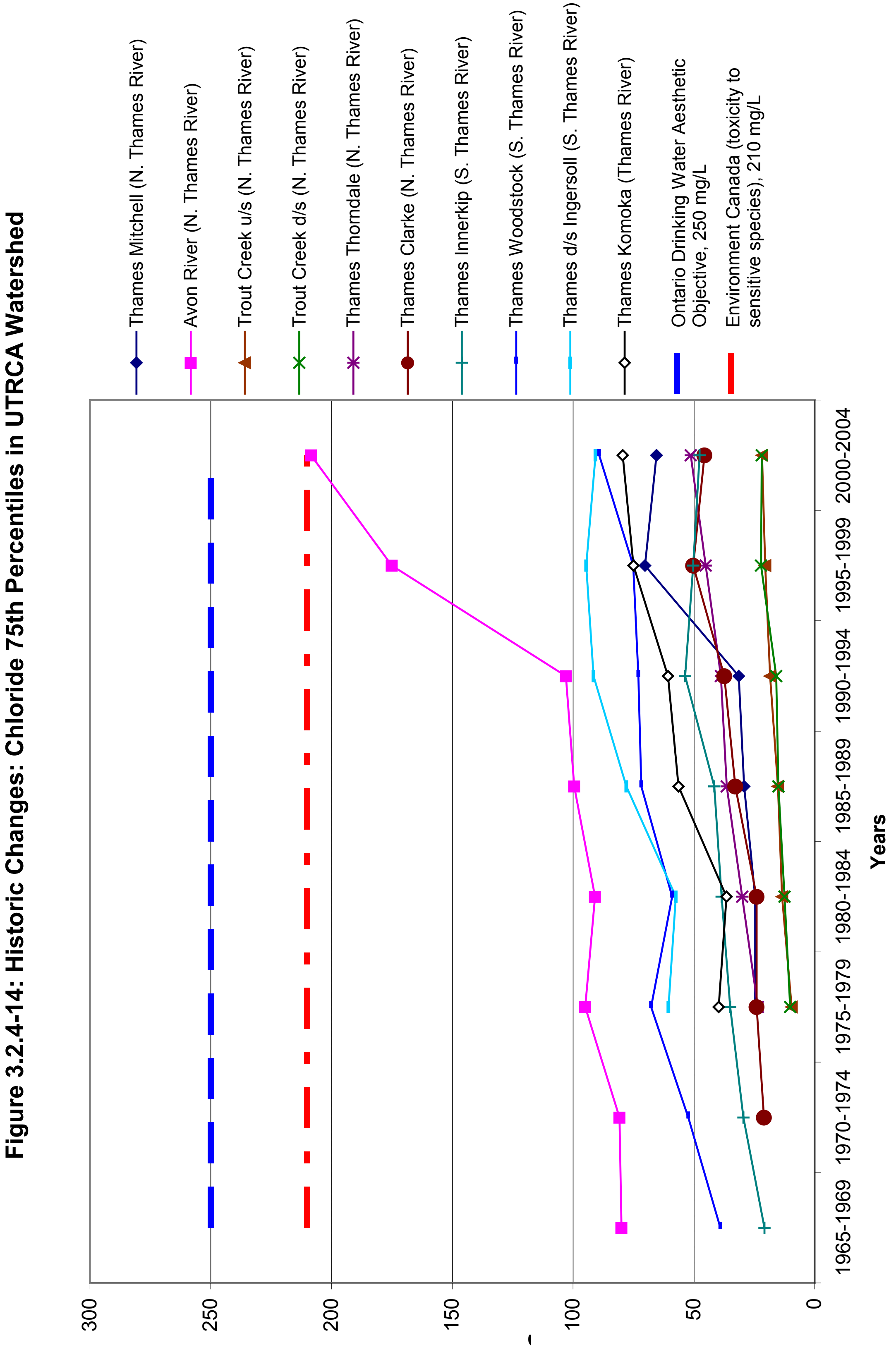


Figure 3.2.4-14: **Historic Changes: Chloride 75th Percentiles in UTRCA Watershed**

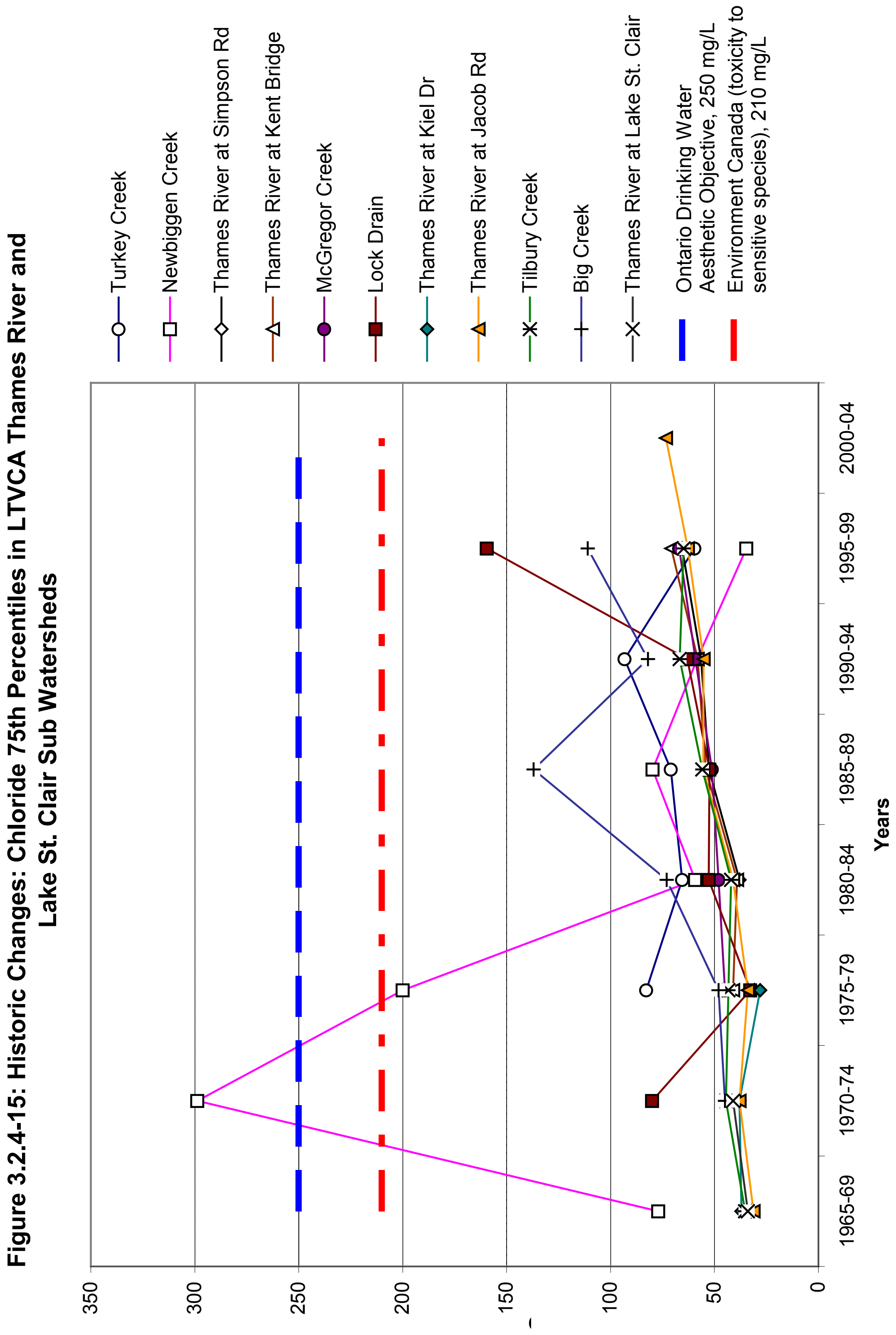


Figure 3.2.4-15: **Historic Changes: Chloride 75th Percentiles in LTVCA Thames River and Lake St. Clair Subwatersheds**

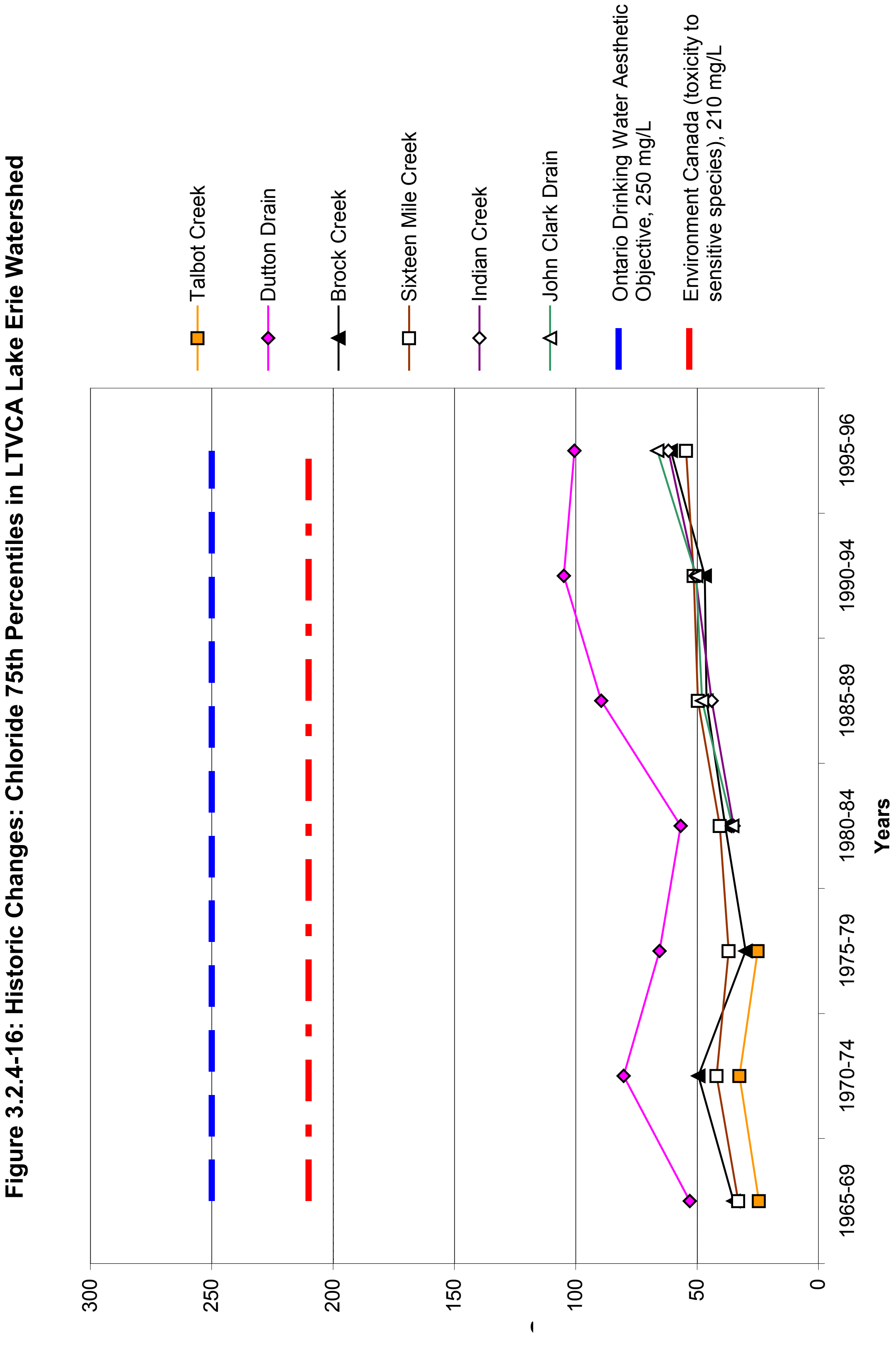


Figure 3.2.4-16: **Historic Changes: Chloride 75th Percentiles in LTVCA Lake Erie Watershed**

(4) Suspended Solids

Fate and Behaviour: Suspended solids consist of silt, clay, and fine particles of organic and inorganic matter. These particles are significant carriers of phosphorus, metals, and other hazardous contaminants. Suspended solids can be detrimental to aquatic organisms including fish (spawning beds, damage gills, etc.). Oxygen levels in the stream can be impaired by decaying organic solids from sources such as wastewater treatment plants and storm sewers.

Sources: Soil erosion is the most common source of suspended solids to a watercourse. Suspended solids from urban sources appear in storm water and combined sewer runoff during storm events. Erosion of soil from cultivated land, construction/development sites and eroded stream banks all contribute sediment to surface water. Natural erosion of streambeds and banks are also sources.

Standards: There are no established standards for suspended solids. However, turbid water is undesirable for water supplies, healthy aquatic life, recreation and aesthetics. Suspended solids can also transport quantities of trace contaminants.

(a) Current Conditions

UTRCA: Figure 3.2.4-17: Current Suspended Solids Conditions in the Thames River Watershed shows current suspended solids conditions in the UTRCA watershed. The highest 75th percentile level of suspended solids is at Stoney Creek (approximately 80 mg/L) and the lowest at Gregory Creek (approximately 5 mg/L). Wildwood Reservoir acts as a sediment (and nutrient) settling basin, decreasing suspended solids from upstream Trout Creek to downstream Trout Creek.

LTVCA: Figure 3.2.4-17 shows that the 75th percentile level of approximately 90 mg/L was observed in Thames River at Jacob Road and that the maximum concentration has been over 500 mg/L. From **Figure 3.2.4-18: Current Suspended Solids Conditions in the LTVCA Watershed**, the highest average for suspended solids is 100 mg/L in the Thames River at Kent Bridge and the lowest is 29 mg/L at Dutton Drain. The highest maximum suspended solids values are 174 mg/L at Thames River at Kent Bridge and 915 mg/L at Thames River at Jacob Road. The lowest value is 9.2 mg/L at Dutton Drain.

(b) Historic changes

UTRCA: In general, levels are less than 30 mg/L as shown in **Figure 3.2.4-19: Historic Changes: Suspended Solids 75th Percentiles in UTRCA Watershed.** While there is fluctuation in 75th percentile levels concentrations over the 40 year study period, most sites in the watershed have the same levels of suspended solids in 2000-2004 as they had in 1965-1969. Dingman Creek had high levels (over 50 mg/L) in the 1980s and early 1990s. The levels of suspended solids in Dingman Creek have decreased since the 1980-84 time block and are now approximately 30 mg/L. Thames at Innerkip had increases in the 1990s but has had a significant decrease in 75th percentile suspended solids levels since 1995.

LTVCA - Thames River and Lake St. Clair Subwatersheds: Figure 3.2.4-20: Historic Changes: Suspended Solids 75th Percentiles shows a wide variation in levels between both stations and time blocks.

The Thames River at Jacob Road had relatively low levels (about 40 mg/L) in the 1960s and 1970s with a large increase in the highest 75th percentile suspended solids concentrations in 1980-1984. Levels decreased in 1985-89 only to increase up to recent years. They remain in the range of 80 to 100 mg/L.

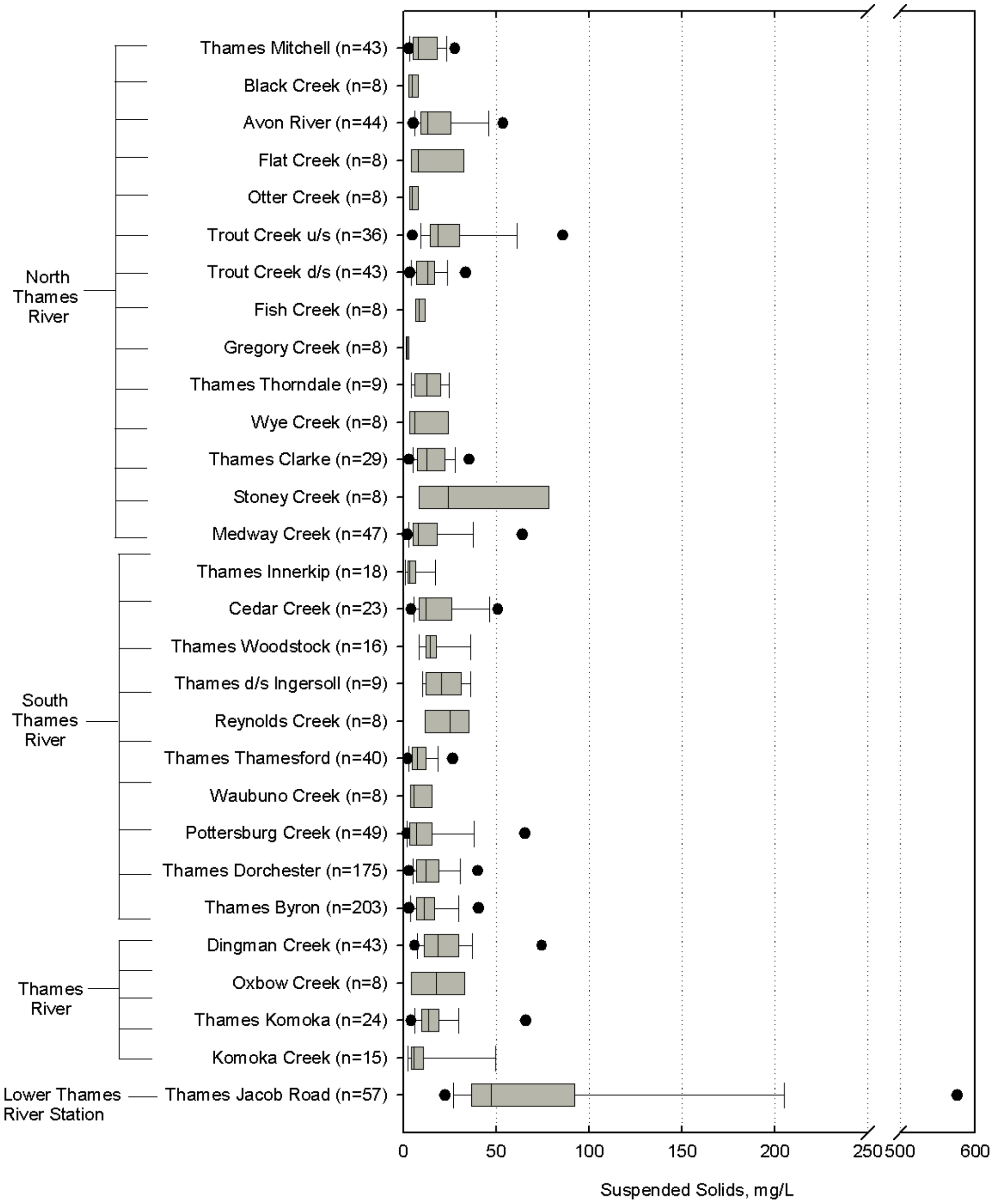
Newbiggen had high (over 160 mg/L) suspended solids level in 1965-69 and 1970-74 but the levels decreased to less than 80 mg/L in the 1990s.

The 75th percentile suspended solids concentrations at other stations have fluctuated over the study period. Stations showing an overall decrease in 75th percentile suspended solids concentrations are Newbiggen

Creek, Tilbury Creek and Big Creek. Stations showing an overall increase in 75th percentile suspended solids concentrations are Thames River at Simpson Road and Lock Drain. The remaining stations do not show a significant overall increase or decrease in 75th percentile suspended solids concentrations.

LTVCA - Lake Erie Subwatershed: Since sample sizes at all stations are small (only four or five samples) for the 2000-2004 time block, 75th percentile values at this time block are not presented. As shown in **Figure 3.2.4-21 Historic Changes: Suspended Solids 75th Percentiles,** from the late 1960s to the late 1990s, the 75th percentile suspended solids concentrations at most stations decrease to approximately 40 mg/L or less. John Clark Drain shows a significant decrease from over 100 mg/L in 1980-04 to slightly above 40 mg/L in 1995-96. However, one station, Indian Creek, does not show a decrease and appears to show an increase.

Figure 3.2.4-17: Current Suspended Solids Conditions in the Thames River Watershed



Suspended solids concentrations (2000-2004) for monitoring stations in the Upper and Lower Thames River watersheds. Sample size per station is indicated in the brackets.

Figure 3.2.4-17: Current Suspended Solids Conditions in the Thames River Watershed

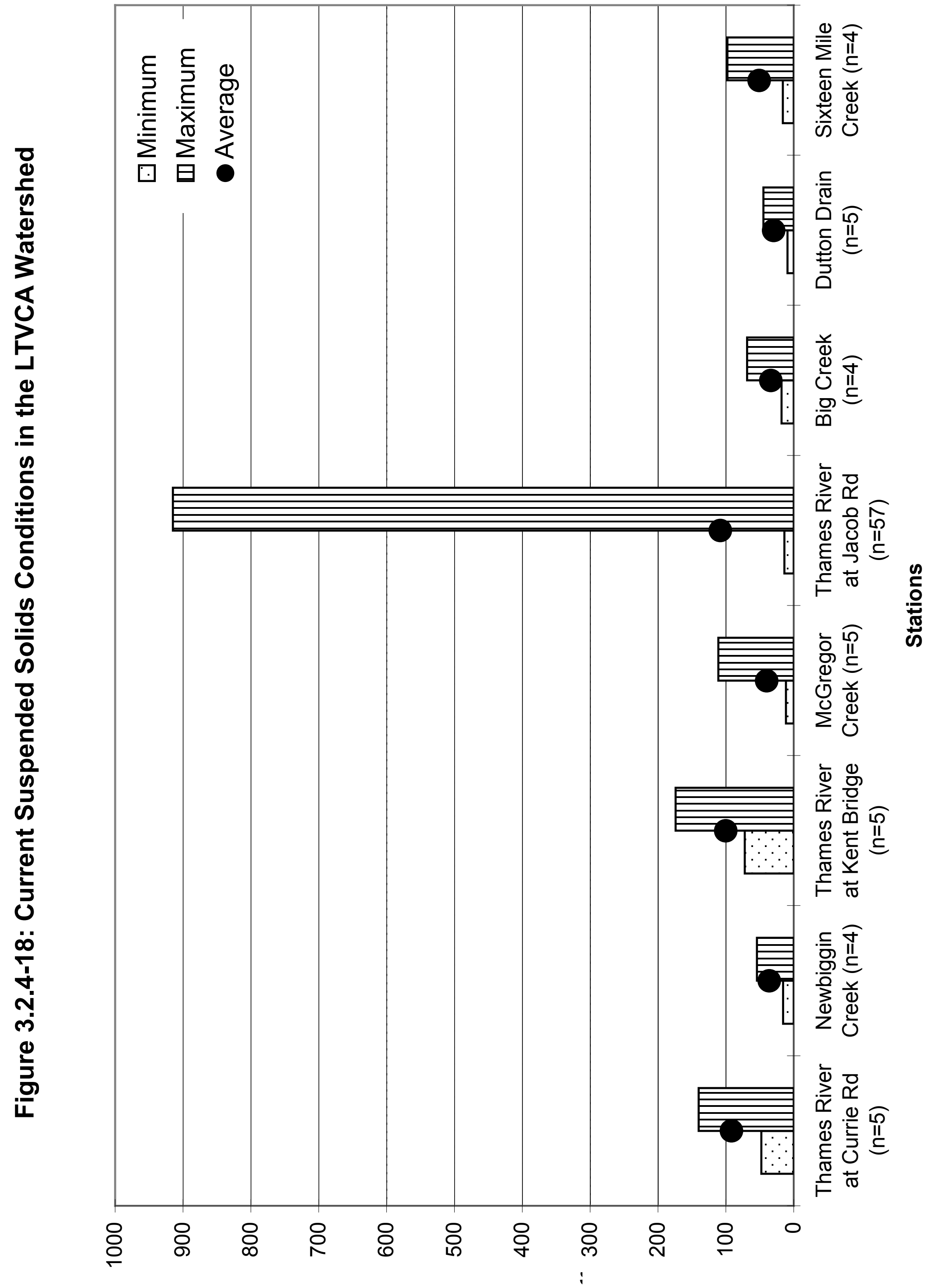


Figure 3.2.4-18: **Current Suspended Solids Conditions in the LTVCA Watershed**

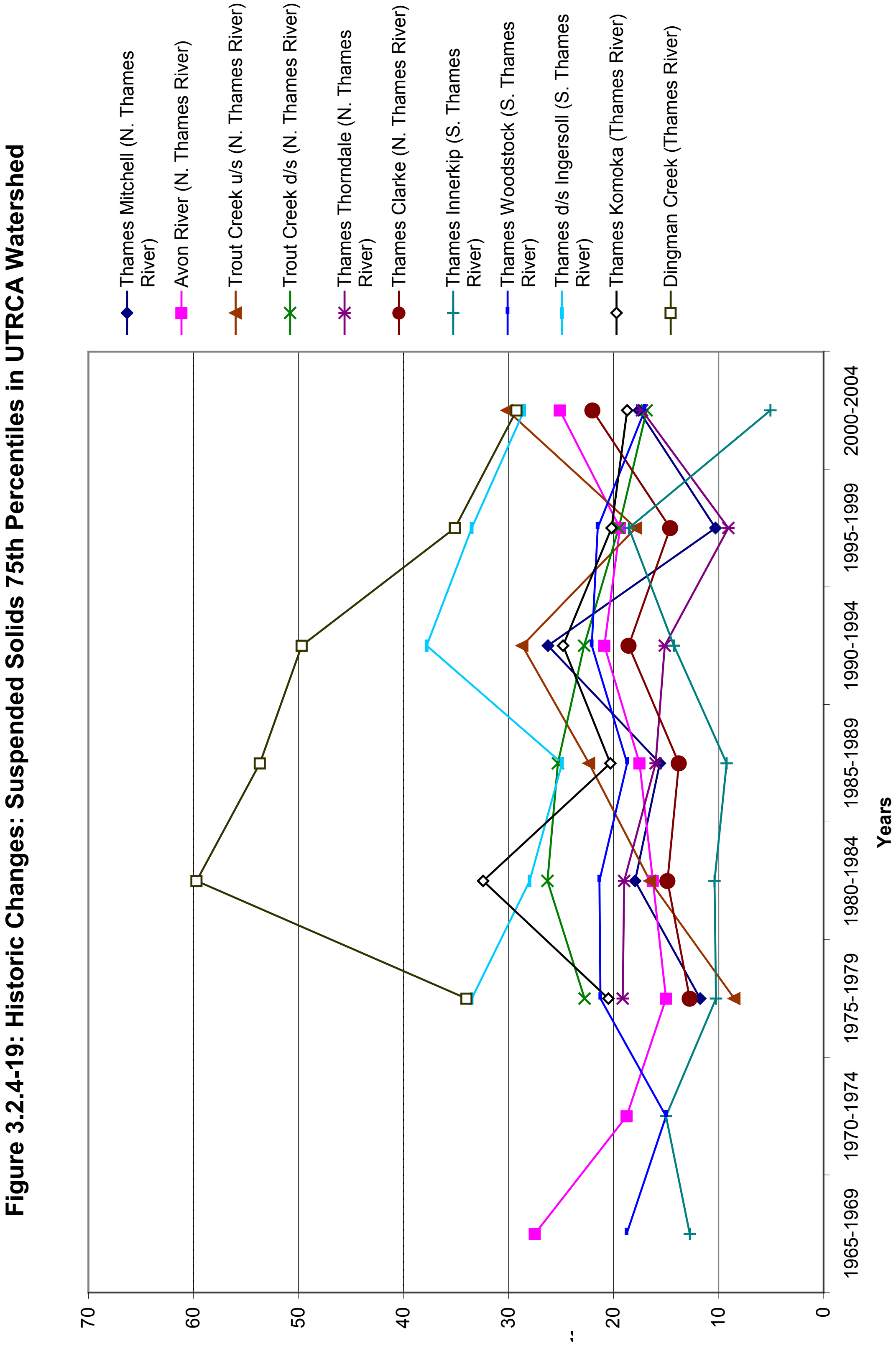


Figure 3.2.4-19: Historic Changes: Suspended Solids 75th Percentiles in UTRCA Watershed

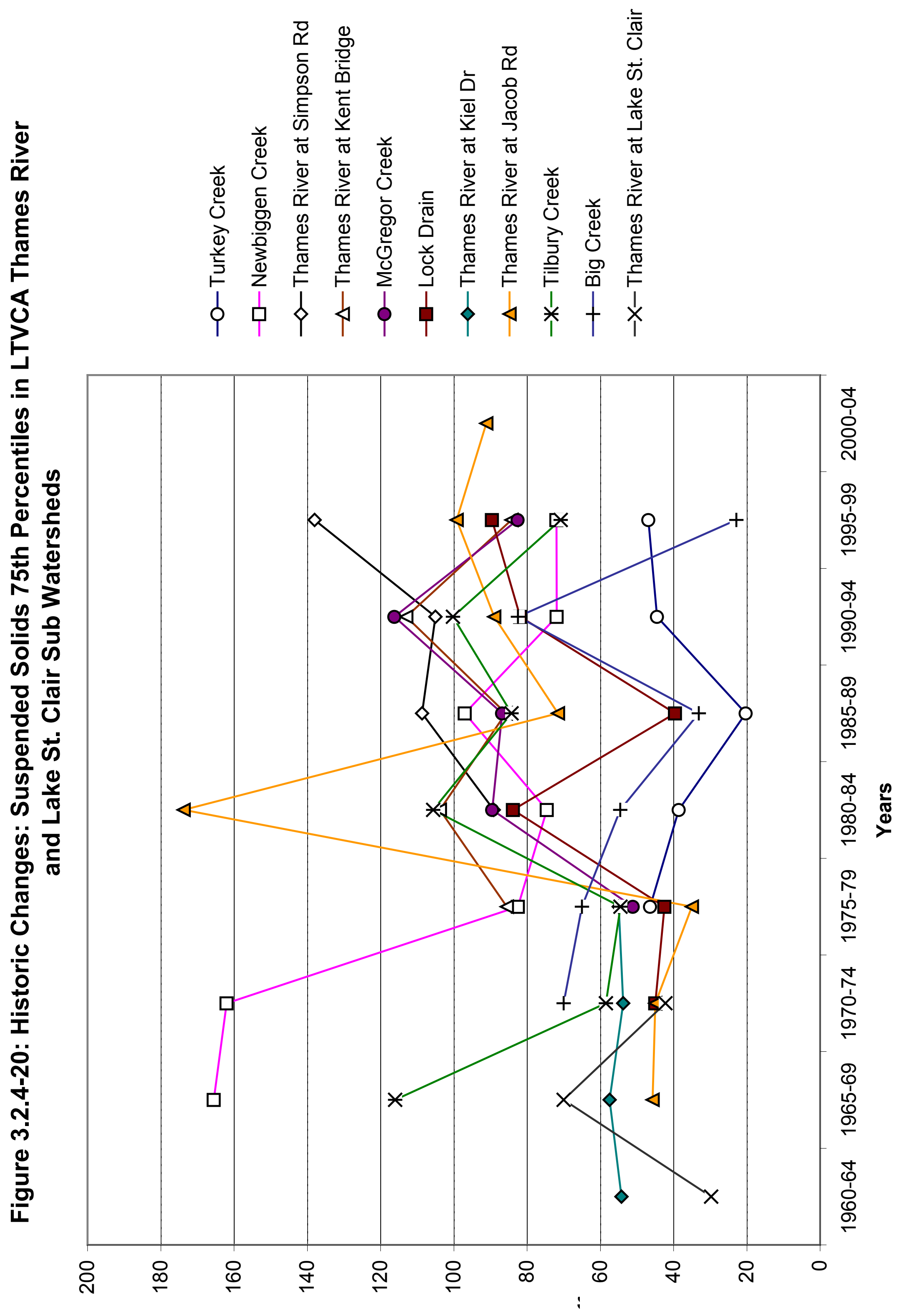


Figure 3.2.4-20: **Historic Changes: Suspended Solids 75th Percentiles in LTVCA Thames River and Lake St. Clair Subwatersheds**

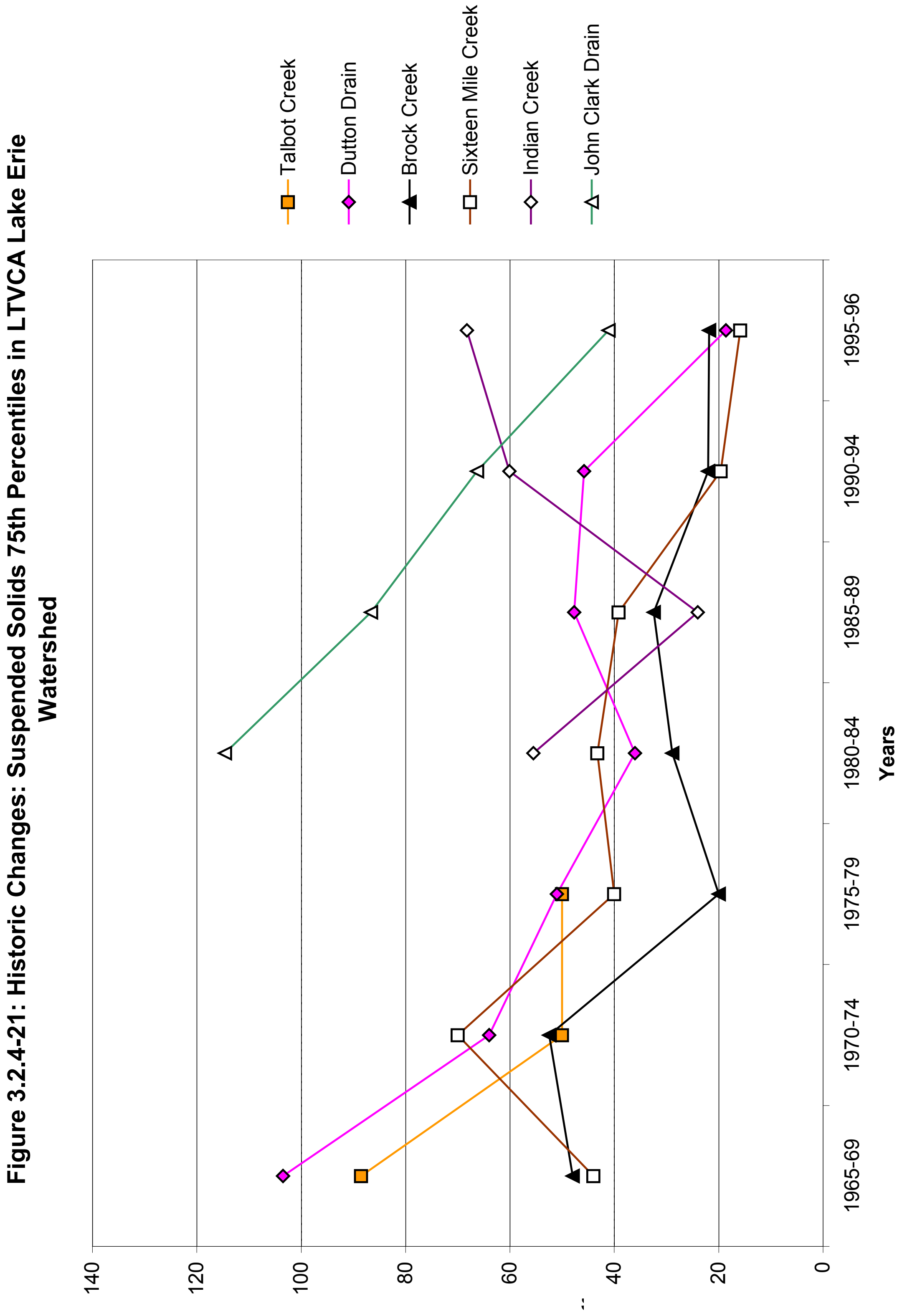


Figure 3.2.4-21: **Historic Changes: Suspended Solids 75th Percentiles in LTVCA Lake Erie Watershed**

(5) Bacteria

Historically, fecal coliform, a type of coliform bacteria, was monitored as an indicator of fecal contamination. The OMOE changed this indicator in 1994 to *Escherichia coli* (*E. coli*), a type of fecal coliform. Since the data is comparable[45], the data can be pooled together to form longer time series to look for historic changes.

Fate and Behaviour: *E. coli* is a fecal coliform bacterium that is monitored as an indicator of other pathogens present in human and animal (domestic and wildlife) waste. A positive *E. coli* test implies sewage contamination, which can include pathogenic bacteria and viruses, such as *Giardia* and *Cryptosporidium*, that are much more difficult to detect than *E. coli*. Bacteria can survive for many months, especially in nutrient-rich sediments. In addition to affecting surface water quality, *E. coli* can contaminate groundwater, putting well water sources at risk.

Sources: *E. coli* and other fecal coliform bacteria are found in the fecal matter of humans, animals and birds. Potential sources include runoff from biosolids/sewage or livestock waste application, faulty private septic systems, inadequate manure storage and urban stormwater runoff.

Standards: The Provincial Water Quality Objective for recreational waters is 100 *E. coli* counts/100 mL (geometric means of five samples from same site). The Ontario Drinking Water Standard for bacteria is that there should be no bacteria present in a drinking water supply.

(a) Current Conditions

UTRCA: Figure 3.2.4-22: Current Bacteria Conditions in the UTRCA Watershed is a box and whisker plot showing the spread of data values of bacteria at stations in the UTRCA watershed. Concentrations of *E. coli* bacteria are above the Ontario Drinking Water Standard for all sites in the watershed. Levels are also routinely above the PWQO recreational guideline of 100 counts/100 mL for all sites.

The highest current 75th percentile level of *E. coli* is at Reynolds Creek (above 4000 counts/100 mL). Several stations, including Trout Creek downstream, Fish Creek, Wye Creek, Stoney Creek, Cedar Creek, Thames at Ingersoll, Reynold Creek, Waubuno Creek and Thames at Byron Bridge, have 75% of percentiles that are over 10 times the recreational guideline. The lowest 75th percentile levels are found at Thames at Woodstock and Thames at Komoka.

Figure 3.2.4-23: Current Bacteria Conditions in the UTRCA Watershed – Geometric Means is a bar chart showing the same data as bacteria geometric mean values at stations in the UTRCA watershed. The geometric mean values of *E. coli* bacteria are above the Ontario Drinking Water Standard for all sites in the watershed. They are also above the Provincial Water Quality Objective for recreational waters at all stations except Thames at Woodstock with 96 counts/100 mL. The highest levels are at Reynolds Creek and Stoney Creek, at 829 and 754 counts/100 mL, respectively.

LTVCA: No PWQMN station has been monitored for bacteria since 1997. As a result, no current condition assessment is available.

(b) Historic changes

The analyzed historical data consists of two parameters. Before 1995, the parameter monitored was fecal coliform. Starting in 1995, the bacteria indicator became *Escherichia coli* (*E. coli*). Since the data is comparable[45], the data was pooled together to form a longer time series.

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[45] Palmer, Merv, and D.W. Draper. March 1991. Support Document for Recreational Water Quality Objectives. BEAK Consultants Limited and Environmental Consulting. BEAK Reference: 4233.1.

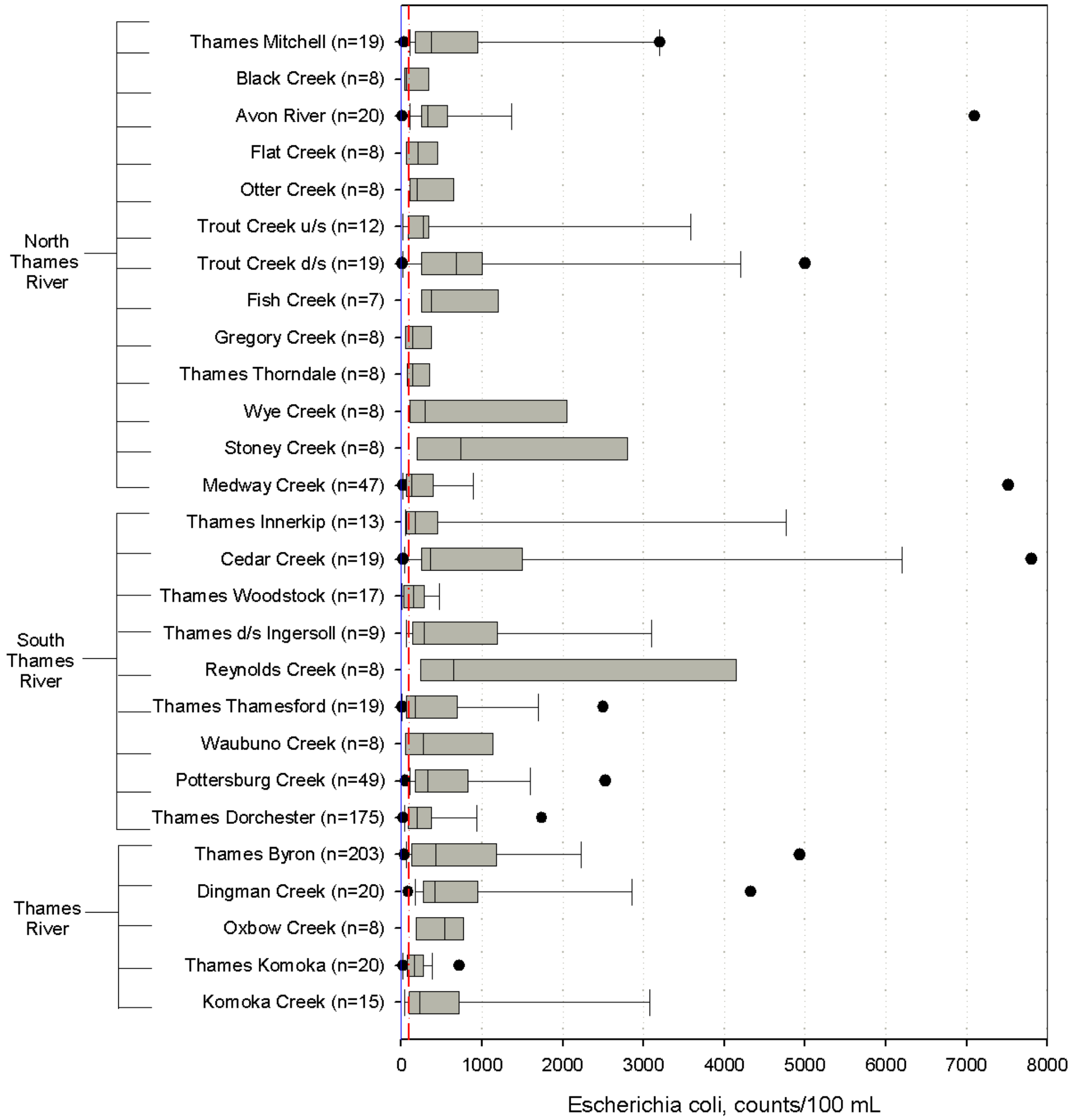
All stations have bacteria present and, thus, have levels above the Ontario Drinking Water Standard. With the exception of Thames River at Clarke Road in the UTRCA, the five year geometric means of coliform bacteria at stations in both the UTRCA and LTVCA watersheds have been higher than the Provincial Water Quality Objective recreational guideline. The Thames at Thorndale, Avon River and Thames at Thamesford stations have some historic levels that are below the PWQO recreational guideline.

UTRCA: Historic information on geometric means of coliform is shown in **Figure 3.2.4-24: Historic Changes: Bacteria Geometric Means in UTRCA Watershed**. The Thames at Woodstock showed a significant decrease in geometric mean levels from over 3000 counts/100 mL in 1975-79 to a level close to the Provincial Water Quality Objective in 2000-04. The coliform levels have increased at Trout Creek below Wildwood Reservoir, the Avon River, and at the Thames river sites below Mitchell, Thamesford and Tavistock over the three decades represented by the historic data. Most other stations show increases through the 1980s and 1990s, with a return to 1975-1979 levels in 2000-2004. Most stations show an increase in 1995-1999 data but a decrease in 2000-04.

LTVCA - Thames River and Lake St. Clair Subwatersheds: Figure 3.2.4-25: Historic Changes: Bacteria Geometric Means shows historic changes over the years. No PWQMN station has been monitored for bacteria since 1997. All stations have bacteria present and thus have levels above the Ontario Drinking Water Standard. Newbiggen Creek and Tilbury Creek had the highest geometric means coliform levels (over 10,000 counts/100 mL) for the duration of monitoring at these stations, from the mid 1960s to the late 1980s. The lowest level of 57 counts/100 mL was at the Thames River at Jacob Road in the mid 1980s. In recent years, the coliform bacteria levels at all stations were higher than the Provincial Water Quality Objective (recreational guideline).With the exception of Newbiggen Creek and Tilbury Creek, historic levels were between 100 and 1000 counts/100 mL.

LTVCA - Lake Erie Subwatershed: Figure 3.2.4-26: Historic Changes: Bacteria Geometric Means shows historic changes over the years. No PWQMN station has been monitored for bacteria since 1997. All stations have bacteria present and thus have levels above the Ontario Drinking Water Standard. The geometric means of the bacteria levels also are higher than the Provincial Water Quality Objective (recreational guideline). Most values between 200 and 1000 counts/100 mL. The geometric means of coliform at all stations decreased from mid 1980s to mid 1990s, with significant decreases at Dutton Drain, Sixteen Mile Creek and Brock Creek. For most of the historic study period, Sixteen Mile Creek has had the highest coliform levels.

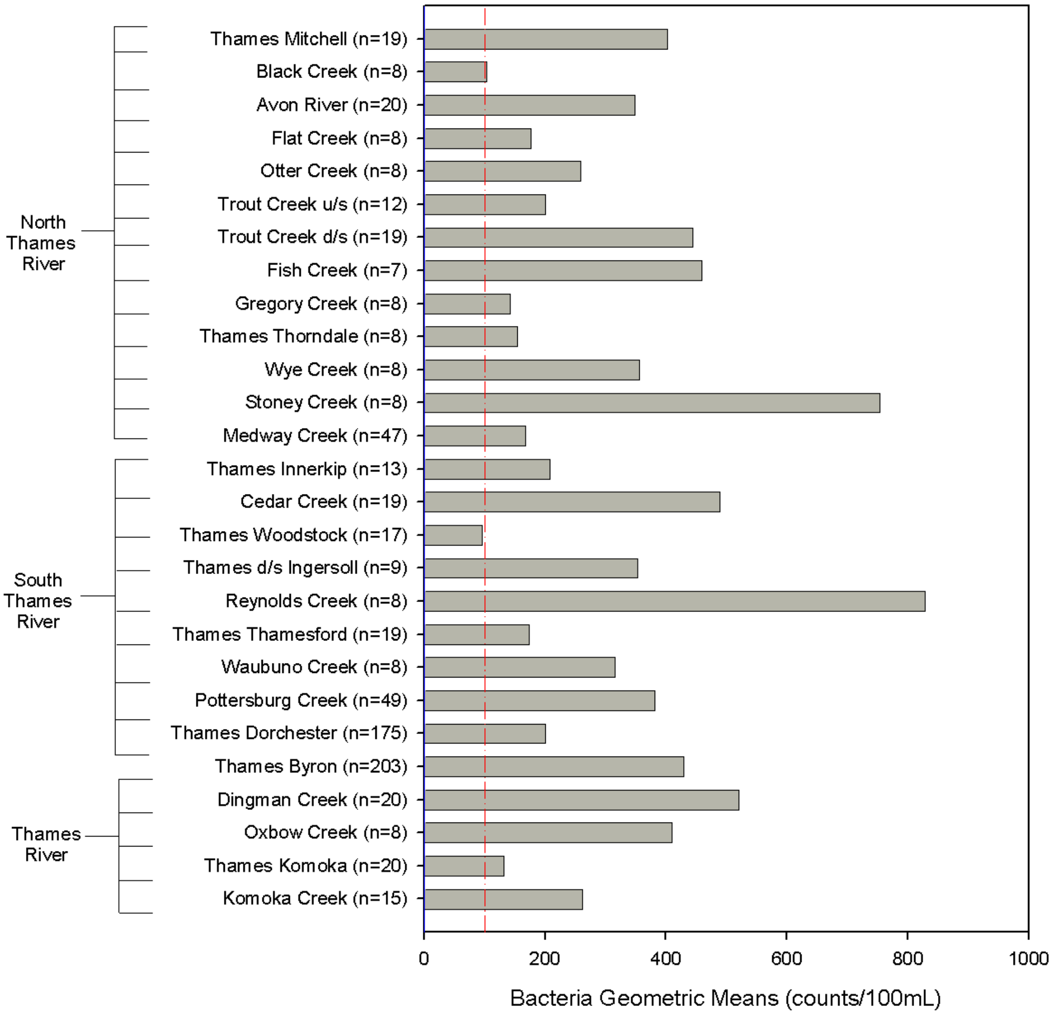
Figure 3.2.4-22: Current Bacteria Conditions in the UTRCA Watershed - Box and Whisker



Current Bacteria (Escherichia coli) count for 2000-2004 for monitoring stations in the Upper Thames River watersheds. Sample size at each site is shown in brackets. The blue line is the Ontario Drinking Water Standard of 'not detectable', depicted here as zero. The red line is the Provincial Water Quality Objective (Recreational Guideline) of 100 counts per 100 mL.

Figure 3.2.4-22: **Current Bacteria Condition in the UTRCA Watershed – Box and Whisker**

Figure 3.2.4-23: Current Bacteria Conditions in the UTRCA Watershed - Geometric Means in Bar Chart



Current Bacteria (Escherichia coli) geometric means for 2000-2004 for monitoring stations in the Upper Thames River watersheds. Sample size at each site is shown in brackets. The blue line is the Ontario Drinking Water Standard of ‘not detectable’, depicted here as zero. The red line is the Provincial Water Quality Objective (Recreational Guideline) of 100 counts per 100 mL.

Figure 3.2.4-23: Current Bacteria Conditions in the UTRCA Watershed – Geometric Means in Bar Chart

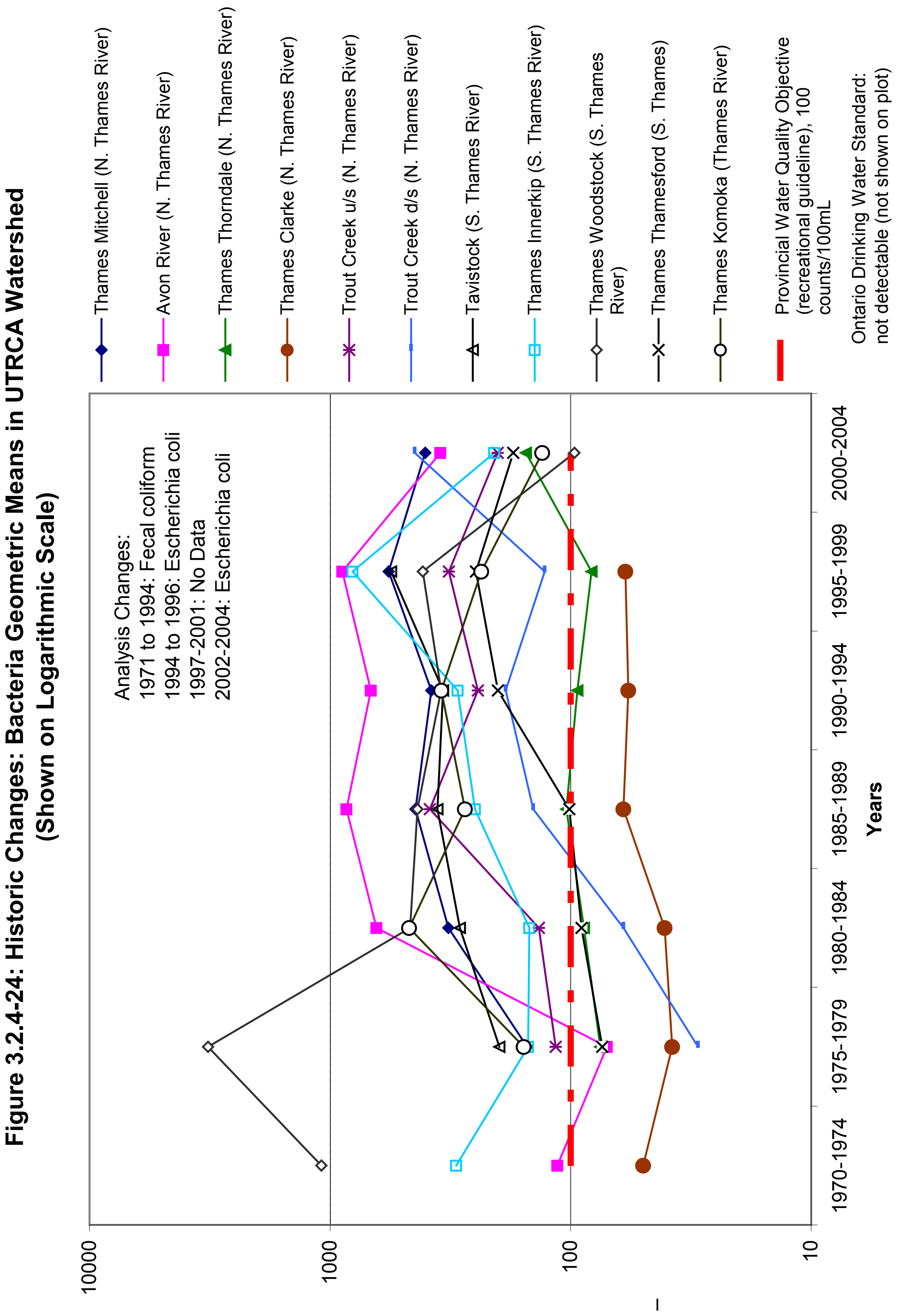


Figure 3.2.4-24: **Historic Changes: Bacteria Geometric Means in UTRCA Watershed (Shown on Logarithmic Scale)**

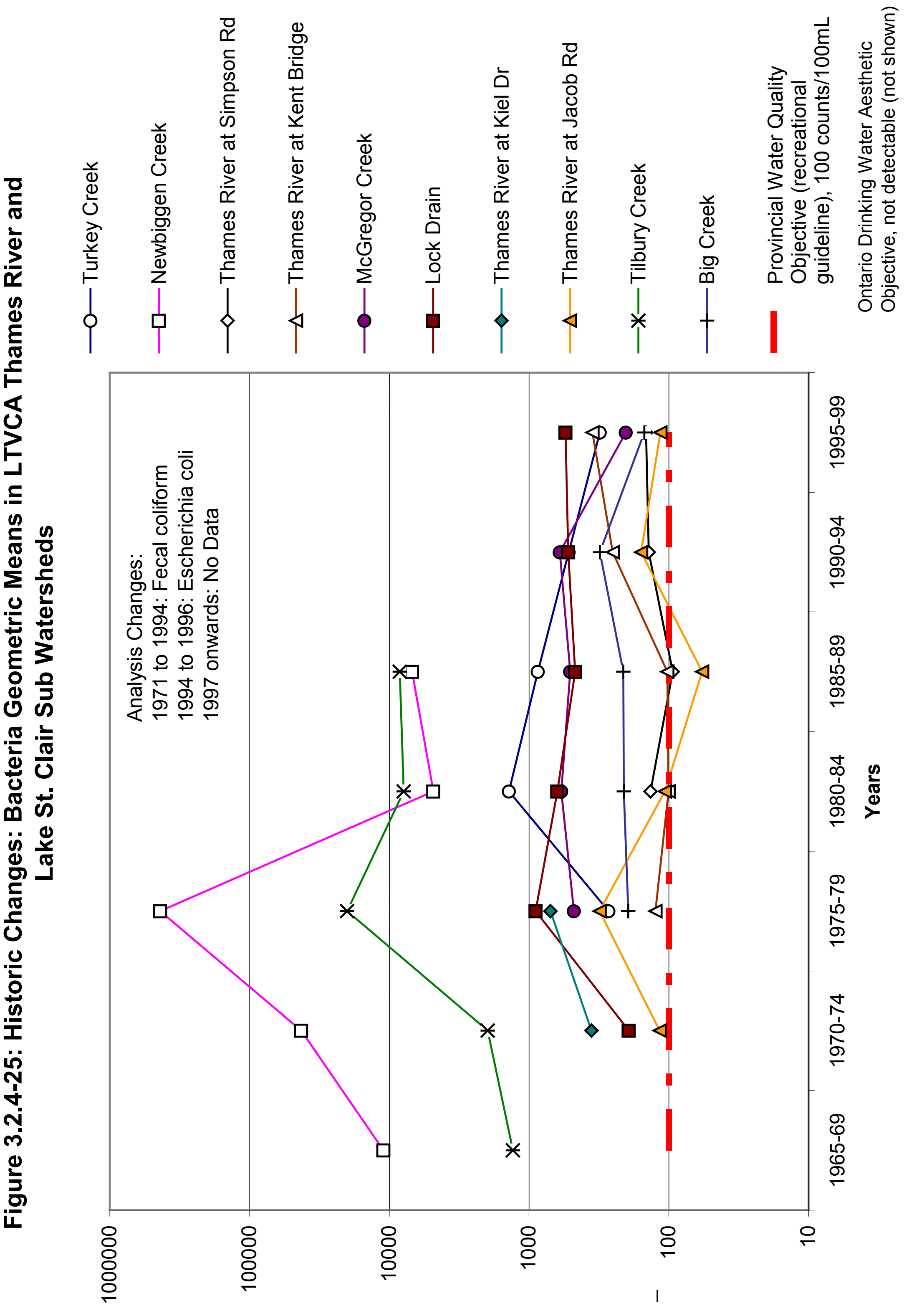


Figure 3.2.4-25: **Historic Changes: Bacteria Geometric Means in LTVCA Thames River and Lake St. Clair Subwatersheds**

Figure 3.2.4-26: Historic Changes: Bacteria Geometric Means in LTVCA Lake Erie Watershed (Shown on a Logarithmic Scale)

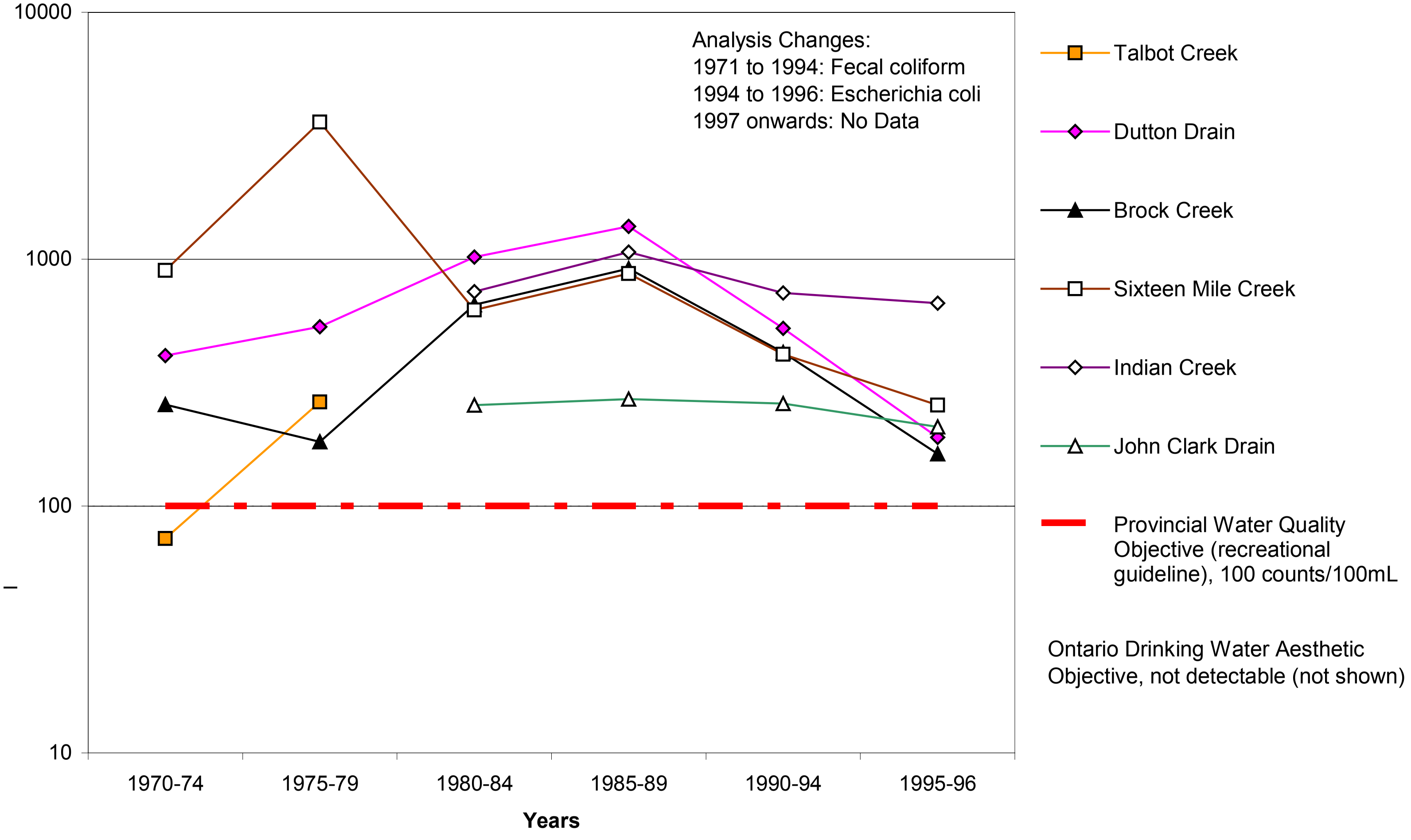


Figure 3.2.4-26: **Historic Changes: Bacteria Geometric Means in LTVCA Lake Erie Watershed (Shown on a Logarithmic Scale)**

(6) Copper

Fate and Behaviour: Copper is an essential element; however, it can be toxic to aquatic life at elevated levels. Metals including copper, lead, and zinc can bio-accumulate in fish, wildlife, and humans causing long-term health effects. Metals are long-lasting in the environment where they tend to accumulate in streambed sediments.

Sources: Anthropogenic (human) sources that can impact on water quality include plumbing fixtures and pipes, textile manufacturing, paints, electrical conductors, wood preservatives, pesticides, fungicides, and sewage treatment plant effluent.

Standards: The Provincial Water Quality Objective for copper is 5 µg/L for healthy aquatic life. The Ontario Drinking Water Standard is 1mg/L (1000 µg/L) for aesthetic water quality.

(a) Current Conditions

UTRCA: As shown in **Figure 3.2.4-27: Current Copper Conditions in the Thames River Watershed**, 75th percentile concentrations of copper are routinely below the Provincial Water Quality Objective for the protection of aquatic life at all sites in the upper Thames River watershed. Only Avon River and Cedar Creek have 90th percentile whiskers above this guideline, which indicates that a number of sample results are above the guideline. All sites have levels well below the Ontario Drinking Water Standard (aesthetic objective).

LTVCA: Figure 3.2.4-27 shows that the Thames River at Jacob Road station has a 75th percentile total copper level over the PWQO but that the concentration is far below the ODWS. From **Figure 3.2.4-28: Current Copper Conditions in the LTVCA Watershed**, the average copper levels at all stations except Thames River at Jacob Road are below the PWQO. The lowest average copper level is 2.1 µg/L. The maximum values at four stations (Thames at Jacob Road, Thames at Currie Road, Thames at Kent Bridge and Big Creek) are above the PWQO of 5 µg/L.

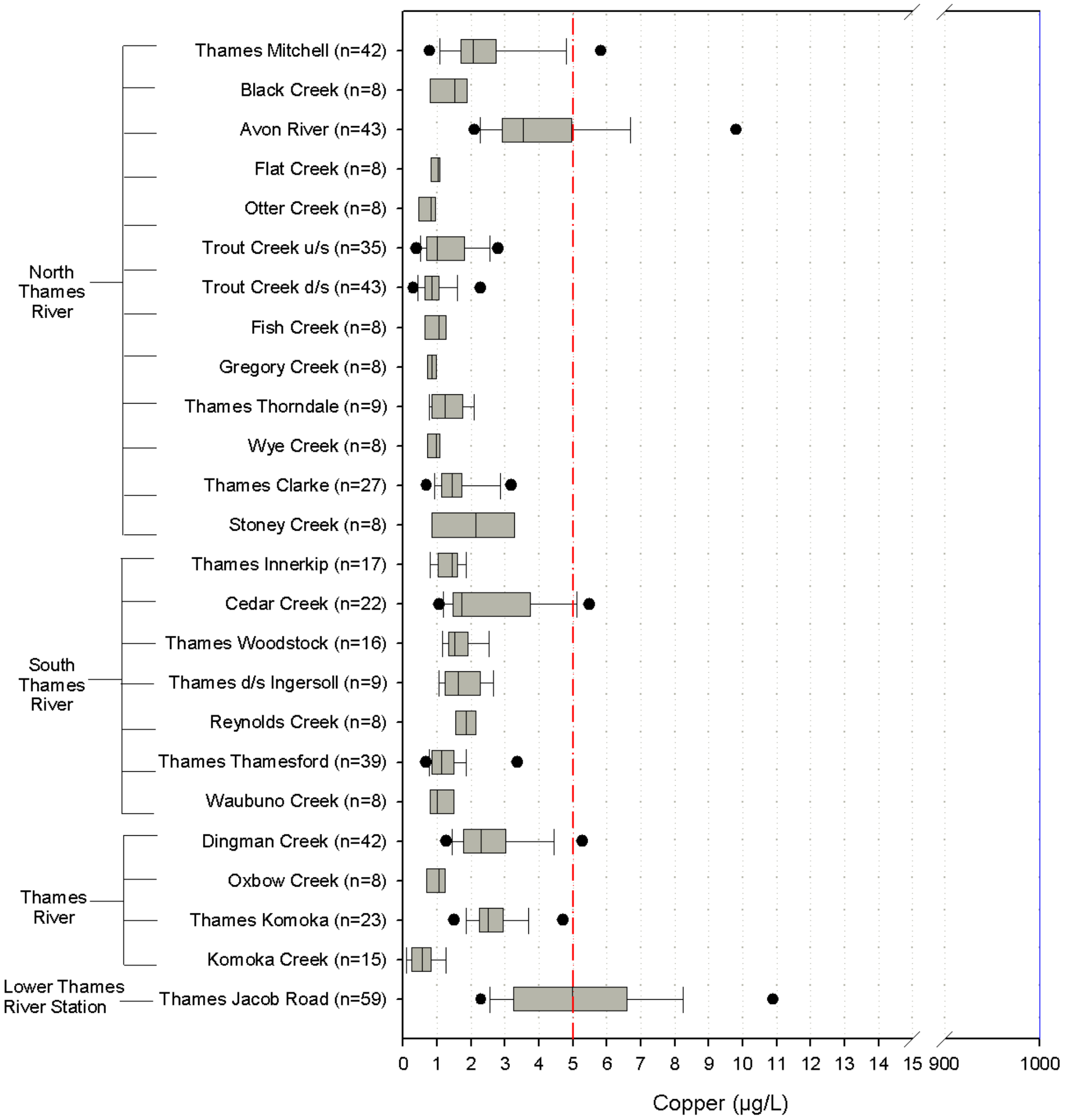
(b) Historic changes

UTRCA: Figure 3.2.4-29: Historic Changes: Copper 75th Percentiles in UTRCA Watershed shows that in the 1970s to the mid 1980s, the stations being monitored had 75th percentile copper levels at two to four times the PWQO. The 75th percentile levels of copper at all historic sites have decreased over the past three decades and the current levels are below the PWQO. However, the Avon River has levels that remain very close to the PWQO.

LTVCA - Thames River and Lake St. Clair Subwatersheds: Figure 3.2.4-30: Historic Changes: Copper 75th Percentiles shows that from 1975 to 1990, 75th percentile levels of copper at all stations are higher than the PWQO except at Big Creek in 1980-1984. From the 1990s to 2004, the 75th percentile copper levels were above the PWQO at all stations that have monitoring information with the exception of Newbiggen Creek.

LTVCA - Lake Erie Subwatershed: Figure 3.2.4-31: Historic Changes: Copper 75th Percentiles shows that the 75th percentile copper at the three stations monitored decreased from about 10 µg/L in the 1980s to levels that were below the PWQO of 5 µg/L in the 1990s.

Figure 3.2.4-27: Current Copper Conditions in the Thames River Watershed



Copper concentrations (2000-2004) for monitoring stations in the Upper and Lower Thames River watersheds. Sample size is shown in brackets at each station. The red line represents the Provincial Water Quality Objective of 5 µg/L. The blue line represents the Ontario Drinking Water Aesthetic Objective of 1000 µg/L.

Figure 3.2.4-27: Current Copper Conditions in the Thames River Watershed

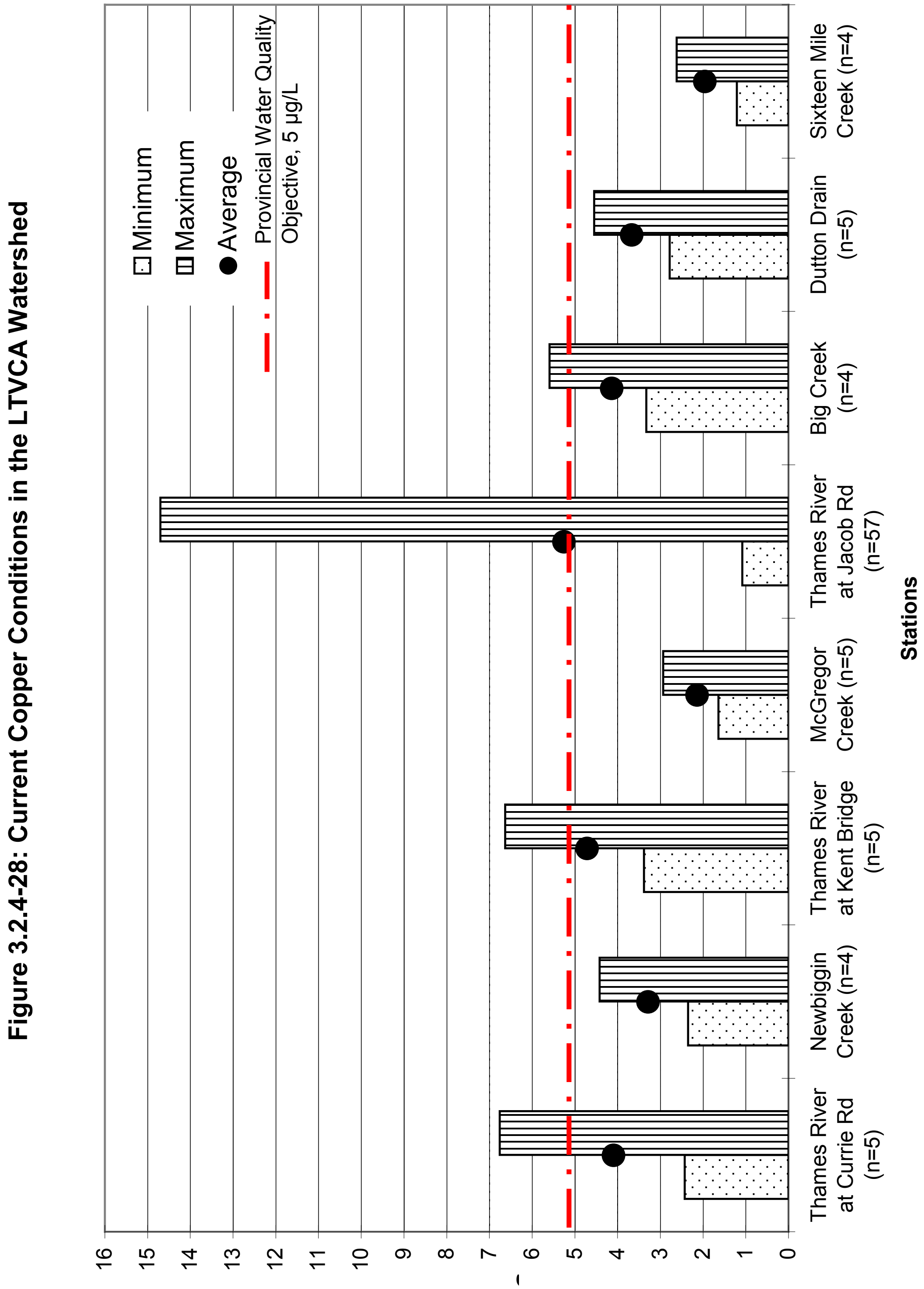


Figure 3.2.4-28: **Current Copper Conditions in the LTVCA Watershed**

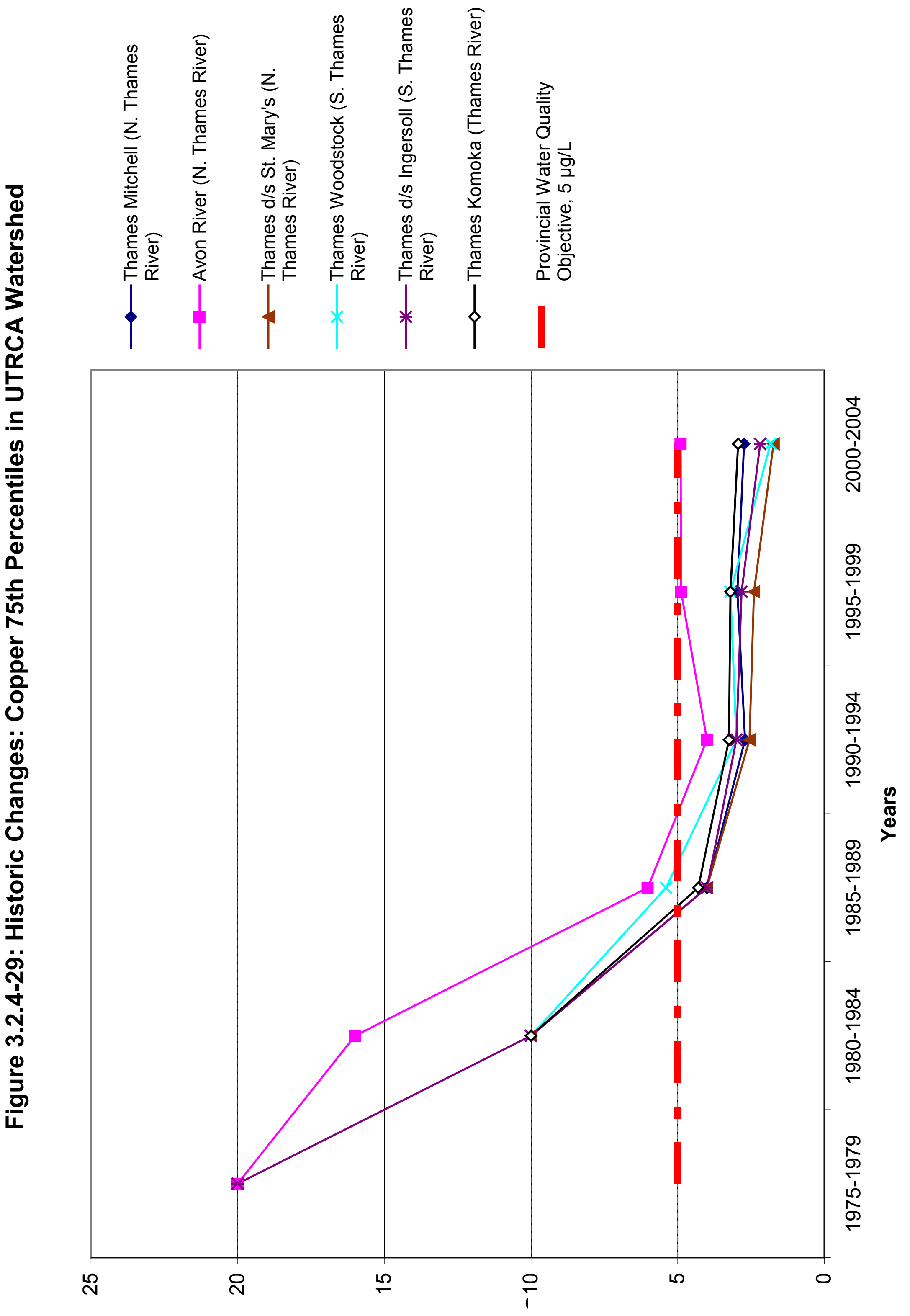


Figure 3.2.4-29: **Historic Changes: Copper 75th Percentiles in UTRCA Watershed**

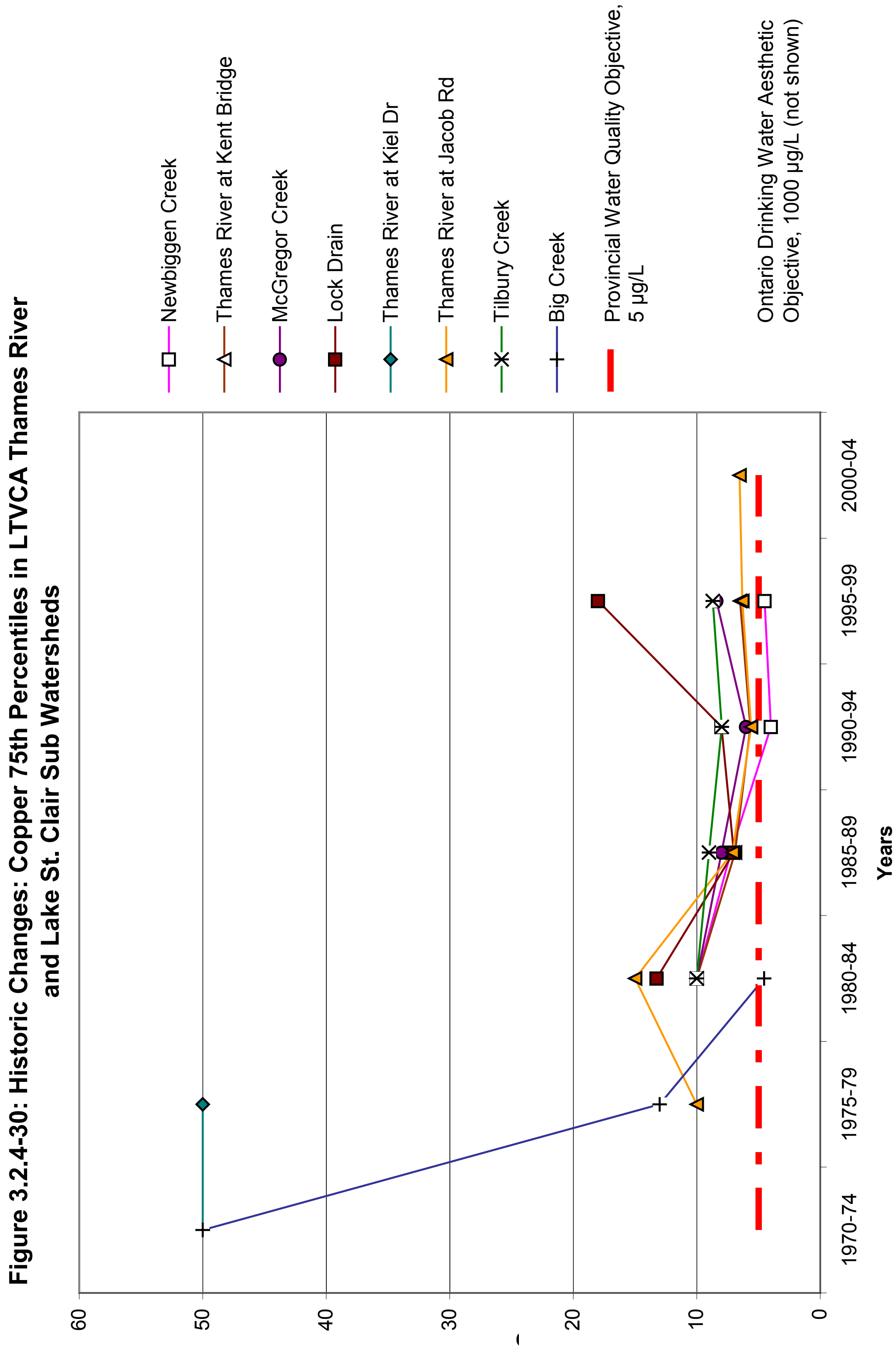


Figure 3.2.4-30: **Historic Changes: Copper 75th Percentiles in LTVCA Thames River and Lake St. Clair Subwatersheds**

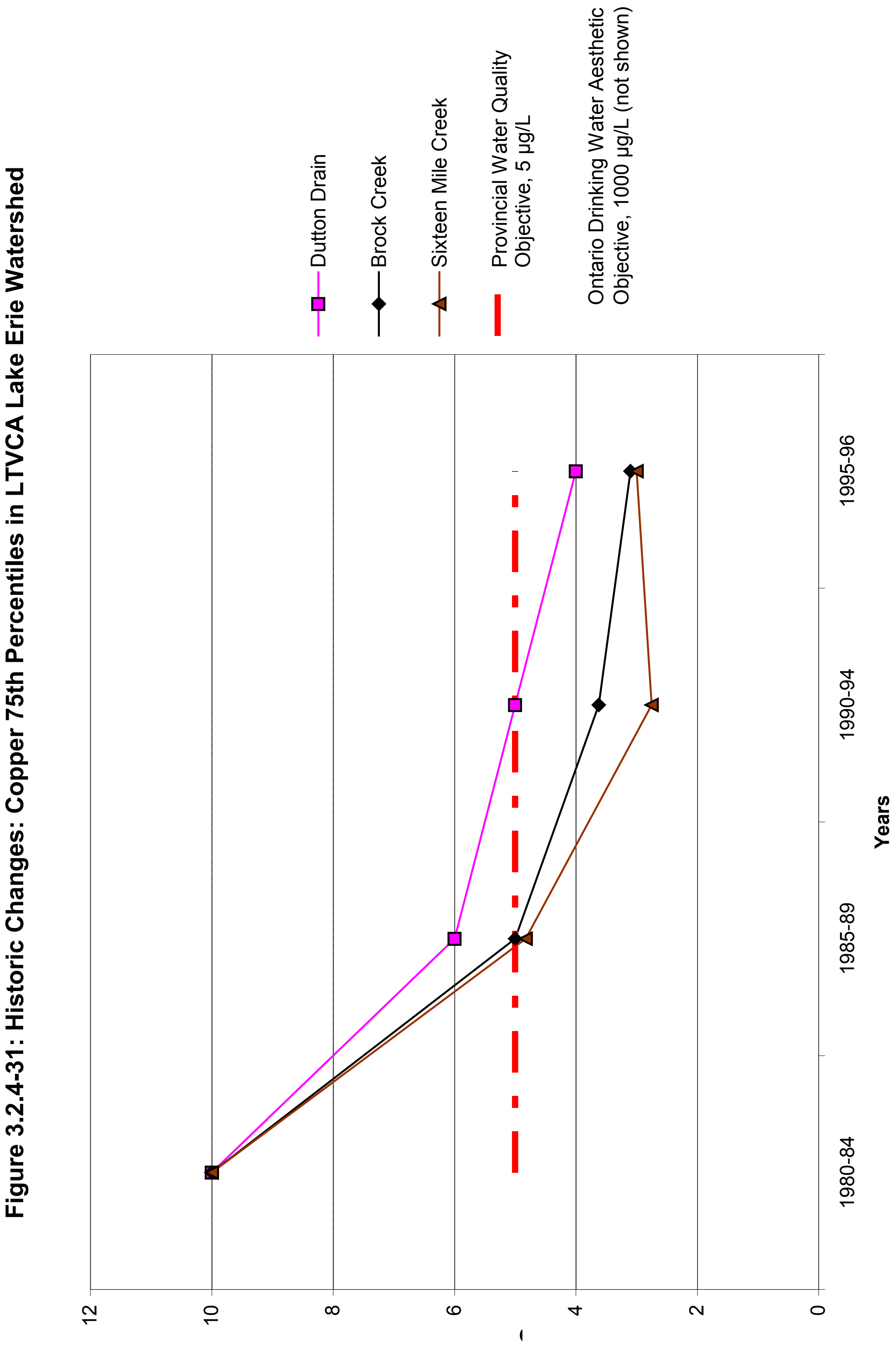


Figure 3.2.4-31: **Historic Changes: Copper 75th Percentiles in LTVCA Lake Erie Watershed**

(7) Zinc

Fate and Behaviour: Zinc is an essential element that is toxic to aquatic life at elevated levels. Zinc adsorbs strongly to particulate matter, especially organic matter. Zinc accumulates in streambed sediments.

Sources: The primary use of zinc is for galvanized products for the automobile and construction industry. Anthropogenic (human) sources of zinc include mining, zinc production facilities, waste disposal and incineration, iron and steel production, corrosion of galvanized structures, coal and fuel combustion, road surface runoff, zinc-containing fertilizers and pesticides.

Standards: The Ontario Drinking Water Standard is 5 mg/L for aesthetic objectives. The Provincial Water Quality Objective for zinc (interim revised) is 20 µg/L for aquatic life. The Canadian Environmental Quality Guideline of CCME is 30 µg/L for aquatic life in freshwater.

(a) Current Conditions

UTRCA: As shown in **Figure 3.2.4-32: Current Zinc Conditions in the Thames River Watershed**, all sites have levels well below the ODWS aesthetic guideline. Concentrations of zinc routinely fall below the PWQO for the protection of aquatic life at all sites in the upper Thames River watershed. Only the Avon River has a 90th percentile whisker that indicates a number of sample results would be above this guideline. The highest 75th percentile zinc concentration is at Avon River (approximately 18 µg/L), and the lowest at Gregory Creek (approximately 1 µg/L).

LTVCA: The zinc levels at all stations are far below the ODWS. **Figure 3.2.4-32** shows that the 75th percentile zinc concentration at the Thames River at Jacob Road is below PWQO criteria. From **Figure 3.2.4-33: Current Zinc Conditions in the LTVCA Watershed**, only the maximum values at three stations (Thames at Jacob Road, Thames at Kent Bridge and Big Creek) are higher than the PWQO of 20 µg/L. The highest average zinc level is 14.3 µg/L at Big Creek and the lowest 3.8 µg/L at McGregor Creek. All average values of zinc are below the PWQO.

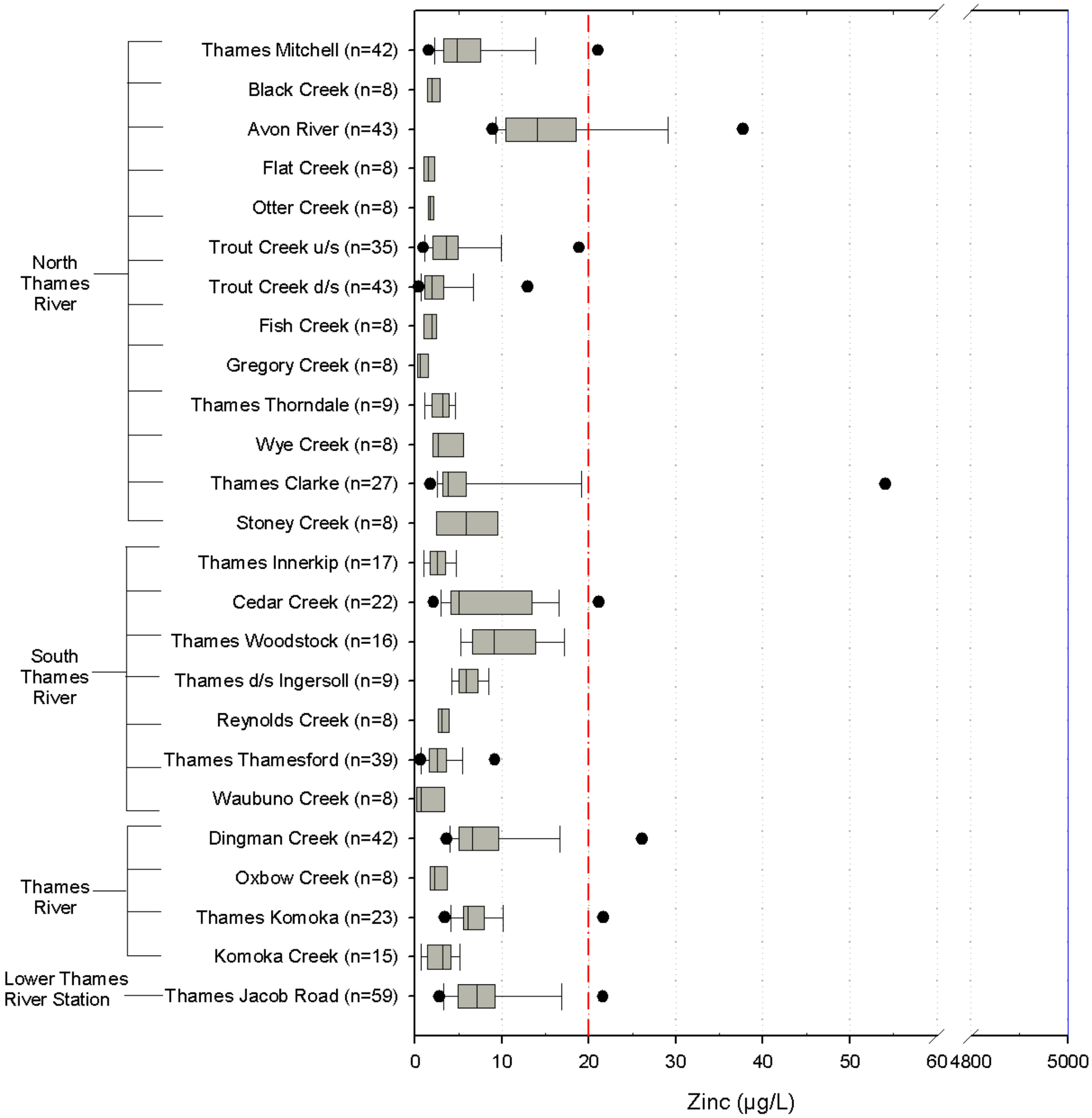
(b) Historic changes

UTRCA: Figure 3.2.4-34: Historic Changes: Zinc 75th Percentiles in UTRCA Watershed indicates that the 75th percentile concentrations of zinc at all historic sites have decreased over the past three decades to current levels that are below the PWQO. Only two stations, the Avon River and the Thames River downstream of Ingersoll, have data sets beginning in the 1970s. Both had 75th percentile levels in 1975-79 that were above the PWQO value of 20 µg/L. In 1985-89, Thames at Woodstock also had a 75th percentile level above the PWQO value. It was only in the 1990s that Avon River samples met the PWQO criteria and the levels remain higher than those at other stations in the UTRCA watershed.

LTVCA - Thames River and Lake St. Clair Subwatersheds: Figure 3.2.4-35: Historic Changes: Zinc 75th Percentiles indicates that the 75th percentile levels of zinc at Newbiggin Creek, Thames River at Kent Bridge and at Jacob Road are below the PWQO from 1980-2004. All other stations were higher than the PWQO at various times or all times from 1970-99.

LTVCA - Lake Erie Subwatershed: As shown in **Figure 3.2.4-36: Historic Changes: Zinc 75th Percentiles**, the three stations monitored had decreasing levels of 75th percentile zinc from the 1980s to the 1990s and were below the PWQO in 1995-96. At Dutton Drain, in 1985-89, the 75th percentile zinc level was above the PWQO. At Brock Creek, there was an increase in the zinc level in the late 1990s but it was still below the PWQO.

Figure 3.2.4-32: Current Zinc Conditions in the Thames River Watershed



Zinc concentrations (2000-2004) for monitoring stations in the Upper and Lower Thames River watersheds. Sample size is shown in brackets at each station. The red line represents the Provincial Water Quality Objective of 20 µg/L. The blue line represents the Ontario Drinking Water Aesthetic Objective of 5000 µg/L.

Figure 3.2.4-32: **Current Zinc Conditions in the Thames River Watershed**

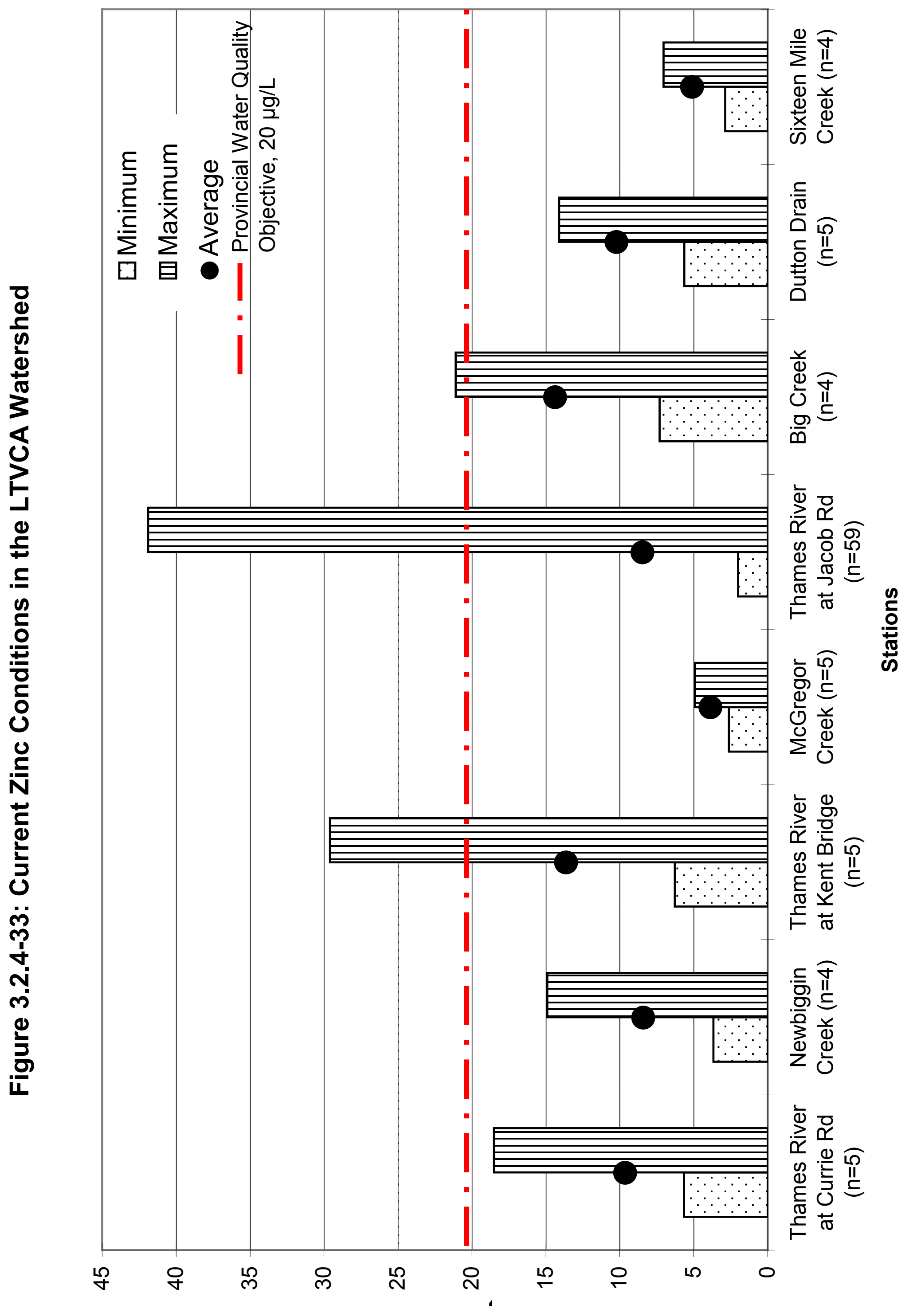


Figure 3.2.4-33: **Current Zinc Conditions in the LTVCA Watershed**

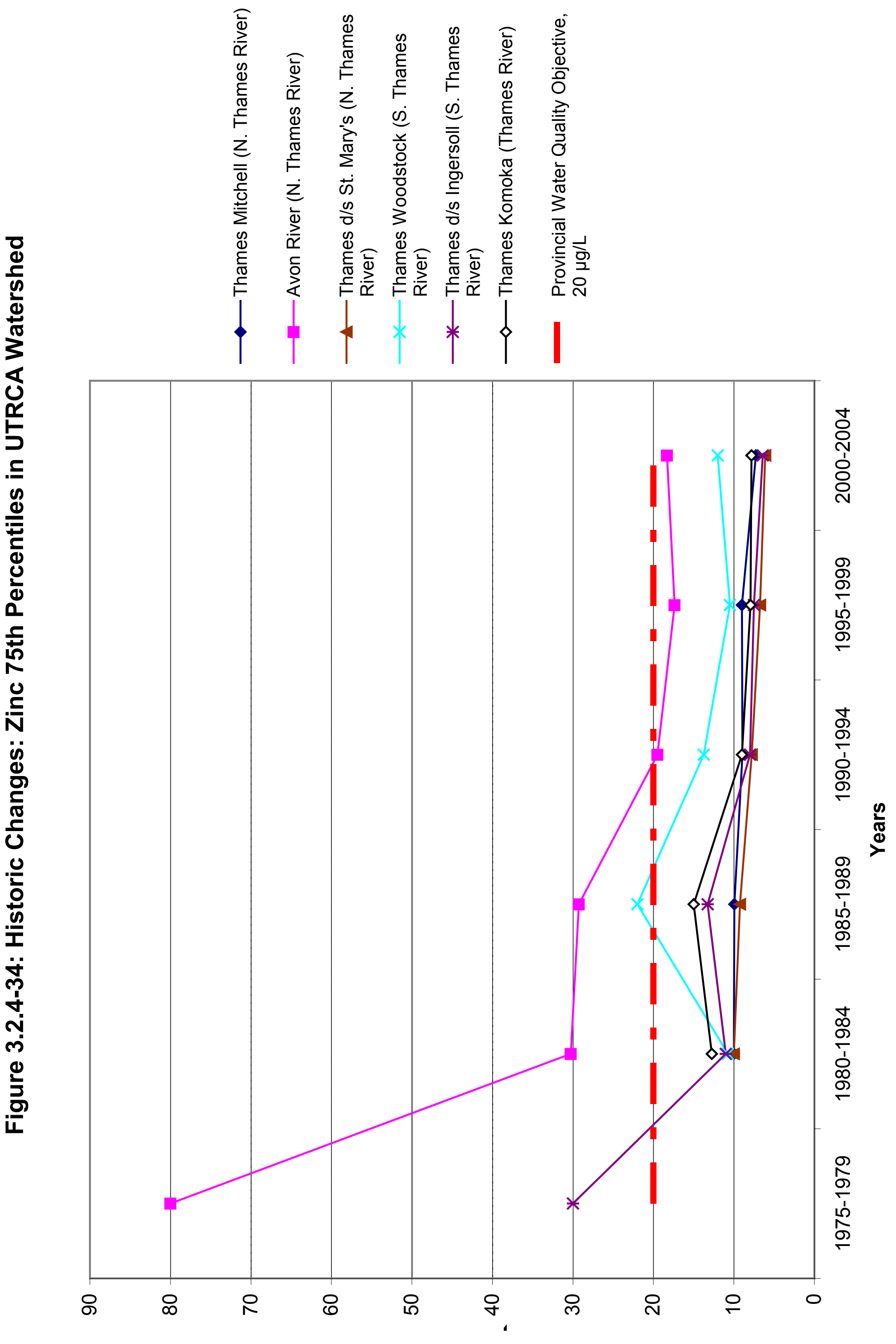


Figure 3.2.4-34: **Historic Changes: Zinc 75th Percentiles in UTRCA Watershed**

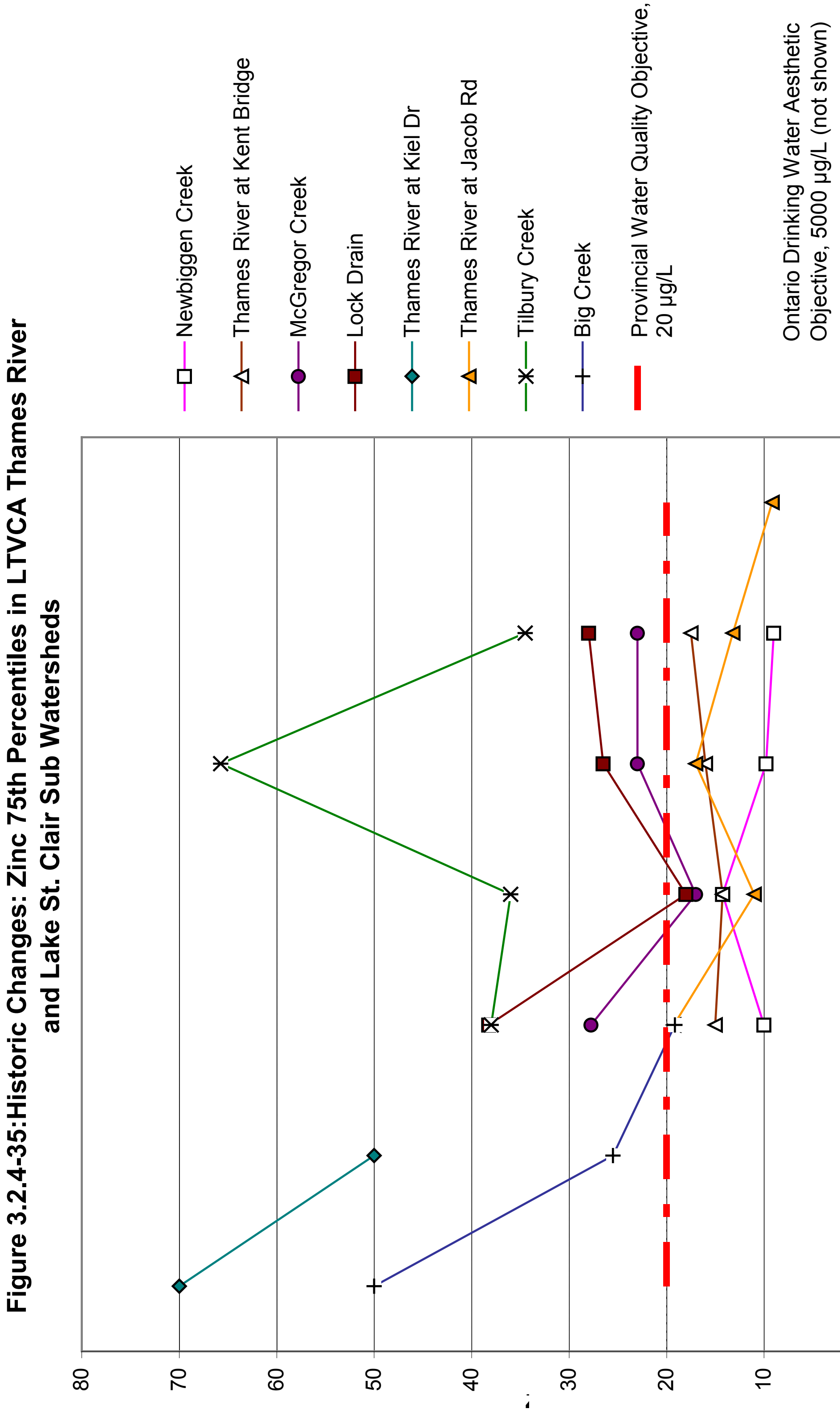


Figure 3.2.4-35: Historic Changes: Zinc 75th Percentiles in LTVCA Thames River and Lake St. Clair Subwatersheds

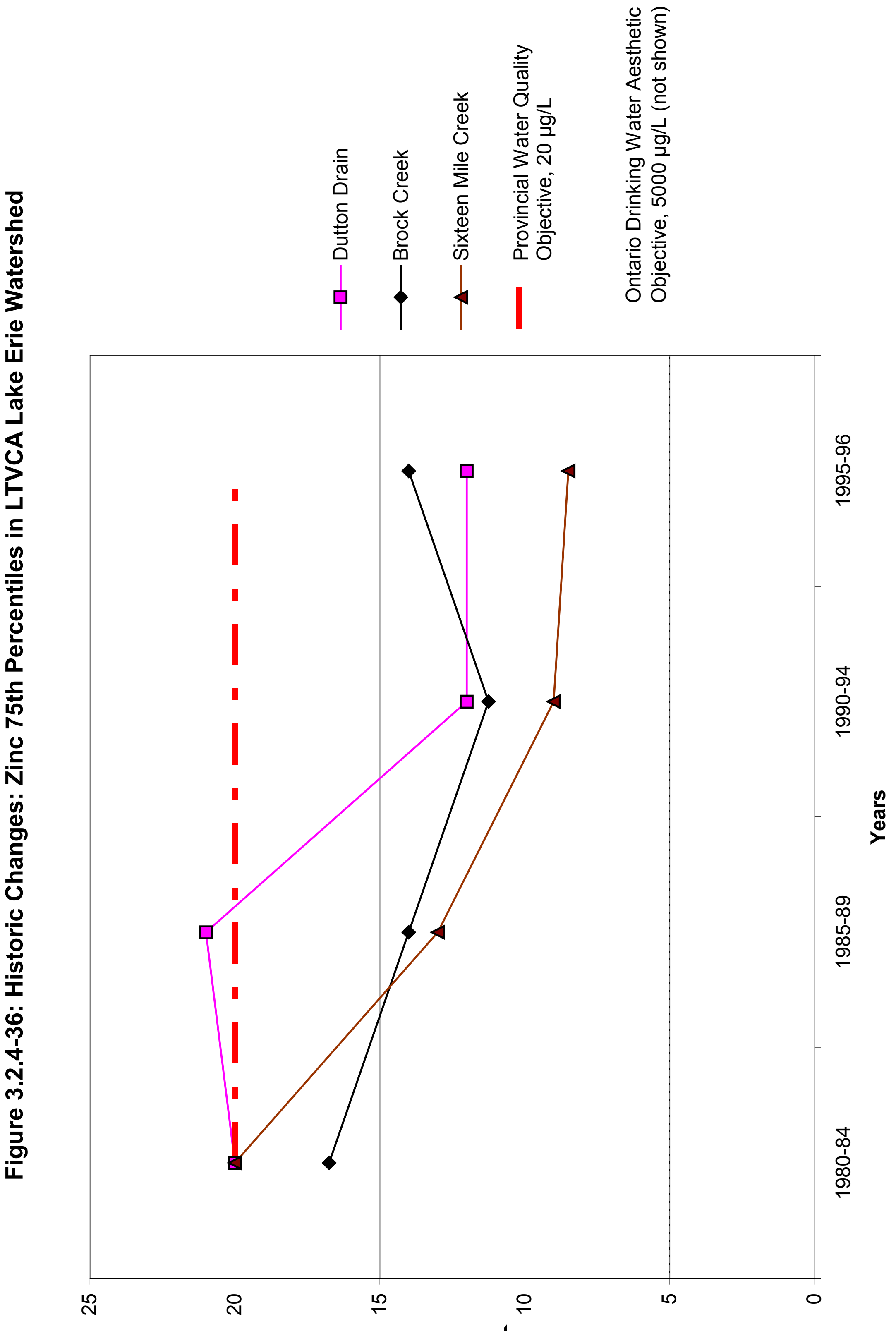


Figure 3.2.4-36: **Historic Changes: Zinc 75th Percentiles in LTVCA Lake Erie Watershed**

(8) Lead

Fate and Behaviour: Lead is a nonessential trace element. It is a cumulative toxin that can affect the central nervous system of animals and humans. The solid form binds with dust and certain types of soil, especially clay and organic matter, and can accumulate in bed sediments.

Sources: The primary use of lead in Canada is the production of acid storage batteries. Anthropogenic sources that can impact water quality include: mining, milling and smelting of lead; burning of fossil fuels, municipal waste incineration, wastewater, sewage sludge, phosphate fertilizers, and certain pesticides. Atmospheric deposition may be a significant source. It has been used extensively in plumbing, and was used in leaded gasoline which was phased out in the 1980s.

Standards: The Provincial Water Quality Objective is 5 µg/L for healthy aquatic life. The Ontario Drinking Water Standard is 10 µg/L.

Lead levels are difficult to assess for several reasons as discussed in the special cases section. As recommended by the Conservation Ontario February 2003 report 'Water Sampling and Data Analysis Manual' for PWQMN partners, lead data was not graphed. Instead, the number and percent of samples above the relevant lead guidelines are provided in tables.

(a) Current Conditions

UTRCA: Sample results as number and percent above the PWQO and ODWS are summarized in **Table 3.2.4-1: Current Conditions of Lead in UTRCA Watershed: Number and Percent of Samples Exceeding PWQO and ODWS**.

For the period of 2000-2004, lead levels routinely fall below the Ontario Drinking Water Standard of 10 µg/L at sites across the upper Thames River watershed. Seven of the 14 stations along the North Thames River, five of the seven stations along the South Thames River, and two of the four stations along the Thames River in the UTRCA watershed had all their samples conform to ODWS lead criteria. All of the other stations (11 of 25) had only one sample higher than the ODWS value.

The stations with samples containing lead below both PWQO and ODWS levels are Thames d/s St. Marys (N. Thames River), Wye Creek (N. Thames River), Thames at Woodstock (S. Thames River) and Thames d/s Ingersoll (S. Thames River).

All of the other stations (21 of 25) had at least one sample above the PWQO of 5 µg/L. The stations with the highest percentage of samples higher than the PWQO were Fish Creek (N. Thames) and Waubuno Creek (S. Thames). Both had three of eight samples (38%) with concentrations of lead over the PWQO. The Avon River had nine of 43 (21%) samples above the PWQO.

LTVCA: Sample results as number and percent above the PWQO and ODWS in the LTVCA watershed are summarized in **Table 3.2.4-2: Current Conditions of Lead in LTVCA Watershed: Number and Percent of Samples Exceeding PWQO and ODWS.**

In the Thames River and Lake St. Clair subwatersheds in 2000-2004, only the Thames River at Currie Road station had a sample that had a lead value higher than the ODWS. Only the Thames River at Kent Bridge conforms to both PWQO and ODWS criteria. All the other stations had at least one sample with lead above the PWQO.

In the Lake Erie subwatershed, the lead levels in samples at Dutton Drain are below both PWQO and ODWS. At the other sampling station, Sixteen Mile Creek, all samples conform to ODWS but one sample was above the PWQO.

Table 3.2.4-1: **Current Conditions of Lead in UTRCA Watershed: Number and Percent of Samples Exceeding PWQO of 5 µg/L and ODWS of 10 µg/L**

Stations	Data	2000-04	Total Number of Samples in 2000-04
Thames Mitchell (N. Thames River)	**A**	4 (10%)	42
	B	0 (0%)	
Thames d/s St. Marys (N. Thames River)	**A**	0 (0%)	8
	B	0 (0%)	
Black Creek (N. Thames River)	**A**	2 (25%)	8
	B	1 (13%)	
Avon River (N. Thames River)	**A**	9 (21%)	43
	B	1 (2%)	
Flat Creek (N. Thames River)	**A**	1 (13%)	8
	B	0 (0%)	
Otter Creek (N. Thames River)	**A**	1 (13%)	8
	B	1 (13%)	
Trout Creek u/s (N. Thames River)	**A**	4 (11%)	35
	B	1 (3%)	
Trout Creek d/s (N. Thames River)	**A**	4 (9%)	43
	B	0 (0%)	
Fish Creek (N. Thames River)	**A**	3 (38%)	8
	B	1 (13%)	
Gregory Creek (N. Thames River)	**A**	2 (25%)	8
	B	0 (0%)	
Thames Thorndale (N. Thames River)	**A**	3 (33%)	9
	B	0 (0%)	
Wye Creek (N. Thames River)	**A**	0 (0%)	8
	B	0 (0%)	
Thames Clarke (N. Thames River)	**A**	2 (7%)	27
	B	0 (0%)	
Stoney Creek (N. Thames River)	**A**	1 (13%)	8
	B	1 (13%)	
Thames Innerkip (S. Thames River)	**A**	2 (12%)	17
	B	1 (6%)	
Cedar Creek (S. Thames River)	**A**	3 (14%)	22
	B	0 (0%)	
Thames Woodstock (S. Thames River)	**A**	0 (0%)	16
	B	0 (0%)	

Stations	Data	2000-04	Total Number of Samples in 2000-04
Thames d/s Ingersoll (S. Thames River)	**A**	0 (0%)	9
	B	0 (0%)	
Reynold's Creek (S. Thames River)	**A**	2 (25%)	8
	B	0 (0%)	
Thames Thamesford (S. Thames River)	**A**	1 (3%)	39
	B	0 (0%)	
Waubuno Creek (S. Thames River)	**A**	3 (38%)	8
	B	1 (13%)	
Dingman Creek (Thames River)	**A**	2 (5%)	42
	B	1 (2%)	
Oxbow Creek (Thames River)	**A**	1 (13%)	8
	B	1 (13%)	
Thames Komoka (Thames River)	**A**	1 (4%)	23
	B	0 (0%)	
Komoka Creek (Thames River)	**A**	3 (20%)	15
	B	0 (0%)	

A = Number and percent of samples exceeding the PWQO of 5 µg/L
B = Number and percent of samples exceeding the ODWS of 10 µg/L
Blank fields indicate no data.

Table 3.2.4-2: Current Conditions of Lead in LTVCA Watershed: Number and Percent of Samples Exceeding PWQO of 5 µg/L and ODWS of 10 µg/L

Stations	Data	2000-04	Total Number of Samples in 2000-04
Thames at Currie Road (Thames River)	**A**	1 (20%)	5
	B	1 (20%)	
Newbiggin Creek (Thames River)	**A**	1 (25%)	4
	B	0 (0%)	
Thames at Kent Bridge (Thames River)	**A**	0 (0%)	5
	B	0 (0%)	
McGregor Creek (Thames River)	**A**	1 (20%)	5
	B	0 (0%)	
Thames at Jacob Road (Thames River)	**A**	7 (12%)	59
	B	0 (0%)	
Big Creek (Thames River)	**A**	1 (25%)	4
	B	0 (0%)	
Dutton Drain (Lake Erie)	**A**	0 (0%)	5
	B	0 (0%)	
Sixteen Mile Creek (Lake Erie)	**A**	1 (25%)	4
	B	0 (0%)	

A = Number and percent of samples exceeding the PWQO of 5 µg/L
B = Number and percent of samples exceeding the ODWS of 10 µg/L
Blank fields indicate no data.

(b) Historic changes

There appears to be an overall decrease in the number of samples with lead levels above the PWQO and ODWS in both the UTRCA and LTVCA watersheds.

UTRCA: Sample results as number and percent above the PWQO and ODWS are summarized in **Table 3.2.4-3: Historic Changes in Lead in UTRCA Watershed: Number and Percent of Samples Exceeding PWQO and ODWS**.

In 1980-84, all stations in the UTRCA subwatersheds had samples with lead levels above the PWQO and ODWS. The percentage of samples higher than both criteria ranged from 21% to 41%. In 1985-89, many stations had a lower percentage of samples above the PWQO and the ODWS values and, in 1990-94, all stations show a reduction from 1980-2004 levels. The Thames at Woodstock in the 1985-90 and Thames d/s of Ingersoll in 1990-94 conformed to the ODWS criteria.

Since 1995-99, five out of six stations had lead levels at or below ODWS and three of the six also had levels below the PWQO. Only the Avon River had samples above both the PWQO and the ODWS throughout the monitoring period. In 2000-04, the Thames at Mitchell and the Thames at Komoka also had samples above the PWQO. The Avon River (N. Thames River) consistently has a higher number of samples containing lead above PWQO and ODWS than other stations over the full monitoring period.

LTVCA - Thames River and Lake St. Clair Subwatersheds: Sample results as number and percent above the PWQO and ODWS are summarized in **Table 3.2.4-4: Historic Conditions in Lead in LTVCA Watershed: Number and Percent of Samples Exceeding PWQO and ODWS**. At all stations, there were samples containing lead above PWQO and ODWS up to the mid 1990s. In 1980-84, the percentage of samples above both criteria ranged from 31% to 47%. By 1995-99, the percentage of samples containing lead above these guidelines decreased at all stations with the exception of Thames River at Jacob Road. This station had significantly high percentages of samples with lead above both the PWQO and ODWS (82% and 75% respectively) in the 1995-99 time block. In 2000-04, all stations being monitored conformed to the ODWS but four of seven stations had at least one sample higher than the PWQO. Note: A considerably higher number of samples were monitored throughout the historic monitoring period at the LTVCA station of Thames River at Jacob Road, with the highest sample size of 416 in the 1980-84 time block.

LTVCA - Lake Erie Subwatershed: Sample results as number and percent above PWQO and ODWS are summarized in **Table 3.2.4-4**. At all three stations monitored, lead levels were above PWQO and ODWS in 1980-89. The percentage of samples higher than both criteria ranged from 36% to 41% in 1980-84, and from 2% to 10% in 1985-89. These percentages decreased by the early to mid 1990s. In 1990-94, lead levels dropped to below the ODWS at Brock Creek and Sixteen Mile. In 1995-99, lead levels were below both PWQO and ODWS at all three stations. In 2000-04, at Sixteen Mile, one sample of four has lead levels higher than PWQO but below ODWS. Brock Creek was not monitored in recent years.

Table 3.2.4-3: **Historic Changes in Lead in UTRCA Watershed: Number and Percent of Samples Exceeding PWQO of 5 µg/L and ODWS of 10 µg/L**

Stations	Data	1980-84	1985-89	1990-94	1995-99	2000-04
Thames Mitchell (N. Thames River)	**A**	8 of 22 (36%)	2 of 52 (4%)	9 of 55 (16%)	3 of 30 (10%)	4 of 42 (10%)
	B	8 of 22 (36%)	1 of 52 (2%)	4 of 55 (7%)	0 of 30 (0%)	0 of 30 (0%)
Avon River (N. Thames River)	**A**	23 of 45 (51%)	18 of 56 (32%)	7 of 55 (13%)	7 of 32 (22%)	9 of 43 (21%)
	B	17 of 45 (38%)	15 of 56 (27%)	1 of 55 (2%)	2 of 32 (6%)	1 of 43 (2%)
Thames d/s St. Marys (N. Thames River)	**A**	9 of 22 (41%)	1 of 56 (2%)	7 of 55 (13%)	0 of 11 (0%)	0 of 8 (0%)
	B	9 of 22 (41%)	1 of 56 (2%)	1 of 55 (2%)	0 of 11 (0%)	0 of 8 (0%)
Thames Woodstock (S. Thames River)	**A**	10 of 22 (45%)	8 of 57 (14%)	6 of 55 (11%)	0 of 12 (0%)	0 of 16 (0%)
	B	8 of 22 (36%)	0 of 57 (0%)	1 of 55 (2%)	0 of 12 (0%)	0 of 16 (0%)
Thames d/s Ingersoll (S. Thames River)	**A**	15 of 36 (42%)	1 of 56 (2%)	7 of 54 (13%)	0 of 12 (0%)	0 of 9 (0%)
	B	9 of 36 (25%)	1 of 56 (2%)	0 of 54 (0%)	0 of 12 (0%)	0 of 9 (0%)
Thames Komoka (Thames River)	**A**	17 of 47 (36%)	16 of 55 (29%)	5 of 52 (10%)	0 of 12 (0%)	1 of 23 (4%)
	B	10 of 47 (21%)	11 of 55 (20%)	1 of 52 (2%)	0 of 12 (0%)	0 of 23 (0%)

A = Number and percent of samples exceeding the PWQO of 5 µg/L
B = Number and percent of samples exceeding the ODWS of 10 µg/L
Blank fields indicate no data.

Table 3.2.4-4: **Historic Changes in Lead in LTVCA Watershed: Number and Percent of Samples Exceeding PWQO of 5 µg/L and ODWS of 10 µg/L**

Stations*	Data	1970-74	1975-79	1980-84	1985-89	1990-94	1995-99	2000-04
Newbiggen Creek	A			8 of 17 (47%)	5 of 40 (13%)	6 of 39 (15.3%)	1 of 9 (11.1%)	1 of 4 (25%)
	B			8 of 17 (47%)	5 of 40 (13%)	6 of 39 (15.3%)	0 of 9 (0%)	0 of 4 (0%)
Thames River at Kent Bridge	A			7 of 21 (33%)	9 of 52 (17%)	14 of 51 (27%)	0 of 11 (0%)	0 of 5 (0%)
	B			7 of 21 (33%)	3 of 52 (6%)	5 of 51 (10%)	0 of 11 (0%)	0 of 5 (0%)
McGregor Creek	A			8 of 20 (40%)	3 of 51 (6%)	11 of 54 (20%)	1 of 13 (8%)	1 of 5 (20%)
	B			8 of 20 (40%)	3 of 51 (6%)	3 of 54 (6%)	1 of 13 (8%)	0 of 5 (0%)
Lock Drain	A			7 of 16 (44%)	5 of 41 (12%)	17 of 48 (35%)	2 of 13 (15%)	
	B			7 of 16 (44%)	1 of 41 (2%)	6 of 48 (13%)	0 of 13 (0%)	
Thames River at Jacob Road	A		9 of 9 (100%)	199 of 416 (48%)	48 of 212 (23%)	44 of 188 (23%)	119 of 145 (82%)	7 of 59 (12%)
	B		9 of 9 (100%)	130 of 416 (31%)	19 of 212 (9%)	13 of 188 (7%)	109 of 145 (75%)	0 of 59 (0%)
Tilbury Creek	A			9 of 21 (43%)	12 of 53 (23)	22 of 54 (41%)	1 of 14 (7%)	
	B			8 of 21 (38%)	5 of 53 (9%)	7 of 54 (13%)	0 of 14 (0%)	
Big Creek	A	8 of 8 (100%)	37 of 150 (25%)					1 of 4 (25%)
	B	7 of 8 (88%)	28 of 150 (19%)					0 of 4 (0%)
Dutton	A			8 of 22 (36%)	5 of 50 (10%)	6 of 42 (14%)	0 of 13 (0%)	0 of 5 (0%)
	B			8 of 22 (36%)	2 of 50 (4%)	6 of 42 (14%)	0 of 13 (0%)	0 of 5 (0%)
Brock Creek	A			10 of 22 (45%)	5 of 50 (10%)	4 of 44 (9%)	0 of 13 (0%)	
	B			9 of 22 (41%)	2 of 50 (4%)	0 of 44 (0%)	0 of 13 (0%)	
Sixteen Mile	A			10 of 22 (45%)	3 of 50 (6%)	3 of 43 (7%)	0 of 13 (0%)	1 of 4 (25%)
	B			9 of 22 (41%)	1 of 50 (2%)	0 of 43 (0%)	0 of 13 (0%)	0 of 4 (0%)

*Dutton, Brock Creek and Sixteen Mile are stations in the Lake Erie subwatershed of LTVCA. Other stations are in the Thames River and Lake St. Clair subwatersheds of LTVCA.
A = Number and percent of samples exceeding the PWQO of 5 µg/L. B = Number and percent of samples exceeding the ODWS of 10 µg/L.
Blank fields indicate no data.

3.2.5 Data Gaps – Inland Water

Much of the surface water quality monitoring in the Thames Watershed & Region has focused on aquatic ecology and has not been specific to drinking water sources and human health issues. With source protection a priority, water quality monitoring programs will need to be reviewed to address information gaps related to drinking water sources. The pollutant-type, location of sampling, and frequency of sampling are issues that will need to be addressed.

(1) Wastewater Discharges

Data sets on Certificates of Approvals (CoAs), and Wastewater Discharges - municipal and industrial, and Private Water Testing are not available as of February 2007.

(2) Historic Monitoring

At the time this report was prepared, PWQMN data were available up to and including the year 2004. **Table 3.2.3-2: Sample Size in UTRCA Watershed** and **Table 3.2.3-3: Sample Size in LTVCA Watershed** show the number of samples taken from every station for selected parameters. When there were no samples taken, it means either the station was inactive or a certain parameter was not monitored. Most of the stations were established from 1964-1975.

In 1996, monitoring at most of the stations was stopped when the OMOE withdrew the monitoring program. The OMOE restarted the program in 2002. As a result, most of the stations have data gaps at least between 1996 and 2002.

In the LTVCA watershed, in 2002, sampling at five of the historic stations was restarted and three new stations were established. Only one station, the Thames River at Jacob Road, has continuous monitoring data including the period of 1996-2002.

For the time block 2000-2004, seven of eight stations monitored in the LTVCA watershed have only four to five samples per parameter. Only the Thames at Jacob Road has above 50 samples per parameter.

There is no fecal coliform data from 1996 onwards for the LTVCA watersheds. However, for the UTRCA watersheds, Ministry of Health (MOH) provided *E. coli* (a fecal coliform) data for the years 2002 to 2004.

(3) Ongoing and Historic Research

One immediate information gap involves compiling all relevant water/aquatic health research ongoing and completed in the Thames watershed. Many agencies including Environment Canada, National Water Research Institute, Agriculture Canada, and academic institutions have conducted water-related research in the Thames watershed that may support the information needs of the source protection process.

(4) Pesticides, Pharmaceuticals, and Other Contaminants

Concerns have been expressed about many types of water contaminants from sources including agriculture, other industry, and residential outputs. Examples of these contaminants include pesticides, pharmaceutical products, fuels and hydrocarbons, and pathogens including bacteria, viruses, and parasites. There is limited information on the presence of these types of contaminants in surface water and the risks associated with their presence. The UTRCA Pesticide Study does provide some recent information for the upper Thames River watershed.

(5) Technical Experts Recommendations

The Technical Experts Committee (TEC) Report to the Minister of the Environment formed a framework for threats assessment related to sources of drinking water. TEC has "…recognized that some threats to drinking water sources are likely to pose greater risks to consumers than other threats. Pathogens and dense non-aqueous phase liquids (DNAPLs) were identified as two types of contaminants that are extremely problematic from a human health protection standpoint once they enter the aquifer" [46]. DNAPLS are chemicals, generally solvents that are heavier than water and include chlorinated hydrocarbons such as coal tar or creosote.

In Appendix 6 of the Technical Experts Committee Report, the Pathogens Sub-Committee recommends that microbiological characterization be done on all source waters. The committee recommends a multi-indicator approach including *E. coli,* enterococci, coliphage, and *Cryptospiridium.*

Existing microbial databases are typically limited to traditional indicators such as *E. coli* and laboratory methods for some of these are not readily available.

(6) Pathways of Contamination

It is important to examine and understand the pathways of contamination in order to aid in protecting the drinking water sources. The contamination of drinking water sources may occur due to point (discrete) sources such as industrial effluents or non-point (diffused) sources such as urban runoff. At the time of writing of this Report, pathways of contamination in the watershed are yet to be considered.

Various studies have examined the pathways of typical contaminants such as nutrients, metals and pathogens that enter surface water and groundwater drinking sources. Examples of these studies include 'Waterborne Pathogens in Agricultural Watersheds'[47] and 'Sources, pathways, and relative risks of contaminants in surface water and groundwater: a perspective prepared for the Walkerton inquiry'[48]. According to the latter study, there is not enough data available on several contaminants, such as pharmaceuticals in drinking water.

The 'Groundwater Studies in Ontario' is a large project by the OMOE currently going on, that includes identifying pathways of groundwater source contamination[49]. Potential sources being mapped include rail yards, stormwater ponds, animal feed lots, gas stations, paint shops, car washes, etc.

(7) Sediment Analysis

Contaminated sediments are a concern, as toxic materials may be stored for a long period of time at the bottom of a watercourse and may be released into the water column during storm events or other disturbances of the riverbed. A review of any available sediment data would be useful in identifying contaminant locations.

(8) Bio-accumulation

Bio-accumulation of toxic materials into aquatic species reflects contaminant levels in surface water systems. The Guide to Eating Ontario Sport Fish provides some useful information and tissue analyses for sport fish consumption guidelines provide some data. Additional compilation of historic and ongoing research in this area would be of value in highlighting areas and critical contaminants.

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[46] OMOE. 2004. Watershed-based Source Protection Planning. Science-based Decision-making for Protecting Ontario's Drinking Water Resources: A Threats Assessment Framework. Technical Experts Committee Report to the Minister of the Environment.

[47] Rosen, B.H. February 2000. Watershed Science Institute Technical Note #2.

[48] Ritter, L., K. Solomon, P. Sibley, K. Hall, P. Keen, G. Mattu, B. Linton. January 2002. Journal of Toxicology and Environmental Health A. 2002 Jan 11;65(1):1-142.

[49] OMOE. March 2004. Groundwater Studies on Ontario: Mapping a hidden treasure. www.ene.gov.on.ca/programs/4197e01.pdf

3.3 Groundwater Quality

Groundwater is an important source of water for both urban and rural residents living in the Thames Watershed & Region. While the Great Lakes are a vast surface water resource and provide a source of drinking water for the region, many municipal supply systems and numerous private individuals depend on groundwater sources.

This section of the Watershed Characterization Report provides a summary of existing groundwater monitoring programs. It gives a brief synopsis of known groundwater quality issues, an overview of groundwater quality in terms of chemical parameters, and a water quality assessment for microbial parameters based on available information for municipal drinking water wells. Microbiological sampling and data for Provincial Groundwater Monitoring Network wells is summarized. It also provides an outline of the work that is underway to consolidate and review historic information on ambient groundwater quality.

In addition to drinking water supply, good quality groundwater is vital for the natural function of groundwater in the ecosystem. It is perceived that a general deterioration in groundwater quality has occurred as a result of anthropogenic activities such as agriculture, industry, and drinking water production. Conservation Authorities are currently gathering water quality data to help them understand the interaction between groundwater and surface water systems in an effort to better manage groundwater systems to maintain surface water ecosystems, public drinking water and private well water quality.

3.3.1 Existing Monitoring

In general, the work associated with collecting groundwater quality information can be divided and grouped into three subsections: protecting public water supply, evaluating private well water and gathering background data.

3.3.1.1 Public/Municipal Water Supply Systems

The public well water used by municipalities in the region is routinely monitored for public health and safety. This information is available in annual reports and other data sets.

Drinking Water Systems (DWS) Annual Reports & Plant Operational Records

Ontario's Drinking Water Systems Regulation (O. Reg. 170/03) (made under the *Safe Drinking Water Act, 2002)* requires that the owner of a drinking water system prepare an annual report on the operation of the system and the quality of its water. Reports must be posted to the municipality's web site if the drinking water system is a large municipal residential system serving more than 10,000 people, or available in hard copy if the system is smaller. Detailed water quality analysis, including parameters not required by Regulation 170/03, is sometimes available at the water treatment plant in operational record hard copies. **Map 38: Drinking Water Supplies/Intakes** shows the location of municipal groundwater sources in the region.

Drinking Water Surveillance Program (DWSP)

The Drinking Water Surveillance Program (DWSP) is a voluntary program operated by the OMOE in cooperation with municipalities to gather scientific data on drinking water quality in Ontario. DWSP was established in 1986 and is not a compliance monitoring program. Testing is carried out on both surface water and groundwater sources. Laboratory analyses are provided by the OMOE and the Ministry of Labour. A very broad range of tests are done including physical, chemical, and radiological parameters. Limited microbiological data is available as well. Municipal groundwater sources tested in the Thames Watershed & Region include Dorchester, Ingersoll, Stratford, and Woodstock.

Drinking Water Information System (DWIS)

The Drinking Water Information System (DWIS) is the large database managed by the OMOE's Environmental Monitoring and Reporting Branch (EMRB) for municipal drinking water systems in the province. The database contains microbiological sample records for the past few years. DWIS is a very comprehensive database, and to utilize the information, permission must be obtained from both the OMOE and the individual municipality. Also, the Drinking Water Systems Regulation (Ontario Regulation 170/03) of the Safe Drinking Water Act (2002) requires that municipal drinking water systems sample raw water supplies (and treated water). Data collected are archived in the DWIS[50]. All municipal sources and systems that are provincially regulated surface water treatment plants are part of this system.

The Thames Watershed & Region is comprised of the UTRCA and LTVCA watersheds. Of the 25 municipal well supply systems in region, 24 are located in the UTRCA watershed. **Map 38: Drinking Water Supplies/Intakes** shows the communities using groundwater sources.

Municipal wells service various areas of the Thames Watershed & Region within Middlesex, Oxford, Perth and Chatham-Kent. There are no municipal wells supplying water to communities in the parts of Elgin and Essex Counties that are in the region.

Responsibility for operation of the municipal wells varies depending on the location of the supply system. Chatham-Kent is a single tier municipality and has responsibility for all municipal drinking water supplies. In Oxford County, the upper tier (County) level of government is responsible for water supply. In Middlesex and Perth Counties, the individual municipalities manage their drinking water supplies.

In Middlesex, there are six active municipal well supply systems serving populations within the UTRCA watershed including Birr, Dorchester, Melrose, Kilworth Heights Subdivision, Mount Brydges and Thorndale. The Mount Brydges well supply system also supplies residents living in the St. Clair Region watershed. The City of London system wells are for emergency backup only. The primary sources of drinking water to the City of London are the Elgin Area Primary Water Supply System (Lake Erie water) and the Lake Huron Primary Water Supply System (Lake Huron water).

In Oxford, the 10 municipal well supply systems in the UTRCA watershed are Beachville-Loweville Subdivision, Embro, Hickson-King Subdivision, Ingersoll, Innerkip, Lakeside, Mount Elgin, Tavistock, Thamesford and Woodstock.

In Perth, the six well supply systems in the UTRCA watershed are Mitchell, Sebringville (Black Creek Estates), Shakespeare (Miller Ave.), St. Marys, St. Pauls and Stratford.

In Chatham-Kent, the Highgate and Ridgetown well supplies are the only municipal systems located in the LTVCA watershed.

The well supply systems have varying capacities and the number of wells in each system ranges from one to 10 to make a total of 83 individual wells. **Table 3.3.1.1-1: Municipal Well Supply Systems in the Thames Watershed & Region** provides a summary of the number of wells, the rated capacity of the systems, and the population served for each of the systems.

Data for the Sweaburg-Oxford Heights Subdivision well supply system was also available for review. This system is no longer in use since August 2006 and is now supplied with Woodstock well system water[51]. The two wells in this system had a rated capacity of 2,401.9 m^3/d and served a population of around 600 peoples. The data review for the Sweaburg Oxford system well water is in a separate subsection.

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[50] OMOE. Ontario Safe Drinking Water Act. Drinking Water Systems under O. Reg. 170/03. www.ontario.ca/ONT/portal51/drinkingwater/Combo?docId=STEL01_049278&breadcrumbLevel=1&lang=en

[51] Oxford County staff. Personal communication.

Table 3.3.1.1-1: Municipal Well Supply Systems in the Thames Watershed & Region

No.	Municipality/Drinking Water System Name	No. of Wells	Rated Capacity, m^3/d	Population Served
A	**Middlesex**			
1	Birr Well Supply	1	122.4	54
2	Dorchester Well Supply	8	7344.0	5100
3	Melrose Well Supply	2	276.5	224
4	Kilworth Heights Subdivision Well Supply	3	1814.4	2300
5	Mount Brydges Well Supply	2	3110.4	3000
6	Thorndale Well Supply	2	717.1	336
7	City of London Back Up Wells	7	36806.4*	348000*
B	**Oxford**			
1	Beachville-Loweville Subdivision Well Supply	1	656.6	180
2	Embro Well Supply	2	915.8	828
3	Hickson-King Subdivision Well Supply	1	388.8	99
4	Ingersoll Well Supply	7	26521	13572
5	Innerkip Well Supply	2	1296.0	840
6	Lakeside Well Supply	1	432	310
7	Mount Elgin Well Supply	1	328	369
8	Tavistock Well Supply	3	5616.0	2300
9	Thamesford Well Supply	3	3672	2016
10	Woodstock Well Supply	10	54500	34000
C	**Perth**			
1	Mitchell Well Supply	3	8640.0	4000
2	Sebringville (Black Creek Estates) Well Supply	1	60.5	32**
3	Shakespeare (Miller Ave.) Well Supply	1	544.3	250
4	St. Marys Well Supply	2	15552.0	6400
5	St. Pauls Well Supply	1	328.3	32**
6	Stratford Well Supply	11	39493.4	30000
D	**Chatham-Kent**			
1	Highgate Pure Water Well Supply	2	527.0	500
2	Ridgetown Well Supply	6	2782.1	3450

*City of London Back Up Wells Capacity only (surface water supply capacity is 413,769.6 m^3/d)
**No. of residences served

3.3.1.2 Private Well Sampling Data

Private wells are not regulated systems that are required to routinely monitor water quality. However, Public Health Units with the support of the Ministry of Health and Long-term Care provide free bacterial sample analysis for homeowners on private wells. In fact, the Health Units recommend sampling private wells up to three times per year. All sample analyses are kept by the Public Health Unit and the analysis is provided to the homeowner. Due to confidentiality concerns, the Health Unit database on water quality is not available to the public or Conservation Authorities at this time.

There are regulations and rules in place for constructing or decommissioning (abandoning) a water well that apply to private wells. **Map 34: Water Well Record Locations** shows the location of wells constructed in the watershed based on the well construction information from the provincial records. There is the potential to obtain widespread information on groundwater quality depending on the extent of sampling and Health Unit databases.

3.3.1.3 Background Monitoring

Provincial Groundwater Monitoring Network (PGMN)

Part Two of the Report of the Walkerton Inquiry focused on five areas, the first one being source protection. Within the context of source protection, the Honourable Dennis R. O'Connor recommended "a source protection system that includes a strong planning component on an ecologically meaningful scale – that is at the watershed scale."

A need was identified to have a baseline database on water quality (and quantity) to be able to document the current status of groundwater; to compare water quality between regions; and to determine the contaminated status of natural groundwater.

In 2001, the Ministry of the Environment and Conservation Ontario together initiated a groundwater quality and quantity network called the Provincial Groundwater Monitoring Network (PGMN) to address this need. The network will support the development of implementation and monitoring for future source protection plans by providing background monitoring information on groundwater levels and quality.

As of May 2007, there are a total of 35 PGMN monitoring wells in the Thames Watershed & Region. The UTRCA has 23 monitoring wells in 19 locations. Multiple wells at Embro, Shakespeare and Fish Creek are used to monitor aquifers at different depths. Two wells are awaiting installation of instrumentation (level loggers). The LTVCA has 12 monitoring wells, all of which are in different locations.

Table 3.3.1.3-1 lists the PGMN wells in the Thames Watershed & Region and **Map 15: Provincial Groundwater Monitoring Network** shows the locations of the monitoring wells.

Some of the wells have been monitoring water levels since 2001, but most were brought into the system between 2002 and 2004. Monitoring wells are sampled once per year and two rounds of samples have been obtained for each of the existing instrumented monitoring wells in the UTRCA and LTVCA watersheds. (The wells that have not been instrumented have not been sampled.) The first round of sampling included a comprehensive analysis by the OMOE laboratory for pesticides, volatiles, metals and basic chemistry (cation/anion suite: calcium, sodium, magnesium, bicarbonate, sulfate and chloride). The second round of samples included a basic cation/anion suite, metals, nitrate and fluoride.

Other Groundwater Monitoring

Sifton Bog

Sifton Bog is a 53 hectare provincially significant wetland located in London. The bog is the most southerly large bog in Canada. In addition to the two PGMN monitoring wells at the bog, UTRCA has a suite of 11 wells in six locations within Sifton Bog where the UTRCA has monitored water quantity and quality since 1990. The bog has a low pH and reduced nutrients.

Table 3.3.1.3-1: Provincial Groundwater Monitoring Network Wells in the Thames Watershed & Region

No.	Well Name and Site	Well ID	County	Northing	Easting
A	**PGMN Wells in the UTRCA Watershed**				
1	Komoka	W0000056	Middlesex	4753498	465611
2	Dorchester	W0000107	Middlesex	4757938	497224
3	Sifton Bog	W0000217	Middlesex	4757909	473350
4	Fanshawe Sugar Bush	W0000370	Middlesex	4768254	485715
5	Workshop Well	W0000437	Middlesex	4766213	485281
6	Westminster	W0000469	Middlesex	4754750	484318
7	Sifton Bog Conductivity	W0000470	Middlesex	4757909	473350
8	Thamesford	W0000053	Oxford	4767020	499622
9	Mt. Elgin	W0000055	Oxford	4755980	516858
10	Innerkip	W0000180	Oxford	4781357	523486
11	Golspie	W0000201	Oxford	4773497	512719
12	Embro Shallow	W0000369-2	Oxford	4779999	506698
13	Embro Deep	W0000369-3	Oxford	4779999	506698
14	Motherwell	W0000054	Perth	4797399	485175
15	Wildwood	W0000076	Perth	4788348	493552
16	Shakespeare Shallow	W0000218-3	Perth	4803029	513351
17	Shakespeare Intermediate	W0000218-4	Perth	4803029	513351
18	Shakespeare Deep	W0000218-5	Perth	4803029	513351
19	North Mitchell Farm	W0000219	Perth	4815243	492157
20	Ellice	W0000368	Perth	4812825	503634
21	Fish Creek Shallow	W0000371-2	Perth	4786632	477962
22	Fish Creek Deep	W0000371-3	Perth	4786632	477962
23	Petroleum Well	W0000405	Perth	4792450	486004
B	**PGMN Wells in the LTVCA Watershed**				
1	Sinclairs Bush, Harwich	W0000181	Chatham-Kent	4685708	422829
2	Morris, Tilbury West	W0000211	Chatham-Kent	4672670	370141
3	Authier, Tilbury East	W0000236	Chatham-Kent	4672831	395382
4	Old Colony, Romney	W0000237	Chatham-Kent	4666875	385322
5	St. Clair St., Chatham	W0000247	Chatham-Kent	4698285	399816
6	Ridgetown, Howard	W0000249	Chatham-Kent	4696787	423463
7	Elm Street, Chatham	W0000250	Chatham-Kent	4719762	428040
8	Thamesville, Howard	W0000438	Chatham-Kent	4710231	420941
9	Van Brenk, Dunwich	W0000185	Elgin	4722045	467563
10	Warwick, Aldborough	W0000445	Elgin	4713240	456656
11	Longwoods, Caradoc	W0000184	Middlesex	4748108	460776

No.	Well Name and Site	Well ID	County	Northing	Easting
12	Mosa School, Mosa	W0000248	Middlesex	4729238	438647
*	Thamesville, Howard	W0000182	Chatham-Kent	4710513	420615

*Decommissioned in 2005; Well #W0000438 is being used as a monitoring well instead.

3.3.2 Groundwater Quality – Chemical Parameter Analysis

In this section, an overview of groundwater quality in terms of chemical parameters is described for the Thames Watershed & Region. Groundwater quality is important for usages such as a possible source of drinking water when pumped to the surface and for the base flow that groundwater may contribute to surface water sources.

3.3.2.1 Chemical Parameter Selection and Standards

Drinking water is monitored for a variety of parameters to assess the physical and chemical water quality of both the raw water and the treated water that is distributed to the community. The data sources available include:

- Drinking Water Surveillance Program (DWSP)
- Drinking Water Information System (DWIS)
- Provincial Groundwater Monitoring Network (PGMN)
- Annual Drinking Water System (DWS) and Ministry of the Environment (OMOE) Inspection reports

In general, groundwater characteristics are considered to be relatively consistent and the chemical parameter monitoring is not as extensive as that of surface water sources in terms of monitoring frequency and long-term data collection. Thus, municipal water supply wells and PGMN monitoring wells offer limited water quality data compared to the data used to review surface water sources in **Section 3.2: Raw Water Characterization for Inland Surface Water** and **Section 3.4: Raw Water Characterization for Drinking Water Intakes**.

Parameter selection to assess groundwater quality was influenced by:

- Conservation Ontario recommendations for water quality monitoring parameters
- Drinking Water Systems Ontario Regulation 170/03 parameters
- Additional water quality parameters available from the above data sources (DWSP, DWIS, PGMN, annual DWS and OMOE reports)

Broad lists of parameters from the above sources are described in **Section 3.1: Selecting Indicator Parameters**. Of these, some parameters were not reviewed due to reasons described in Section 3.1. There are parameter overlaps between various programs. The significance of the parameters is discussed in Section 3.1.

There are inorganic and organic chemicals that must be tested in treated drinking water according to Ontario Reg. 170/03 (Drinking Water Systems Regulation) Safe Drinking Water Act, 2002. The results of testing are reported to the OMOE and the data is available in DWSP and DWIS databases as well as the annual DWS and OMOE reports.

Table 3.3.2.1-1: List of Drinking Water Systems Reg. 170/03 Parameters Reviewed to Assess Groundwater Quality and **Table 3.3.2.1-2: List of Parameters (not in Drinking Water Systems Reg. 170/03) Reviewed to Assess Groundwater Quality** provide a list of the parameters reviewed to assess groundwater quality. Based on available data, there were 108 parameters that could be reviewed. Of these, 68 parameters are Ontario Regulation 170/03 parameters that drinking water systems are required to report. However, it is important to note that data for all of these parameters are not available for each municipal well supply and each PGMN monitoring well.

Table 3.3.2.1-1: List of Drinking Water Systems Reg. 170/03 Parameters Reviewed to Assess Groundwater Quality

No.	Reg. 170/03 Parameter	DWIS	PGMN	DWS Report	OMOE Report
Schedule 23					
1	Antimony	√	√	√	√
2	Arsenic	√	√	√	√
3	Barium	√	√	√	√
4	Boron	√	√	√	√
5	Cadmium	√	√	√	√
6	Chromium	√	√	√	√
7	Mercury	√		√	√
8	Selenium	√	√	√	√
9	Uranium	√	√	√	√
10	Zinc		√		√
Schedule 24					
11	Alachlor	√		√	
12	Aldicarb	√		√	
13	Aldrin + Dieldrin	√		√	
14	Atrazine + N-dealkylated metabolites	√		√	
15	Azinphos-methyl	√		√	
16	Bendiocarb	√		√	
17	Benzene	√	√	√	√
18	Benzo(a)pyrene	√		√	
19	Bromoxynil	√		√	
20	Carbaryl	√		√	
21	Carbofuran	√		√	
22	Carbon Tetrachloride	√		√	√
23	Chlordane (Total)	√		√	
24	Chlorpyrifos	√		√	
25	Cyanazine	√		√	
26	Diazinon	√		√	
27	Dicamba	√		√	
28	Dichlorodiphenyltrichloroethane (DDT) + metabolites	√		√	
29	Dichloromethane	√		√	√
30	Diclofop-methyl	√		√	
31	Dimethoate	√		√	
32	Dinoseb	√		√	
33	Diquat	√		√	
34	Diuron	√		√	
35	Glyphosate	√		√	
36	Heptachlor + Heptachlor Epoxide	√		√	
37	Lindane (Total)	√		√	
38	Malathion	√		√	
39	Methoxychlor	√		√	

No.	Reg. 170/03 Parameter	DWIS	PGMN	DWS Report	OMOE Report
40	Metolachlor	√		√	
41	Metribuzin	√		√	
42	Monochlorobenzene	√		√	
43	Paraquat	√		√	
44	Parathion	√		√	
45	Pentachlorophenol	√		√	
46	Phorate	√		√	
47	Picloram	√		√	
48	Polychlorinated Biphenyls (PCB)	√		√	
49	Prometryne	√		√	
50	Simazine	√		√	
51	Temephos	√		√	
52	Terbufos	√		√	
53	Tetrachloroethylene (perchloroethylene)	√		√	
54	Triallate	√		√	
55	Trichloroethylene	√		√	
56	Trifluralin	√		√	
57	Vinyl Chloride	√		√	
58	1,1-dichloroethylene (vinylidene chloride)	√		√	
59	1,2-dichlorobenzene	√		√	√
60	1,2-dichloroethane	√		√	√
61	1,4-Dichlorobenzene	√		√	√
62	2,3,4,6-tetrachlorophenol	√		√	
63	2,3,7,8 TCDD (dioxin)	√			
64	2,3,7,8 TCDF	√			
65	2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	√		√	
66	2,4,6-trichlorophenol	√		√	
67	2,4-dichlorophenol	√		√	
68	2,4-dichlorophenoxyacetic acid (2,4-D)	√		√	

Table 3.3.2.1-2: List of Parameters (not in Drinking Water Systems Reg. 170/03) Reviewed to Assess Groundwater Quality

No.	Parameter (not in Reg.170/03)	DWIS	PGMN	DWS Report	OMOE Report
Nutrients					
1	Phosphorus		√		√
2	Nitrate	√	√	√	√
3	Nitrite	√	√	√	√
4	Nitrate + Nitrite	√	√		√
Other Parameters					
5	Alkalinity		√		
6	Aluminum		√		√
7	Beryllium		√		
8	Bromoform		√		√
9	Chloride		√		
10	Cobalt		√		√
11	Copper		√		√
12	Dissolved Organic Carbon		√		
13	Ethyl benzene		√		√
14	Fluoride	√	√	√	√
15	Hardness		√		
16	Iron		√		√
17	Lead		√		√
18	Manganese		√		√
19	Nickel		√		√
20	Organic N			√	
21	pH		√		
22	Sodium	√	√	√	√
23	Styrene		√		√
24	Sulphate		√		
25	Thallium		√		√
26	Toluene		√		√
27	Total Dissolved Solids		√		
28	Total Trihalomethanes		√	√	√
29	Vanadium		√		√

Drinking water standards are established for treated drinking water supplied to communities. In this report, the data for raw (untreated) water are compared to the treated water standards since there are none specifically for raw water. **The comparison with these treated water standards is only intended to provide a means of quality assessment using a reference number (the standard) and not to judge conformance of raw water to the treated water standards. Our review of the available water quality data whether raw or treated samples, is to characterize the raw (untreated) source of drinking water.** Where a drinking water standard is absent, detection limits are used to find the number of times a chemical is detected in the water samples.

The OMOE published standards for drinking water, referred to as the Ontario Drinking Water Standards[52] (ODWS), in 2003. The ODWS are further categorized into Maximum Acceptable Concentration (MAC), Interim MAC (IMAC), Aesthetic Objective (AO), and Operational Guidelines (OG).

The **Maximum Acceptable Concentration (MAC)** is established for parameters that, when present above a certain concentration, have known or suspected adverse health effects.

The **Interim Maximum Acceptable Concentration (IMAC)** is established for parameters either when there are insufficient toxicological data to establish a MAC with reasonable certainty, or when it is not feasible, for practical reasons, to establish a MAC at the desired level.

The **Aesthetic Objective (AO)** is established for parameters that may impair the taste, odour or colour of water or that may interfere with good water quality control practices. For certain parameters, both aesthetic objectives and health-related MACs have been derived.

The **Operational Guideline (OG)** is established for parameters that, if not controlled, may negatively affect the efficient and effective treatment, disinfection and distribution of the water.

The ODWS are used to assess the quality of groundwater drinking water sources for most of the parameters. However, not all of the parameters have an ODWS. Where the ODWS is not available for other parameters, an alternative assessment method was followed by using the parameter detection limit. Parameters without ODWS but that are equal to or greater than the detection limit are noted as ‘detected’ in the water sample. The one exception is the nutrient phosphorus, which also does not have an ODWS, but was assessed using an Interim Provincial Water Quality Objective (IPWQO) meant to prevent the nuisance growth of algae in surface waters.

The flow chart in **Figure 3.3.2.1-1: Review of Parameter Data** aids in the explanation of the approach used to review parameter data.

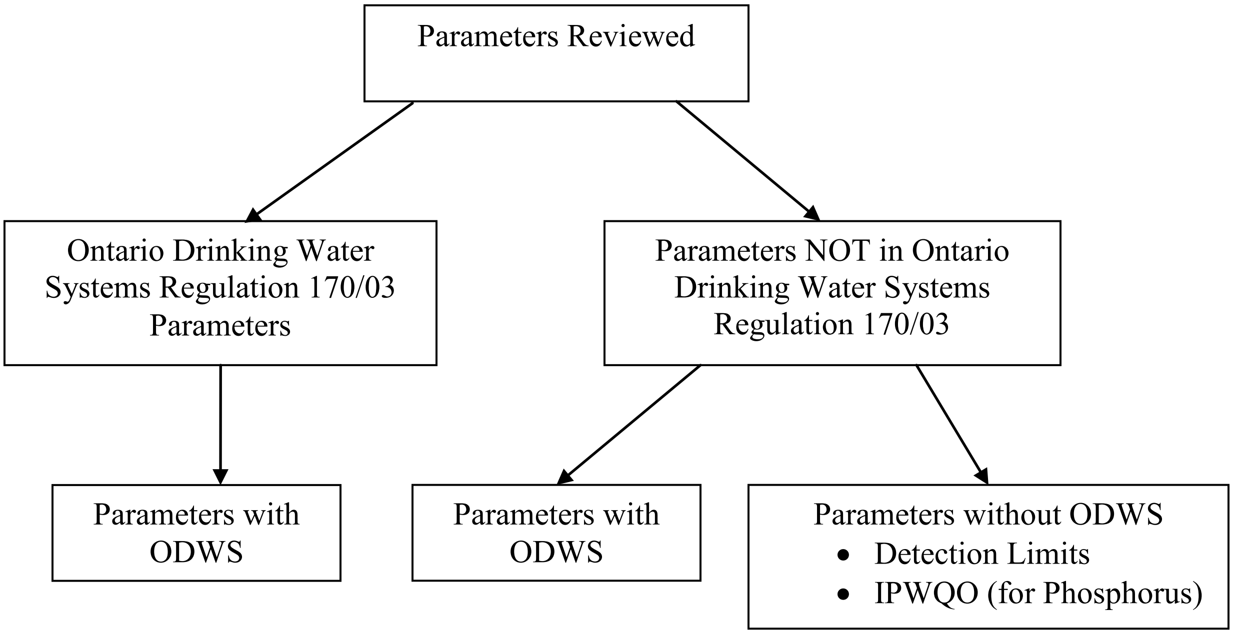

Figure 3.3.2.1-1: Review of Parameter Data

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[52] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

Table 3.3.2.1-3: Ontario Drinking Water Standards, Objectives and Guidelines for Drinking Water Systems Reg. 170/03 Parameters and **Table 3.3.2.1-4: Ontario Drinking Water Standards, Objectives and Guidelines for Parameters not in Drinking Water Systems Reg. 170/03** provide a summary of the current (most recent) standards that were used to evaluate groundwater quality.

Table 3.3.2.1-5: Detection Limit Ranges for Parameters without ODWS lists the ranges of detection limits of parameters that do not have Ontario Drinking Water Standards, Objectives and Guidelines. The UTRCA watershed PGMN well samples were analyzed by four different laboratories between 2002 and 2006 including the Ministry of the Environment laboratory at Etobicoke. The LTVCA watershed PGMN well samples were analyzed by three different laboratories between 2002 and 2006 including the Ministry of the Environment laboratory at Etobicoke.

Table 3.3.2.1-3: Ontario Drinking Water Standards, Objectives and Guidelines for Drinking Water Systems Reg. 170/03 Parameters

Parameter	Ontario Drinking Water Standard/ Objective/ Guideline
Ontario Regulation 170/03 Schedule 23 Inorganic Parameters	
Antimony	0.006 mg/L (ODWS IMAC)[a]
Arsenic	0.025 mg/L (ODWS IMAC)[a]
Barium	1 mg/L (ODWS MAC)[a]
Boron	5 mg/L (ODWS IMAC)[a]
Cadmium	0.005 mg/L (ODWS MAC)[a]
Chromium	0.05 mg/L (ODWS MAC)[a]
Mercury	0.001 mg/L (ODWS MAC)[a]
Selenium	0.01 mg/L (ODWS MAC)[a]
Uranium	0.02 mg/L (ODWS MAC)[a]
Zinc	5 mg/L (ODWS AO)[a]
Ontario Regulation 170/03 Schedule 24 Organic Parameters	
Alachlor	0.005 mg/L (ODWS IMAC)[a]
Aldicarb	0.009 mg/L (ODWS MAC)[a]
Aldrin + Dieldrin	0.0007 mg/L (ODWS MAC)[a]
Atrazine + N-dealkylated metabolites	0.005 mg/L (ODWS IMAC)[a]
Azinphos-methyl	0.02 mg/L (ODWS MAC)[a]
Bendiocarb	0.04 mg/L (ODWS MAC)[a]
Benzene	0.005 mg/L (ODWS MAC)[a]
Benzo(a)pyrene	0.00001 mg/L (ODWS MAC)[a]
Bromoxynil	0.005 mg/L (ODWS IMAC)[a]
Carbaryl	0.09 mg/L (ODWS MAC)[a]
Carbofuran	0.09 mg/L (ODWS MAC)[a]
Carbon Tetrachloride	0.005 mg/L (ODWS MAC)[a]
Chlordane (Total)	0.007 mg/L (ODWS MAC)[a]
Chlorpyrifos	0.09 mg/L (ODWS MAC)[a]
Cyanazine	0.01 mg/L (ODWS IMAC)[a]
Diazinon	0.02 mg/L (ODWS MAC)[a]
Dicamba	0.12 mg/L (ODWS MAC)[a]
1,2-Dichlorobenzene	0.2 mg/L (ODWS MAC)[a]
1,4-Dichlorobenzene	0.005 mg/L (ODWS MAC)[a]

Parameter	Ontario Drinking Water Standard/ Objective/ Guideline
Dichlorodiphenyltrichloro-ethane (DDT) + metabolites	0.03 mg/L (ODWS MAC)[a]
1,2-dichloroethane	0.005 mg/L (ODWS IMAC)[a]
1,1-Dichloroethylene	0.014 mg/L (ODWS MAC)[a]
Dichloromethane	0.05 mg/L (ODWS MAC)[a]
2,4-Dichlorophenol	0.9 mg/L (ODWS MAC)[a]
2,4-Dichlorophenoxy acetic acid (2,4-D)	0.1 mg/L (ODWS IMAC)[a]
Diclofop-methyl	0.009 mg/L (ODWS MAC)[a]
Dimethoate	0.02 mg/L (ODWS IMAC)[a]
Dinoseb	0.01 mg/L (ODWS MAC)[a]
Diquat	0.07 mg/L (ODWS MAC)[a]
Diuron	0.15 mg/L (ODWS MAC)[a]
Glyphosate	0.28 mg/L (ODWS IMAC)[a]
Heptachlor + Heptachlor Epoxide	0.003 mg/L (ODWS MAC)[a]
Lindane (Total)	0.004 mg/L (ODWS MAC)[a]
Malathion	0.19 mg/L (ODWS MAC)[a]
Methoxychlor	0.9 mg/L (ODWS MAC)[a]
Metolachlor	0.05 mg/L (ODWS IMAC)[a]
Metribuzin	0.08 mg/L (ODWS MAC)[a]
Monochlorobenzene	0.08 mg/L (ODWS MAC)[a]
Paraquat	0.01 mg/L (ODWS IMAC)[a]
Parathion	0.05 mg/L (ODWS MAC)[a]
Pentachlorophenol	0.06 mg/L (ODWS MAC)[a]
Phorate	0.002 mg/L (ODWS IMAC)[a]
Picloram	0.19 mg/L (ODWS IMAC)[a]
Polychlorinated Biphenyls (PCB)	0.003 mg/L (ODWS IMAC)[a]
Prometryne	0.001 mg/L (ODWS IMAC)[a]
Simazine	0.01 mg/L (ODWS IMAC)[a]
Temephos	0.28 mg/L (ODWS IMAC)[a]
Terbufos	0.001 mg/L (ODWS IMAC)[a]
Tetrachloroethylene (perchloroethylene)	0.03 mg/L (ODWS MAC)[a]
2,3,4,6-Tetrachlorophenol	0.1 mg/L (ODWS MAC)[a]
Triallate	0.23 mg/L (ODWS MAC)[a]
Trichloroethylene	0.005 mg/L (ODWS MAC)[a]
2,4,6-Trichlorophenol	0.005 mg/L (ODWS MAC)[a]
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	0.28 mg/L (ODWS MAC)[a]
Trifluralin	0.045 mg/L (ODWS IMAC)[a]
Vinyl Chloride	0.002 mg/L (ODWS MAC)[a]

Note: ODWS: Ontario Drinking Water Standard
MAC: Maximum Acceptable Concentration
IMAC: Interim Maximum Acceptable Concentration
AO: Aesthetic Objective

Source of Water Standard, Guideline or Objective in Table 3.3.2.1-3

[a] Ministry of the Environment. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

Table 3.3.2.1-4: Ontario Drinking Water Standards, Objectives and Guidelines for Parameters not in Drinking Water Systems Reg. 170/03

Parameter	Ontario Drinking Water Standard/Objective/Guideline
Nutrients	
Nitrate	10 mg/L (ODWS MAC)[a]
Nitrite	1 mg/L (ODWS MAC)[a]
Nitrate + nitrite	10 mg/L (ODWS MAC)[a]
Other Parameters	
Alkalinity	30 to 500 mg/L (ODWS OG)[a]
Aluminum	0.1 mg/L (ODWS OG)[a]
Chloride	250 mg/L (ODWS AO)[a]
Copper	1000 µg/L (ODWS AO)[a]
Dissolved Organic Carbon	5 mg/L (ODWS AO)[a]
Ethyl benzene	0.0024 mg/L (ODWS AO)[a]
Fluoride	1.5 mg/L (ODWS MAC)
Hardness	80-100 mg/L (ODWS OG)[a]
Iron	0.3 mg/L (ODWS AO)[a]
Lead	10 µg/L (ODWS MAC)[a]
Manganese	0.05 mg/L (ODWS AO)[a]
Organic Nitrogen	0.15 mg/L (ODWS OG)[a]
pH	6.5 to 8.5 (ODWS OG)[a]
Sodium	200 mg/L (ODWS AO)[a] and 20 mg/L (local Health Officer is to be notified if sodium is above this)
Sulfate	500 mg/L (ODWS AO)[a]
Toluene	0.024 mg/L (ODWS AO)[a]
Total Dissolved Solids	500 mg/L (ODWS AO)[a]
Total trihalomethanes	0.1 mg/L (ODWS AO)[a]

Note: ODWS: Ontario Drinking Water Standard
MAC: Maximum Acceptable Concentration
AO: Aesthetic Objective
OG: Operational Guidelines
IPWQO: Interim Provincial Water Quality Objective

Source of Water Standard, Guideline or Objective in Table 3.3.2.1-4:

[a] Ministry of the Environment. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

[b] OMOE. 1979. Rationale for the establishment of Ontario's Water Quality Objectives. 236 pp.

Table 3.3.2.1-5: **Laboratory Detection Limits for Parameters not in Drinking Water Systems Reg. 170/03 (and which do not have an Ontario Drinking Water Standard/ Objective/Guideline)**

Parameter	Detection Limit
Beryllium	0.00005 to 0.001 mg/L
Cobalt	0.00002 to 0.0005 mg/L
Nickel	0.0002 to 0.001 mg/L
Thallium*	0.00005 mg/L
Vanadium	0.00005 to 0.001 mg/L
Bromoform**	0.0005 mg/L
Styrene**	0.00005 mg/L

*Same detection limit for all three laboratories used
**These parameters were analyzed by the OMOE laboratory only

3.3.2.2 Provincial Groundwater Monitoring Network

A general breakdown of the groundwater types is provided in **Table 3.3.2.2-1: Groundwater Types in the Thames Watershed & Region**. Initial monitoring from the Provincial Groundwater Monitoring Network (PGMN) system indicates that the basic water type of both the bedrock and overburden aquifers is dominated by bicarbonate water throughout the region. The locations of the PGMN wells are shown in **Map 15: Provincial Groundwater Monitoring Network**.

Table 3.3.2.2-1: **Groundwater Types in the Thames Watershed & Region**

Water Type*	Geology (Well #)	Conservation Authority
Ca, Mg, HCO_3	**8 wells:** 3 bedrock (54, 55, 201) 5 overburden (107, 218-3, 218-4, 370, 371-2)	UTRCA
Ca, Mg, SO_4, HCO_3	**3 wells:** 2 bedrock (180, 369-3) 1 overburden (369-2)	
Na, HCO_3	**1 well:** overburden (56)	
Na, Ca, Mg, HCO_3	**3 wells:** 2 bedrock (368, 219) 1 overburden (76)	
Ca, Mg, HCO_3, SO_4	**2 wells:** bedrock (53), overburden (371-3)	
Ca, Mg, Na, HCO_3	**1 well:** bedrock (218-5)	
Ca, Na, Cl, HCO_3	**1 well:** overburden (217)	
Na, Ca, Cl, HCO_3	**1 well:** bedrock / overburden contact (237)	LTVCA
Na, Mg , HCO_3	**1 well:** overburden (248)	
Ca, Mg, HCO_3	**1 well:** overburden (184)	
Na, Cl	**2 wells:** 1 bedrock (211) 1 overburden (236)	

*Note: Analysis incomplete: UTRCA has three wells that have had the first round of samples, but the analyses have not been received and one well has not been sampled. LTVCA has one well that is used for water quantity but not quality and one that has been decommissioned.

The UTRCA overburden and bedrock wells are dominated by calcium-magnesium-bicarbonate water. The carbonate, magnesium (and sulphate) ions in the groundwater primarily originate from the carbonate rock at depth (bedrock: dolostones, limestones and evaporites) and the carbonate material incorporated in overburden sediments.

The primary difference between the LTVCA and the UTRCA areas is the predominance of sodium and chloride in the LTVCA watershed groundwater where the sodium and chloride content is significantly higher.

Method of Review of PGMN Data for the Thames Watershed & Region

The PGMN groundwater quality data were reviewed by performing cross tab queries in Microsoft Access, which facilitates the comparison of chemical parameter values to the Ontario Drinking Water Standards/ Guidelines/ Objectives established for treated drinking water supplied to communities. Where these standards/ guidelines/ objectives do not exist, detection limits are used, with the exception of the nutrient phosphorus. The Interim Provincial Water Quality Objective (IPWQ) for total phosphorus (meant for the prevention of nuisance growth of algae) is used. Sample sizes are typically one per year but range from one to three per year as shown in the tables.

It is important to note that there may be data discrepancies in the raw water data obtained from OMOE. A caveat is included in this report to caution the reader:

"This data has not been reviewed at this time and therefore should be considered to be preliminary in nature. The Ministry of Environment and Program Partners do not assume any liability for any discrepancies, inaccuracies or gaps that may be present within the data. The data is considered to be Joint Intellectual Property between the Ministry of Environment and the Program Partner."

In this report, data from 2002 up to and including 2006 is analyzed.

Special Cases

(1) Sodium - Sodium values above 20 mg/L are reported in this section, even though the ODWS aesthetic objective is 200 mg/L. Water with the lower sodium level can be of concern for individuals on a sodium restricted diet and the local Medical Officer of Health is notified when the sodium concentration is above 20 mg/L.

(2) Parameters without Ontario Drinking Water Standards/ Guidelines/ Objectives -

a) The parameters listed in **Table 3.3.2.1-5** are compared against the highest of the three different laboratory method detection limits to generate tables of 'detected parameters.'

b) Phosphorus also does not have an ODWS but is a nutrient of concern. Phosphorus levels of the Thames watershed PGMN wells are reviewed by comparing to an Interim Provincial Water Quality Objective (IPWQO) of 0.03 mg/L for total phosphorus. While this is a guideline for the prevention of nuisance growth of algae in surface waters, this objective is used to assess groundwater that may be a possible source of base flow for surface water or that could be pumped to the surface. Levels of nutrient phosphorus that are above the objective to prevent excessive algae growth may also pose a taste and odour concern in drinking water.

(3) Different Analysis Methods for Samples in PGMN Data - Total phosphorus is comprised of dissolved and particulate phosphorus. Phosphorus in the PGMN well samples has been measured as total phosphorus in the 2002, 2003 and 2004 samples, but as dissolved phosphorus in three of the 2005 and all of the 2006 samples.

(4) Detection Limit Higher than a Standard/ Guideline/ Objective - The detection limit of phosphorus analyzed by one of the three laboratories in 2005 and 2006 is 0.05 mg/L, higher than the IPWQO of 0.03 mg/L for total phosphorus. Also these samples were analyzed for dissolved phosphorus as explained above.

Results of Review of PGMN Data for the Upper Thames River & Lower Thames Valley Watersheds

The PGMN groundwater quality data has been reviewed and the parameter ranges and significances are discussed, after which the results are presented in the form of tables. Parameters above the Ontario Drinking Water standard/guideline/objective in both the UTRCA and LTVCA watersheds are fluoride, hardness, manganese, total dissolved solids, chloride and iron. Sodium above 20 mg/L (Health Unit notification) is also seen in both watersheds.

There are a few chemical parameters that are above health related Ontario Drinking Water Standards (ODWS) Maximum Acceptable Concentration (MAC).

- In the UTRCA watershed, fluoride (7 wells), nitrate+nitrite (1 well), nitrate (1 well), arsenic (1 well) and cadmium (1 well) are above the ODWS MAC.
- In the LTVCA watershed, fluoride (3 wells), lead (1 well) and barium (1 well) are above the ODWS MAC.

Some parameters are also above the Ontario Drinking Water Aesthetic Objective (AO).

- In the UTRCA watershed, these are total dissolved solids (5 wells), manganese (6 wells), chloride (1 well), iron (13 wells), dissolved organic carbon (3 wells) and trihalomethanes (1 well). The one incident of trihalomethanes may be attributed to the sample being taken immediately after chlorination of the well (chloride reacts with organic matter in the water to form trihalomethanes).
- In the LTVCA watershed, parameters that are above the Ontario Drinking Water AO are total dissolved solids (5 wells), manganese (4 wells), chloride (5 well), iron (6 wells) and zinc (1 well). High sodium levels (over the ODWS of 200 mg/L) have been found in 5 Lower Thames PGMN wells. Sodium above 20 mg/L (but below 200 mg/L) is seen in 9 Upper Thames wells and 4 Lower Thames wells.

Some parameters are above the Ontario Drinking Water Operational Guidelines (OG).

- In the UTRCA watershed, these are pH (1 well), hardness (19 wells) and aluminum (4 wells).
- In the LTVCA watershed, parameters that are above the Ontario Drinking Water OG are hardness (7 wells) and alkalinity (1 well).

Parameters without ODWS are compared to the highest laboratory detection limit. It is important to note that these parameters are detected using low levels of detection and, at those levels, may not pose human health concerns.

- In the UTRCA watershed, these parameters are detected: nickel (9 wells), vanadium (5 wells), cobalt (1 well), and thallium (4 wells).
- In the LTVCA watershed, nickel (1 well), vanadium (6 wells) and cobalt (3 wells) are detected.

Phosphorus is above the IPWQO of 0.03 mg/L (for the prevention of nuisance algae growth) at a number of locations.

- In the UTRCA watershed, there are 9 PGMN wells with phosphorus above 0.03 mg/L. As well, phosphorus may be above the IPWQO in 7 more UTRCA wells but it is uncertain, owing to a detection limit (0.05 mg/L) of one of the laboratories, which is higher than the IPWQO of 0.03 mg/L.
- In the LTVCA watershed, there are 2 wells with phosphorus above 0.03 mg.

Parameter Range and Significance

The ranges of parameters above the Ontario drinking water standard/guideline/objective in the PGMN wells of the Thames Watershed & Region, between 2002 and 2006, are shown in the **Table 3.3.2.2-2.** Significance of parameters above the Ontario drinking water limit and parameters detected are described below.

Table 3.3.2.2-2: Range of Parameters Above the Ontario Drinking Water Standards/ Guidelines/ Objectives in the Thames PGMN Wells, for 2002-2006

Parameter (from PGMN data for 2002 to 2006)	Upper Thames Watershed			Lower Thames Watershed		
	Min. (mg/L)	Max. (mg/L)	n	Min. (mg/L)	Max. (mg/L)	n
Fluoride	0.1	3	75	0	2.5	20
Sodium	2.7	140	76	9.2	489	18
Hardness	5.5	660	76	30	548	20
Manganese	0.0005	0.17	76	0.00076	0.279	20
Total Dissolved Solids	98	924	76	268	1450	20
Chloride	0.5	265	76	16	790	20
Iron	0	3	76	-0.003	2.1	20
pH	7.58	10.1	75	None above the ODWS		
Aluminum	0	0.48	75			
Nitrate	0.05	10.6	48			
Nitrate+Nitrite	0.05	10.6	74			
Arsenic	0	0.03	75			
Dissolved Organic Carbon	0.1	16.1	67			
Trihalomethanes	0	0.274	24			
Cadmium	-0.00003*	0.012	75			
Zinc	None above the ODWS			0	12.3	20
Lead				0	0.0134	20
Alkalinity				130	723	19
Barium				0.0239	2.18	20

Note: n is sample size (2002 to 2006)
*Laboratory reporting method can result in negative values being reported (see discussion on cadmium)

Fluoride and Arsenic

Fluoride and arsenic can occur naturally in groundwater at levels that are above the drinking water standard[53]. Arsenic is a metalloid and fluoride is an anion. Both are highly mobile in groundwater. Fluoride is often associated with sodium bicarbonate groundwater[54]. High fluoride levels affect dental

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[53] Lesage, S. Groundwater quality in Canada: a national overview. In Bringing groundwater quality research to the watershed scale. Proceedings of GQ2004, the 4th International Groundwater Quality Conference, held at Waterloo, Canada, July 2004. p 2-10.

[54] Griffioen, J., R. Brunt, S. Vasak and J. Van der Gun. 2005. A global inventory of groundwater quality: first results. In Bringing groundwater quality research to the watershed scale (Proceedings of GQ2004, the 4th International Groundwater Quality Conference, held at Waterloo, Canada July 2004. p 2-10.)

health by causing dental fluorosis in children. Low levels result in a deficiency and may cause dental caries. Arsenic may be from natural causes such as the weathering of rocks. Inorganic arsenic may be used while producing pressure treated lumber while organic arsenic may be used in pesticides[55].

Fluoride levels in the Thames watershed PGMN wells range from 0 to 3 mg/L. Arsenic was detected in Upper Thames Well 201 only, in 2003. There were no arsenic levels above the Ontario Drinking Water Standard in the Lower Thames wells.

Sodium and Chloride

The ODWS Aesthetic Objective for sodium is 200 mg/L. However, levels of sodium (Na) that are higher than 20 mg/L level must be reported to local Health Units. Sodium levels are higher in the LTVCA wells (9.2 to 489 mg/L) than the UTRCA wells (2.7 to 140 mg/L). Chloride levels in the LTVCA wells are also higher, ranging from 19 to 790 mg/L, while chloride levels in the UTRCA wells range between 0 to 265 mg/L.

This data may indicate a longer groundwater flow path in Chatham-Kent with a further distance from the groundwater recharge area or the presence of older groundwater (> 10,000 years) due to an upward gradient from deeper depths. It could also indicate a difference in bedrock lithology. However, the high concentrations of sodium and chloride could indicate contamination due to road salt. Chloride ions are conservative, moving with water without being lost. Nearly all chloride added to the environment will eventually migrate to surface water or groundwater. Chloride can be toxic to aquatic organisms at high concentrations, and affects growth and reproduction at lower concentrations.

Hardness

Hardness is the sum of the Ca and Mg carbonate concentrations expressed in terms of mg/L of calcium carbonate. Calcium and magnesium carbonate are less soluble at higher temperatures and form an insoluble residue with soap typified as bath tub ring. Detergents were introduced to overcome this. This calcium carbonate precipitation is a major problem in boilers because it results in poor heat conduction[56]. Hardness as calcium carbonate has an ODWS Operating Guideline of 80-100 mg/L. Hardness is typically caused by dissolved calcium and magnesium, and may be due to the natural presence of limestone or dolomite. High levels of hardness cause taste issues in drinking water, scaling problems in plumbing fixtures and heaters, and hinder the lathering of soap[57]. Hardness above 200 mg/L is ‘poor but tolerable’ and above 500 mg/L is unacceptable for most domestic uses.[57]

The hardness levels range from 5.5 to 660 mg/L in the Thames Watershed & Region. Throughout the region, the monitoring wells commonly show hardness levels that are above the ODWS Operating Guideline of 80-100 mg/L. The UTRCA wells are dominated by calcium-magnesium-bicarbonate water. While hardness levels above the ODWS are seen in eight of 11 LTVCA wells, sodium and chloride dominate the groundwater chemical matrix.

Total Dissolved Solids (TDS)

The progressive solution of minerals, as groundwater moves down gradient in an aquifer, will result in increases in the TDS and hardness. The ODWS Aesthetic Objective of TDS is 500 mg/L. TDS is the dissolved inorganic matter in water and is comprised mainly of chloride, sulphate, calcium, magnesium and bicarbonates[57]. High TDS causes various problems such as hardness, taste, scales or corrosion, depending on the amounts of the constituents present[57].

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[55] ATSDR. August 2007. ToxFAQs for Arsenic. www.atsdr.cdc.gov/tfacts2.html

[56] Hem, J. D. 1992. Study and Interpretation of Chemical Characteristics of Natural Water. USGS Water Supply Paper 2254.

[57] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

The TDS levels range from 268 mg/L (Well #249) to 1450 mg/L (Well #236) in the LTVCA wells, and from 98 mg/L (Well #56) to 924 mg/L (Well #369-3) in the UTRCA wells.

Alkalinity

Alkalinity is a measure of the 'capacity' of water to neutralize acid or base. Alkalinity or acidity (pH) can be used to evaluate the potential of the groundwater to dissolve aquifer material (i.e. rock or sand and gravel). In almost all natural waters the alkalinity is produced by the dissolved carbon dioxide (CO_2) species, bicarbonate and carbonate. The principal source of CO_2 species in groundwater is dissolved from the soil or air above the saturated zone and the carbonate and bicarbonate species are dissolved from the soil or saturated zone.

The recommended ODWS Operational Guideline for alkalinity in coagulant-treated drinking water is 30 to 500 mg/L expressed as calcium carbonate. Alkalinity over 30 mg/L assists floc formation during the coagulation process. Water with low alkalinity may tend to accelerate natural corrosion leading to "red water" problems whereas high alkalinity waters may produce scale incrustations on utensils, service pipes and water heaters[57] .

The alkalinity levels range from 213 to 640 mg/L. Alkalinity above the ODWS Operational Guideline of 30 to 500 mg/L was observed at only one LTVCA monitoring well, in Chatham-Kent. There were no samples with alkalinity above the ODWS in the Upper Thames wells.

Iron and Manganese

Although iron is the second most abundant metallic element in the earth's outer crust, concentrations present in water are generally small. The chemistry of iron in aqueous systems depends strongly on the oxidation intensity and pH. Iron is an essential element in the metabolism of animals and plants. If present in water in excessive amounts, it can be an objectionable impurity and it forms red precipitates that stain laundry and plumbing fixtures[56]. The ODWS Aesthetic Objective for iron (Fe) is 0.3 mg/L.

Manganese is also one of the abundant metallic elements in the earth's crust, similar to iron. It is not an essential constituent of any of the more common rock minerals. The chemistry of manganese is somewhat like that of iron. The manganese (Mn) ODWS Aesthetic Objective is 0.05 mg/L.

Iron and manganese in groundwater are usually due to the natural weathering of rocks and minerals, but anthropogenic sources include industrial discharge, sewage and landfill leachate[58]. High levels of these elements in drinking water cause taste and odour problems.

Across the Thames watershed, iron levels range from 0 to 3 mg/L, while manganese ranges from 0.0005 to 0.279 mg/L.

pH

The ODWS operational guideline (OG) of pH is 6.5 and 8.5. The principal objective in controlling the pH level in water is to avoid corrosiveness, which occurs when pH is below 6.5, or incrustation, bitter taste and decrease in the efficiency of chlorine disinfection and alum coagulation, which occur when pH is above 8.5[57]

The pH levels were within the operational guideline range in the LTVCA wells but range from 7.58 to 10.1 in the UTRCA wells.

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[58] British Columbia Ministry of the Environment website, Water Stewardship Information Series: Iron and Manganese in Groundwater. www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/library/ground_fact_sheets/pdfs/fe_mg(020715)_fin2.pdf

Aluminum

Aluminum (Al) was above the ODWS Operational Guideline of 0.1 mg/L in a few Upper Thames monitoring wells and ranged between 0 to 0.48 mg/L. The guideline is meant to limit the residual aluminum concentration in treated water to avoid the coating of distribution pipes. There is no conclusive evidence that aluminum poses a health risk[57].

Nitrate, Nitrate+Nitrite

The ODWS Maximum Acceptable Concentration (MAC) of nitrate is 10 mg/L. The total nitrate plus nitrite-nitrogen concentration should also not be above the ODWS MAC of 10 mg/L. Nitrates are usually considered to be associated with septic systems, fertilizer use, and human and animal waste. The nitrate ion is soluble and does not adsorb to sediment or organic matter. Therefore, nitrate has a high potential for mobility through surface runoff and by leaching into groundwater. Due to its solubility in water, nitrates can readily reach streams by infiltration through soil and percolation via shallow groundwater, or through tile drains. Elevated levels in a watercourse can be toxic to aquatic organisms, especially amphibians. A condition called blue baby syndrome (methaemoglobinaemia) can result from young children drinking water with elevated nitrates. It is important to also test for nitrites in groundwater. The nitrate ion is not directly responsible for the syndrome, but must be converted to nitrite by intestinal bacteria; the nitrite then causes reduced oxygen carrying capacity of the red blood cells to body tissues.[57]

Each of the two parameters (nitrate and nitrate+nitrite) ranges from 0.05 to 10.6 mg/L in the UTRCA watershed, with levels above the ODWS at one well only. Nitrite may be absent since the concentration of both parameters are the same. There were no parameters above drinking water standards in the LTVCA wells.

Dissolved Organic Carbon

The ODWS Aesthetic Objective of dissolved organic carbon (DOC) is 5 mg/L. The ODWS limit is meant to help eliminate bacterial regrowth during treated water storage and distribution due to the availability of nutrient carbon[57]. DOC is from the partial decomposition of organic matter (plants and animals) in water. In a groundwater aquifer, the DOC may be due to soil organic carbon or subsurface sedimentary organic sources such as buried peat[59]. High water tables, storm events when large amounts of DOC enter the saturated zone, and recharge sites with saturated soils (such as tundra or peat bogs) result in high groundwater DOC, while the anthropogenic sources of DOC are landfill sites and septic tanks[60].

The DOC ranged from 0.1 mg/L to as high as 16.1 mg/L at one UTRCA well. DOC was not above the ODWS in the LTVCA wells.

Trihalomethanes

Trihalomethanes (THMs) are synthetic organics comprised of chloroform, bromodichloromethane, dibromochloromethane and bromoform. The ODWS MAC is 0.100 mg/L (100 µg/L) based on a locational running annual average of a minimum of quarterly samples taken at the point in the distribution system reflecting the maximum residence time[57]. THMs are produced in chlorinated drinking water when organic matter and chlorine react. Chloroform is a suspected carcinogen and high levels of THMs may cause reproductive problems[61].

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[59] Aravena and Wassenaar. 1993. Dissolved organic carbon and methane in a regional confined aquifer, southern Ontario, Canada: Carbon isotope evidence for associated subsurface sources. In Applied Geochemistry Vol. 8, no. 5, pp. 483-493.

[60] Clark, I. D., and P. Fritz. 1997. Environmental Isotopes in Hydrogeology. CRC Press LLC, Florida. Sentences from Chapter 5 ‘Tracing the Carbon cycle’ on website www.science.uottawa.ca/~eih/ch5/ch5.htm#DOC

[61] Health Canada. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document Trihalomethanes. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/trihalomethanes/

The one incident of trihalomethanes occurred in an UTRCA well (maximum of 0.274 mg/L). It may be attributed to the presence of natural organic matter in the well and the sample being taken immediately after chlorination of the well.

Cadmium

The ODWS MAC for cadmium is 0.005 mg/L. Cadmium is a relatively rare element that is extremely unlikely to be present as a significant natural contaminant in drinking water. Sources could be electroplated materials and electroplating wastes[57].

Cadmium (Cd) was above the ODWS MAC in only one UTRCA monitoring well (0.012 mg/L). There were no cadmium levels above the drinking water standards in the Lower Thames wells.

Zinc

The ODWS Aesthetic Objective (taste related drinking water limit) is 5 mg/L. Zinc is an essential element that is toxic to aquatic life at elevated levels. Zinc adsorbs strongly to particulate matter, especially organic matter and accumulates in streambed sediments. The primary use of zinc is for galvanized products for the automobile and construction industry. Anthropogenic (human) sources of zinc include mining, zinc production facilities, waste disposal and incineration, iron and steel production, corrosion of galvanized structures, coal and fuel combustion, road surface runoff, zinc-containing fertilizers and pesticides.

Zinc ranged between 0 and 12.3 mg/L. Zinc (Zn) was above the ODWS Aesthetic Objective in one LTVCA monitoring well in Chatham-Kent. There were no zinc levels above the drinking water standards in the UTRCA wells.

Lead

The ODWS MAC of lead (Pb) is 10 µg/L (0.01 mg/L). Lead is a cumulative toxin that can affect the central nervous system of animals and humans. The solid form binds with dust and certain types of soil, especially clay and organic matter, and can accumulate in riverbed sediments. The primary use of lead in Canada is the production of acid storage batteries. Anthropogenic sources that can impact water quality include: mining, milling and smelting of lead; burning of fossil fuels; municipal waste incineration; wastewater; sewage sludge; phosphate fertilizers; and certain pesticides. Atmospheric deposition may be a significant source. Lead has been used extensively in plumbing, and was used in leaded gasoline (phased out in the 1980s).

Lead (Pb) was above the ODWS MAC of 10 µg/L (0.01 mg/L) in one LTVCA well only. There were no lead levels above the drinking water standards in the UTRCA wells.

Barium

The ODWS MAC for Barium is 1 mg/L. Barium is a common constituent in sedimentary rocks such as limestone and dolomite where it is accompanied by strontium and much larger amounts of calcium. Hence, hard water contains small amounts of barium but seldom at concentrations greater than 1 mg/L[57].

Barium (Ba) was above the ODWS MAC of 1 mg/L in one LTVCA well only. There were no lead levels above the drinking water standards in the UTRCA wells.

Phosphorus

The Federal-Provincial-Territorial Committee on Drinking Water has not developed a guideline for phosphorus in drinking water; phosphorus does not pose a direct threat to human health; and it is an essential component of all cells and is present in bones and teeth[62]. Phosphorus occurs naturally in rocks and is used in many products including detergents, cleaning agents, fertilizers and animal feed. The

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[62] CCNE website: Phosphorus. www.ccme.ca/sourcetotap/phosphorus.html.

nutrients nitrates and phosphorus are usually considered to be associated with septic systems, wastewater discharges, fertilizer use, or human and animal waste. Phosphorus binds to soil and is readily transported to streams with eroding soil. Although phosphorus tends to bind to soil, phosphorus leaching to groundwater does occur especially in soils that are low in clay, organic carbon, iron and aluminum and in soils where downward flow occurs in macropores[63].

The nutrient phosphorus (P) is found to be above the IPWQO aquatic water guideline of 0.03 mg/L in the Thames Watershed & Region, ranging from 0 to 12 mg/L in the UTRCA wells, and from 0 to 0.07 mg/L in the LTVCA wells.

Cobalt (Co)

There is no Ontario Drinking Water Standard for cobalt. Cobalt occurs naturally in trace amounts in rocks, soil, surface water and groundwater. Anthropogenic sources include vehicular exhaust, and waste from industries that manufacture superalloy, paint drier, porcelain enamel ground coat and pigments; cobalt is a possible carcinogen[64].

Cobalt was detected in one of the UTRCA PGMN monitoring wells (0.0017 mg/L) and three of the LTVCA (maximum 0.0016 mg/L) PGMN monitoring wells. It appears reasonable to conclude that uncontaminated[56] natural water should generally contain no more than a few micrograms per litre of cobalt. One microgram per litre is one thousandth of a milligram per litre.

Nickel (Ni)

There is no Ontario Drinking Water Standard for nickel. Natural weathering and erosion of geological materials (e.g. glacial overburden and bedrock) release nickel into surface waters and soils in Canada[65]. It is often used in electroplating, stainless steel and alloy products, mining, and refining[66]. Human health effects due to excessive nickel exposure include skin irritancy and lung and nasal cancer[65].

Nickel was detected in nine UTRCA (maximum of 0.018 mg/L) PGMN monitoring wells and one LTVCA (maximum of 0.0047 mg/L) well. Nickel occurs at slightly higher concentrations than cobalt in natural fresh water but would still be in the order of a few to several micrograms per litre[56].

Vanadium (V)

There is no Ontario Drinking Water Standard for vanadium. It is a metal that occurs naturally in fossil fuels[67]. It is used primarily as an additive to strengthen steel, and in dye, pesticide and ceramic industries; its alloys are used in the aeronautical industry[68]. Human health effects of vanadium are yet to be determined[69].

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[63] Alberta Agriculture, Food and Rural Development, Irrigation Branch. Agricultural impacts on Groundwater Quality in the Irrigated Areas of Alberta. Fact Sheet IB002-2000.

[64] OMOE. March 2001. Ministry of the Environment programs and initiatives: Cobalt in the environment. www.ene.gov.on.ca/cons/3793e.htm

[65] Health Canada. Environmental and Workplace Health: Nickel and its Compounds. Summary of Information Critical to Assessment of "Toxic." www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/compounds_nickel_composes/compounds_nickel_composes_2_e.html

[66] United States Geological Survey website, Water Science for Schools: Groundwater Quality. http://ga.water.usgs.gov/edu/earthgwquality.html

[67] International Program on Chemical Safety. 1988. Environmental Health Criteria 81: Vanadium. World Health Organization Publication. www.inchem.org/documents/ehc/ehc/ehc81.htm#SectionNumber:1.2

[68] National Research Council of Canada website, Periodic Table of the Elements: Vanadium. www.nrc-cnrc.gc.ca/eng/education/elements/el/v.html

[69] ATSDR. July 1992. ATSDR Toxicological Profile for Vanadium. www.atsdr.cdc.gov/toxprofiles/tp58.pdf

Vanadium was detected in five of the UTRCA (maximum of 0.002 mg/L) PGMN monitoring wells and six of the LTVCA (maximum of 0.009 mg/L) wells. Data on vanadium concentrations in natural or ordinary surface water or groundwater indicates that it would be less than 10 micrograms per litre[56].

Thallium

There is no Ontario Drinking Water Standard for thallium. Thallium is a heavy metal used mainly in specialized electronic research equipment like gamma radiation detection[70]. Thallium would enter groundwater from soils and waste discharges[71]. Long-term human health effects include blood chemistry changes, and damage to the liver[72] and kidney. [73]

Thallium was detected in three of the UTRCA (maximum of 0.0374 mg/L) PGMN monitoring wells and none of the LTVCA wells.

Review of Thames PGMN Data by County

The PGMN groundwater quality data has been reviewed. The results are presented in:

- **Table 3.3.2.2-3: Parameters Above the Ontario Drinking Water Standards/ Guidelines/ Objectives in PGMN Wells in the UTRCA Watershed**
- **Table 3.3.2.2-4: Parameters Above the Ontario Drinking Water Standards/ Guidelines/ Objectives in PGMN Wells in the LTVCA Watershed**
- **Table 3.3.2.2-5: Parameters Detected in PGMN Wells in the UTRCA Watershed**
- **Table 3.3.2.2-6: Parameters Detected in PGMN Wells in the LTVCA Watershed**
- **Table 3.3.2.2-7: Phosphorus Above IPWQO in PGMN Wells in the UTRCA Watershed**
- **Table 3.3.2.2-8: Phosphorus Above IPWQO in PGMN Wells in the LTVCA Watershed**

The 20 UTRCA PGMN wells are grouped, based on their location, into:

- Middlesex County wells (well no. 56, 107, 217, 370, 437),
- Oxford County wells (well no. 53, 55, 180, 201, 369-2, 369-3), and
- Perth County wells (well no. 54, 76, 218-3, 218-4, 218-5, 219, 368, 371-2, 371-3).

The 11 LTVCA PGMN wells are grouped, based on their location, into:

- Middlesex County wells (well no. 184, 248),
- Chatham-Kent wells (well no. 182, 211, 236, 237, 247, 249, 250, 438), and
- Elgin County well (well no. 445).

The locations of the PGMN wells in the Thames watershed are shown in **Map 15: Provincial Groundwater Monitoring Network**.

Sample sizes range from one to three per year in the Upper Thames watershed, and one per year in the Lower Thames watershed as shown in the tables. The parameters above the ODWS and number of detects are discussed below. Abbreviations commonly used in the parameter review discussion are:

- ODWS: Ontario Drinking Water Standard
- MAC: Maximum Acceptable Concentration
- AO: Aesthetic Objective
- OG: Operational Guideline
- IPWQO: Interim Provincial Water Quality Objective

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[70] USGS website, Minerals Information: Thallium. http://minerals.usgs.gov/minerals/pubs/commodity/thallium

[71] USGS website, Water Science for Schools: Groundwater Quality. http://ga.water.usgs.gov/edu/earthgwquality.html

[72] USEPA. Consumer Fact Sheet on Thallium. www.epa.gov/safewater/contaminants/dw_contamfs/thallium.html

[73] ATSDR. July 1992. ATSDR Toxicological Profile for Vanadium. www.atsdr.cdc.gov/toxprofiles/tp58.pdf

Oxford County Wells

All six Oxford PGMN wells (53, 55, 180, 201, 369-2 and 369-3) are in the Upper Thames watershed. As discussed below, parameters above the Ontario Drinking Water Standards/ Guidelines/ Objectives in Oxford County are fluoride, total dissolved solids, hardness, manganese, arsenic, trihalomethanes, dissolved organic carbon, nitrate, nitrate+nitrite and iron. Sodium is above the local health unit notification limit.

Fluoride (F) levels are above the ODWS MAC in wells 55 and 369-3. Sodium (Na) above 20 mg/L (but below the ODWS AO of 200 mg/L) was observed in wells 53, 180 and 369-2. Hardness in all Oxford wells is above the ODWS OG. The total dissolved solids (TDS) is above the ODWS AO in wells 180, 369-2 and 369-3.

Elevated arsenic (As) above the ODWS of 0.025 mg/L was in well 201 in 2003. The nutrient nitrate (and nitrate+nitrite) was found to be above the ODWS of 10 mg/L in well 180 only. Iron (Fe) is above the ODWS AO of 0.3 mg/L in wells 53, 55, 201, 369-2 and 369-3. Manganese (Mn) is above the ODWS AO of 0.05 mg/L in wells 369-2 and 369-3. Dissolved Organic Carbon (DOC) is above the ODWS AO of 5 mg/L in well 201 only.

The one incident of trihalomethanes above the ODWS MAC of 0.1 mg/L occurred in well 369-2 (maximum of 0.274 mg/L) and may be attributed to the presence of natural organic matter in the well and the sample being taken immediately after chlorination of the well.

Nickel is detected in wells 180 and 369-2, while vanadium is detected in well 55 and thallium in well 180.

Phosphorus is above the Interim Provincial Water Quality Objective (IPWQO) of 0.03 mg/L (to prevent the nuisance growth of algae) in wells 53, 201 and 369-2. It is unknown if the phosphorus levels in 2006 samples of wells 53, 55, 180 and 369-3 were above the IPWQO since the samples were tested for dissolved (not total) phosphorus and were below the detection limit of 0.05 mg/L, higher than the IPWQO (other samples had detection limits below the IPWQO).

Perth County Wells

All nine Perth County PGMN wells (54, 76, 218-3, 218-4, 218-5, 219, 368, 371-2, 371-3) are in the Upper Thames watershed. Parameters above the Ontario Drinking Water Standards/ Guidelines/ Objectives in Perth County are fluoride, total dissolved solids, hardness, manganese, cadmium, dissolved organic carbon, aluminum and iron. Sodium is above the local health unit notification limit.

Fluoride (F) levels are above the ODWS MAC of 1.5 mg/L in wells 76, 219, 368 and 371-3. The total dissolved solids (TDS) concentration was higher than the ODWS AO of 500 mg/L in well 371-3 only. The hardness levels are above the ODWS OG range of 80 to 100 mg/L in all Perth wells. Sodium (Na) above 20 mg/L (but below the ODWS AO of 200 mg/L) was observed in wells 76, 219, 368 and 371-3.

Dissolved Organic Carbon (DOC) was above the ODWS AO of 5 mg/L in wells 54 and 368. Manganese (Mn) is higher than the ODWS AO of 0.05 mg/L in wells 54 and 219. Cadmium (Cd) was above the ODWS MAC of 0.005 mg/L in well 54 only, in 2005. Both wells 371-2 and 371-3 had aluminum (Al) levels above the ODWS OG of 0.1 mg/L. Iron (Fe) was above the ODWS AO of 0.3 mg/L in wells 54, 76, 218-3, 218-4, 218-5, 219, 368, and 371-3.

Nickel is detected in wells 54, 218-3, 218-4, 218-5, 371-2 and 371-3. Thallium is detected in wells 54, 76 and 219 while vanadium is detected in wells 218-3 and 371-3. Cobalt is detected in well 371-2.

Phosphorus is above the Interim Provincial Water Quality Objective (IPWQO) of 0.03 mg/L (to prevent the nuisance growth of algae) in wells 54 (2003), 368 (the first 2006 sample), 371-2 (2003, 2004 and 2005) and 371-3 (2005). It is unknown if the phosphorus levels in 2006 samples of wells 54, 76, 218-5, 219, 368 (the second 2006 sample), 371-2 and 371-3 as well as the 2005 samples of 54 and 368 were above the IPWQO since the samples were tested for dissolved (not total) phosphorus and were below the detection limit of 0.05 mg/L, higher than the IPWQO (other samples had detection limits below the IPWQO).

Middlesex County Wells

There are five Middlesex PGMN wells in the Upper Thames watershed (56, 107, 217, 370, 437), and two in the Lower Thames watershed (184 and 248). Parameters above the Ontario Drinking Water Standards/ Guidelines/ Objectives in Middlesex County are fluoride, chloride, total dissolved solids, hardness, pH, manganese, aluminum and iron. Sodium is above the local health unit notification limit.

Fluoride (F) is above the ODWS MAC of 1.5 mg/L in well 56 (Upper Thames) and well 248 (Lower Thames). Sodium (Na) above 20 mg/L (local health unit notification limit) but below 200 mg/L (ODWS AO) is observed in wells 56, 217 and 437 (Upper Thames), as well as in well 248 (Lower Thames). Levels of chloride (Cl) and total dissolved solids (TDS) above the respective ODWS AOs of 250 mg/L and 500 mg/L are observed in Upper Thames well 217 and wells 211, 236, 237, 247 and 250 (Lower Thames). Hardness above the ODWS OG range of 80 to 100 mg/L is observed in wells 107, 217, 370, 437 (Upper Thames) and both Lower Thames Middlesex wells 184, 248.

The pH was above 8.5 in well 56 (Upper Thames) and well 248 (Lower Thames). Manganese (Mn) was above the ODWS AO of 0.05 mg/L in Upper Thames well 107 only. Aluminum (Al) is above the ODWS OG of 0.1 mg/L and iron (Fe) above the ODWS AO of 0.3 mg/L in Upper Thames well 370 only.

Vanadium is detected in Middlesex County wells 56, 217 and 184. Nickel is detected in well 217 only.

Phosphorus is above the Interim Provincial Water Quality Objective (IPWQO) of 0.03 mg/L (to prevent the nuisance growth of algae) in wells 370 and 437. It is unknown if the phosphorus level in well 56 (2006) was above the IPWQO since the sample was tested for dissolved (not total) phosphorus and was below the detection limit of 0.05 mg/L, higher than the IPWQO (other samples had detection limits below the IPWQO).

Chatham-Kent Wells

All Chatham-Kent PGMN wells (182, 211, 236, 237, 247, 249, 250 and 438) are in the Lower Thames watershed. Parameters above the Ontario Drinking Water Standards/ Guidelines/ Objectives in Chatham-Kent are fluoride, sodium, chloride, total dissolved solids, hardness, alkalinity, pH, manganese, iron, barium, zinc and lead.

Fluoride (F) levels were above the ODWS MAC of 1.5 mg/L in well 249 only. The levels of sodium (Na) are higher in the Chatham-Kent monitoring wells than other wells in the Thames watershed, with a maximum of 489 mg/L (at Well 236 in 2003). Sodium levels are above the 20 mg/L health unit notification limit (but below ODWS of 200 mg/L) in wells 249 and 250. Sodium and chloride levels in wells 211, 236, 237, 247 and 250 are above the Ontario Drinking Water Standard Aesthetic Objective of 200 mg/L and 250 mg/L, respectively.

The total dissolved solids is higher than the ODWS Aesthetic Objective of 500 mg/L in wells 211, 236, 237, 247 and 250. The hardness levels are above the ODWS OG range of 80 to 100 mg/L in wells 182, 211, 236, 237, 250 and 438. Alkalinity above the ODWS OG range of 30 to 500 mg/L is observed in well 247 only. The pH was higher than the ODWS OG range of 6.5 to 8.5 in well 247.

Manganese (Mn) was above the ODWS AO of 0.05 mg/L in wells 182, 236, 237, 249 and 250. Iron (Fe) was higher than the ODWS AO of 0.3 mg/L in wells 211, 236, 237, 247 and 250. Barium is above the ODWS MAC of 1 mg/L in well 249 only. Zinc is above the ODWS AO of 5 mg/L in well 211 only. Lead is above the ODWS MAC of 10 µg/L in well 237 only.

Vanadium is detected in wells 211, 236, 237, 247 and 250. Nickel is detected in well 250 only. Cobalt is detected in wells 211, 237 and 249.

Phosphorus is above the Interim Provincial Water Quality Objective (IPWQO) of 0.03 mg/L (to prevent the nuisance growth of algae) in wells 247 and 249.

Elgin County Wells

Elgin County well 445 is in the LTVCA. There was one instance of fluoride being above the ODWS MAC of 1.5 mg/L.

Table 3.3.2.2-3: Parameters Above the Ontario Drinking Water Standards/ Guidelines/ Objectives in PGMN Wells in the UTRCA Watershed

Well No.	2003	n	2004	n	2005	n	2006	n
Middlesex County								
56	F, Na	1	Na	1	F (nn=2), Na (nn=2), pH (nn=2)	2	F, Na, pH	1
107	Hardness, Mn	1	Hardness, Mn	1		0		0
217	Hardness, Na, TDS, Cl	1	Hardness, Na, TDS, Cl	1		0		0
370	Hardness	1	Al, Fe, hardness	1		0		0
437		0		0	Hardness, Na	1	Hardness	1
Oxford County								
53		0	Fe, hardness, Na	1		0	Fe, hardness, Na	1
55	F, hardness	2	F, Fe, hardness	1	F (nn=2), hardness (nn=2)	2	Hardness	1
180	Hardness, Na	1	Hardness, Na, TDS, nitrate+nitrite, nitrate	1		0	Hardness, TDS	1
201	As, Fe, hardness, DOC	1	Fe, hardness, DOC	1	Fe (nn=2), hardness, DOC	2	Fe (nn=2), hardness (nn=2), DOC (nn=2)	2
369-2	Na, TDS, Mn, hardness, Trihalomethanes	1	Na, TDS, Mn, hardness	1	Fe (nn=2), Mn (nn=2), Na (nn=2), TDS, hardness	2		0
369-3	F, Fe, hardness, Mn, TDS	1	F, Fe, hardness, Mn, TDS	1	F, Fe, hardness, Mn, TDS	1	Fe, hardness, Mn, TDS	1

Well No.	2003	n	2004	n	2005	n	2006	n
Perth County								
54	Hardness	1	Fe, hardness, DOC	1	Cd, Mn, hardness	1	Hardness	1
76	F, hardness, Na	1	Na	1	F (nn=2), Na (nn=2)	2	Fe, hardness, Na	1
218-3	Hardness	1	Fe, hardness, Al	1		0		0
218-4	Hardness	1	Fe, hardness	1		0		0
218-5	Hardness	1	Fe, hardness	1		0	Fe, hardness	1
219	F, hardness, Mn, Na	1	F, hardness, Mn, Na	1	F (nn=2), Fe, hardness, Mn (nn=2), Na (nn=2)	2	F, hardness, Mn, Na	1
368	F, Fe, hardness, Na, DOC	1	F, Fe, hardness, Na, DOC	1	F (nn=3), Fe (nn=3), Na (nn=3), hardness (nn=2), DOC	3	Fe (nn=2), Na (nn=2), hardness (nn=2), DOC (nn=2)	2
371-2	Hardness	1	Al, Mn, hardness	1	Hardness	1	Hardness	1
371-3	F, hardness, Na	1	F, hardness, Na, TDS	1	F (nn=2), Na (nn=2), TDS (nn=2), hardness, Al, Fe	2	F, hardness, Na, TDS, Al	1

Note
1) 'n' is sample size
2) For all wells, one occurrence per year unless specified otherwise in brackets (nn)
3) Well #53 had iron, hardness levels higher than ODWS and sodium higher than health unit notification in 2002, and Well #180 had iron and hardness levels higher than ODWS in 2000

Table 3.3.2.2-4: Parameters Above the Ontario Drinking Water Standards/ Guidelines/ Objectives in PGMN Wells in the LTVCA Watershed

Well No.	2003	n	2004	n	2006	n
Chatham-Kent						
182	Mn, Na, hardness	1		0		0
211	Cl, hardness, Na, TDS	1	Cl, hardness, Na, TDS, Fe, Zn	1		0
236	Cl, hardness, Na, TDS, Fe, Mn	1		0		0
237	Cl, hardness, Na, TDS, Fe	1	Cl, hardness, Na, TDS, Fe, Mn, Pb	1		0
247	Cl, Fe, alkalinity, Na, TDS	1	Fe, alkalinity, Na, TDS, pH	1	Fe, alkalinity, Na, TDS	1
249	Na	1	F, Na	1	Ba, Mn, Na	1
250	Cl, Fe, hardness, Mn, Na, TDS	1	Cl, Fe, hardness, Mn, Na, TDS	1		0
438		0		0	Fe, hardness	1
Middlesex						
184	hardness	1	hardness	1		0
248	Na, pH	1	F, hardness, Na	1		0
Elgin						
445		0		0	F	1

Note:
1) 'n' is sample size
2) No sampling was done in 2005
3) For all wells, one occurrence per year unless specified otherwise in brackets

Table 3.3.2.2-5: Parameters Detected in PGMN Wells in the UTRCA Watershed

Well No.	2003	n	2004	n	2005	n	2006	n
Middlesex County								
56		1		1	V	2		1
107		1		1		0		0
217	Ni, V	1		1		0		0
370		1		1		0		0
437		0		0		1		1
Oxford County								
53		0		1		0		1
55		2		1	V	2		1
180	Ni	1	Ni, Tl	1		0	Ni, Tl	1
201		1		1		2		2
369-2	Ni	1		1		2		0
369-3		1		1		1		1
Perth County								
54	Ni, Tl	1	Ni, Tl	1	Ni, Tl	1	Ni, Tl	1
76	Tl	1		1		2		1
218-3	Ni	1	V	1		0		0
218-4	Ni	1		1		0		0
218-5	Ni	1		1		0		1
219		1	Tl	1		2		1
368		1		1		3		2
371-2	Ni	1	Co, Ni	1		1		1
371-3		1	Ni	1	Ni, V	2		1

Note

1) 'n' is sample size

2) For all wells, one occurrence per year unless specified otherwise in brackets

3) Well #53 had cobalt, vanadium and phosphorus detected in 2002

Table 3.3.2.2-6: Parameters Detected in PGMN Wells in the LTVCA Watershed

Well No.	2003	n	2004	n	2006	n
Chatham-Kent						
182		1		0		0
211	V	1	Co	1		0
236	V	1		0		0
237	V	1	Co	1		0
247	V	1	V	1		1
249		1	Co	1		1
250	Ni, V	1	Ni	1		0
438		0		0		1
Middlesex						
184	V	1	V	1		0
248		1		1		0
Elgin						
445		0		0		1

Note:
1) 'n' is sample size
2) No sampling was done in 2005
3) For all wells, one occurrence per year unless specified otherwise in brackets

Table 3.3.2.2-7: Phosphorus Above IPWQO in PGMN Wells in the UTRCA Watershed

Well No.	2003	n	2004	n	2005	n	2006	n
Middlesex County								
56		1		1		2	P*	1
107		1		1		0		0
217		1		1		0		0
370	**P**	1		1		0		0
437		0		0		1	**P**	1
Oxford County								
53		0	**P**	1		0	P*	1
55		2		1		2	P*	1
180		1		1		0	P*	1
201		1		1	**P**	2	**P (nn=2)**	2
369-2	**P**	1		1	**P**	2		0
369-3		1		1		1	P*	1
Perth County								
54	**P**	1		1	P*	1	P*	1
76		1		1		2	P*	1
218-3		1		1		0		0
218-4		1		1		0		0
218-5		1		1		0	P*	1
219		1		1		2	P*	1
368		1		1	P*	3	**P,** P*	2
371-2	**P**	1	**P**	1	**P**	1	P*	1
371-3		1		1	**P**	2	P*	1

Note

1) For all wells, one occurrence per year unless specified otherwise in brackets (nn)

2) 'n' is sample size (no. of samples taken in a specified year)

3) The Interim Provincial Water Quality Objective (IPWQ) for total phosphorus is 0.03 mg/L, for the prevention of the nuisance growth of algae

4) **It is unknown if these phosphorus levels were above the IPWQO; the samples were tested for dissolved (not total) phosphorus and were below the detection limit of 0.05 mg/L, higher than the IPWQO (other samples had detection limits below the IPWQO)

Table 3.3.2.2-8: **Phosphorus (P) Above the IPWQO in PGMN Wells in the LTVCA Watershed**

Well No.	2003	n	2004	n	2006	n
Chatham-Kent						
182		1		0		0
211		1		1		0
236		1		0		0
237		1		1		0
247		1	**P**	1		1
249		1		1	**P**	1
250		1		1		0
438		0		0		1
Middlesex						
184		1		1		0
248		1		1		0
Elgin						
445		0		0		1

Note
1) For all wells, one occurrence per year unless specified otherwise in brackets (nn)
2) 'n' is sample size (no. of samples taken in a specified year); no sampling in 2005
3) The Interim Provincial Water Quality Objective (IPWQO) for total phosphorus is 0.03 mg/L, for the prevention of the nuisance growth of algae

3.3.2.3 Method of Review of Municipal Groundwater Supply Systems in the Thames Watershed & Region

There are a few drinking water systems in the Thames Watershed & Region that have documented levels of drinking water constituents that are above regulated limits. Some of these levels are for chemicals that can occur naturally in the groundwater and others are anthropogenic (associated with human activities).

The sources of water chemistry data available to assess water quality for municipal groundwater well supplies in the Thames Watershed & Region are listed below. They are described in detail in **Section 3.1: Selecting Indicator Parameters**.
1) Drinking Water Surveillance Program (DWSP)
2) Drinking Water Information System (DWIS)
3) Annual DWS Reports
4) OMOE Inspection Reports

The groundwater quality data has been reviewed and the results are presented in the form of tables. Most of the data obtained was for treated groundwater samples. Where raw water sample data was available, it was reviewed as well. Our review of the available water quality data, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water.

The DWSP and DWIS data were reviewed by performing cross tab queries in Microsoft Access which facilitates the comparison of chemical parameter values to Ontario Drinking Water Standards/ Guidelines/ Objectives established for treated drinking water supplied to communities. Where drinking water standards do not exist, laboratory detection limits are used.

The DWS and OMOE annual reports typically provide a single treated water sample data per year. Hence, they are provided here for information purposes only and are not considered conclusive review.

Special Cases

Sample Type – Treated Water

In the results section, sample type (raw or treated water) is specified. While treated water sample results are used to review groundwater quality when raw water sample results are not available, it must be noted that taste and odour control treatment techniques such as aeration, filtration, ozonation, and use of chemicals like potassium permanganate would remove organic pollutants in drinking water. Chlorination may also result in combining chloride with organic compounds to produce trihalomethanes (THMs), a disinfection by-product. The use of chemicals such as sodium hypochlorite for disinfection and sodium silicate for iron removal can also add small amounts of a parameter such as sodium to the treated water.

Hence, where treated water sample results above the Ontario Drinking Water Standard (ODWS) are reported, it is important to note the type of treatment technology while reviewing the Results Section. Treatment may possibly remove organic compounds from raw water. **Table 3.3.2.3-1: Thames Watershed Municipal Well Supply Systems Treatment Methods** lists the treatment techniques used in each well supply system.

DWSP Data

The OMOE DWSP database provides water chemistry data for municipal well supply systems. This is a volunteer program that was established in the 1990s and does not cover all municipal supply systems. Raw water quality data for the following four well supply systems in the Thames Watershed Region is available for review (data years in brackets): Dorchester (1993-2005), Ingersoll (1995-2002), Stratford (1991-2005) and Woodstock (1994-2002).

The data is reported as one raw water quality data set for each system but is not for each individual well within a system. For example, the Dorchester system has eight individual wells but data provided is only one set of parameters. The DWSP database provides annual average, maximum and minimum values only. The annual average and maximum values for raw water were compared to drinking water standards meant for water quality fit for human consumption.

OMOE Inspection Reports

Ministry of the Environment Annual Inspection Reports are reports of findings of drinking water supply system inspections conducted by MOE annually. These reports also identify parameters above drinking water standards or guidelines. However, the number of parameters is less than those done for annual DWS reporting, and the type of parameters analyzed vary from year to year and between well supply systems.

Chemical Parameters – Sodium and Fluoride

Sodium is a chemical parameter with an Ontario Drinking Water Standard Aesthetic Objective of 200 mg/L. However if sodium is above 20 mg/L, the local health unit must be notified and the values reported in the annual DWS and OMOE inspection reports. Hence, in this groundwater quality report, sodium levels above 20 mg/L are reported as being above health unit notification but the sodium concentration in the groundwater may not be higher than the ODWS of 200 mg/L. To provide additional information on sodium, a table has been prepared showing the range values for the municipal wells that have sodium concentrations over 20 mg/L.

Fluoride is a chemical parameter that can occur naturally in groundwater. It is very common in the wells in the region and there are a significant number of wells with floride reported. To provide additional information on fluoride, a table has been prepared showing the range of values for the municipal wells that have fluoride concentrations over to the ODWS of 1.5 mg/L.

Table 3.3.2.3-1: Thames Watershed & Region Municipal Well Supply Systems Treatment Methods

No.	Municipality/ Drinking Water System	Water Treatment Method
Middlesex		
1	Birr Well Supply	Disinfection with sodium hypochlorite
2	Dorchester Well Supply	Disinfection with sodium hypochlorite
3	Melrose Well Supply	Aeration (iron removal), disinfection with sodium hypochlorite
4	Kilworth Heights Subdivision Well Supply	Filters, disinfection with sodium hypochlorite, potassium permanganate
5	Mount Brydges Well Supply	Disinfection with sodium hypochlorite
6	Thorndale Well Supply	Sodium silicate (iron removal), disinfection with sodium hypochlorite
7	City of London Back Up Wells*	Disinfection with chlorine gas
Oxford		
1	Beachville-Loweville Subdivision Well Supply	Disinfection with sodium hypochlorite
2	Embro Well Supply	Aeration, iron removal, filtration, disinfection with sodium hypochlorite
3	Hickson-King Subdivision Well Supply	Polyphosphate (for iron sequestering) and disinfection with sodium hypochlorite
4	Ingersoll Well Supply	Disinfection with chlorine gas or sodium hypochlorite, filtration for hydrogen sulfide removal
5	Innerkip Well Supply	Filtration (iron removal), disinfection with sodium hypochlorite
6	Lakeside Well Supply	Disinfection with sodium hypochlorite and iron sequestering
7	Mount Elgin Well Supply	Disinfection with sodium hypochlorite
8	Tavistock Well Supply	Sodium silicate (iron sequestering), disinfection with sodium hypochlorite
9	Thamesford Well Supply	Filtration (iron and manganese removal) and disinfection with UV radiation
10	Woodstock Well Supply	Some wells have disinfection with UV light and other wells have filtration for iron removal and disinfection with chlorine gas or sodium hypochlorite

No.	Municipality/ Drinking Water System	Water Treatment Method
Perth		
1	Mitchell Well Supply	Sodium silicate (iron removal), disinfection by mixed oxidants (hypochlorous acid, chlorine dioxide, oxygen, ozone, hydrogen peroxide, chlorine)
2	Sebringville (Black Creek Estates) Well Supply	Disinfection with chlorination and ultraviolet radiation
3	Shakespeare (Miller Ave.) Well Supply	Disinfection with sodium hypochlorite
4	St. Marys Well Supply	Disinfection with chlorine and ultraviolet radiation
5	St. Pauls Well Supply	Sodium silicate (iron removal), disinfection with sodium hypochlorite and ultraviolet radiation
6	Stratford Well Supply	Sodium silicate (iron removal), disinfection with chlorine
Chatham-Kent		
1	Highgate Pure Water Well Supply	Disinfection with sodium hypochlorite and ultraviolet radiation
2	Ridgetown Well Supply	Aeration (methane gas removal), disinfection with sodium hypochlorite

3.3.2.4 Results and Discussion - Municipal Groundwater Well Supply Systems

The municipal groundwater well supply systems that service various areas of the Thames Watershed & Region are discussed in this section. The well systems are grouped based on their location in the municipalities of Middlesex, Oxford, Perth and Chatham-Kent. Where available, the data for each individual well within a system is reviewed and summarized in tables. As discussed in Section 3.3.2, most of the parameters are assessed using the Ontario Drinking Water Standards/ Guidelines/ Objectives (ODWS). The ODWS are meant for treated water, but in this report are used to review raw (untreated) water as well. Where these limits are absent, detection limits are employed.

Our review of the water quality data obtained, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water. Differences in the period of the data sets reviewed are identified as ‘data gaps.’ The specific reasons for these gaps in data are not ascertained and are not relevant to the characterizing of the water source. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these ‘data gaps.’ The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

Drinking Water Surveillance Program (DWSP) and County of Oxford Data

Raw (untreated) water data for four well supply systems (Dorchester, Ingersoll, Stratford and Woodstock) was available to be reviewed from the DWSP data set. In addition, more comprehensive County of Oxford data for raw water nitrates was obtained.

Tables 3.3.2.4-1: DWSP Data Chemical Parameters Detected in Raw Water to Well Supply Systems and **Table 3.3.2.4-2: DWSP Data Chemical Parameters Above ODWS in Raw Water to Well Supply Systems** provide information on chemicals reviewed as part of the DWSP data.

Table 3.3.2.4-3: Woodstock (Thornton Wellfield) Raw Water Nitrate Data provides a summary of the County of Oxford data on the Woodstock wells of the Thornton wellfield, where elevated levels of nitrate in the raw (untreated) water occur.

From **Table 3.3.2.4-1**, a comparison of annual average and annual maximum values to detection limits shows that nickel was detected in the raw water of all four municipal well supply systems, in most or all of the samples taken. There are no Ontario Drinking Water Standards for nickel.

In the one Woodstock raw water sample that was tested for 16 polyaromatic hydrocarbons (PAHs) in 1994, a comparison of annual average and annual maximum values to detection limits shows that two PAHs compounds were detected. There are no Ontario Drinking Water Standards for these PAHs.

It is important to note that an ODWS is available for one PAH only, benzo (a) pyrene. The benzo (a) pyrene levels in raw (untreated) water samples of the four well supply systems was not above the ODWS.

From **Table 3.3.2.4-2**, no annual average values of chemicals in raw water to the four well supply systems were above the ODWS, according to the DWSP database. As summarized in this table, when the annual maximum value of a chemical parameter in the raw (untreated) well water is compared against its corresponding ODWS, the following points are noted:

- Dorchester raw water has a few annual maximum dissolved organic carbon (DOC) values above the ODWS.
- Ingersoll raw water has three (1995, 1996 and 1997) annual maximum tetrachloroethylene (TCE) values above the ODWS , out of eight annual data (samples taken once per year from 1995 to 2002). TCE is an industrial solvent used for dry cleaning and metal degreasing and may likely be a carcinogen.[74]
- The annual maximum nitrates values in raw (untreated) Woodstock well water were above the ODWS in six years (1994, 1995, 1997, 1999, 2000 and 2001) out of eight years of data, while none of the annual average values were above the ODWS. However the DWSP data does not specify in which wells (or wellfield) the nitrate levels are above ODWS.

Table 3.3.2.4-3 summarizes more comprehensive County of Oxford data on specifically the Thornton wellfield, which has known elevated nitrate levels. The raw (untreated) water annual average nitrate values were above the ODWS a few times from 1994 to 2006 (the 13 years of data reviewed in this report) at Thornton wells # 1, 3 and 5. For the Thornton wells #1, 3 and 5, the annual maximum levels in the raw (untreated) water were above the ODWS in most data years, while only twice for Well #8. In order to reduce the treated water nitrate concentration to well below the OMOE's MAC of 10 mg/L, the County of Oxford has implemented a pumpage strategy that includes minimizing use of high nitrate wells and blending the water with water from low-nitrate wells. (Deborah Goudreau, Addressing and Mitigating Known Water Quality Issues: A Source Protection Case Study. 2007 OWWA/OMWA Annual conference)

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[74] ATSDR. September 1997. ToxFAQs for Tetrachloroethylene. www.atsdr.cdc.gov/tfacts18.html

Table 3.3.2.4-1: DWSP Data Chemical Parameters Detected in Raw Water to Well Supply Systems

Well Supply	Parameter Detected in Raw Water Sample	No. of Annual Data	No. of annual averages above MDL	No. of annual maximums above MDL
Dorchester	Nickel	11	11	11
Ingersoll	Nickel	8	7	8
Stratford	Nickel	12	9	10
Woodstock	Nickel	8	7	7
	Chrysene (PAH)	1	1	1
	Fluoranthene (PAH)	1	1	1

MDL: method detection limit
PAH: polyaromatic hydrocarbons

Table 3.3.2.4-2: DWSP Data Chemical Parameters Above ODWS in Raw Water to Well Supply Systems

Well Supply	Parameter in Raw Water Sample	No. of Annual Data	No. of annual averages above ODWS	No. of annual maximums above ODWS
Dorchester	Dissolved Organic Carbon (DOC)	11	0	3
Ingersoll	Tetrachloroethylene (TCE)	8	0	3
Woodstock	Nitrates, total	8	0	6

ODWS: Ontario Drinking Water Standard/Guideline/Objective

Table 3.3.2.4-3: Woodstock (Thornton Wellfield) Raw Water Nitrate Data

Woodstock Well Supply (Thornton wells)	No. of Annual Nitrate Data	No. of annual averages above ODWS	No. of annual maximums above ODWS
#1	13	4	10
#3	13	5	11
#5	13	4	9
#8	13	0	2

ODWS: Ontario Drinking Water Standard/Guideline/Objective

Drinking Water Information System (DWIS) Data

Parameters above Ontario Drinking Water Standards (for sodium: above the health unit notification) in municipal well supply systems in the Thames Watershed & Region are shown in the following tables:

- **Table 3.3.2.4-4: DWIS Data Parameter Above ODWS in Middlesex County**
- **Table 3.3.2.4-5: DWIS Data Parameter Above ODWS in Oxford County**
- **Table 3.3.2.4-6: DWIS Data Parameter Above ODWS in Perth County**
- **Table 3.3.2.4-7: DWIS Data Parameter Above ODWS in Chatham-Kent**

Most of the samples are treated water, and parameters are compared against the Ontario Drinking Water Standards (ODWS). In the DWIS database, only parameters with ODWS are available for review. Hence detection limits were not used to assess groundwater quality data from the DWIS database.

In addition, **Table 3.3.2.4-8: Range of Sodium Concentrations in the Thames Watershed & Region** and **Table 3.3.2.4-9: Range of Fluoride Concentrations in the Thames Watershed & Region** have been prepared to provide supplementary information on these parameters.

In Middlesex, sodium was below the drinking water standard of 200 mg/L but above the 20 mg/L Health Unit notification level. One instance of fluoride above ODWS occurred in the Thorndale system in 2004.

Table 3.3.2.4-4: DWIS Data Parameter Above ODWS in Middlesex County

Well Supply	Sample Type	Parameter	No. of Instances			
			2003	2004	2005	2006
Birr	Treated water	Sodium		1 (n=1)		2 (n=2)
Dorchester	Treated water	Sodium	2 (n=2)	1 (n=1)		
Melrose	Treated water	Sodium		1 (n=1)		2 (n=2)
Kilworth Heights	Treated water	Sodium	1 (n=1)	1 (n=1)		2 (n=2)
Thorndale	Treated water	Sodium	1 (n=1)	1 (n=1)	1 (n=1)	
	Treated water	Fluoride		1 (n=1)	0 (n=1)	
City of London*						
1) Fanshawe Well #5	Raw Water	Sodium	1 (n=1)	2 (n=2)		
2) Hyde Park well	Raw Water	Sodium	1 (n=1)	2 (n=2)		
3) Komoka Well #1	Raw Water	Sodium	1 (n=1)			
4) Komoka Well #2	Raw Water	Sodium	1 (n=1)			
5) Komoka Well #3	Raw Water	Sodium	1 (n=1)			
Mount Brydges	No DWIS data					

Note:
'n' is the number of times the parameter was analyzed in the year specified
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)
Blank cells: data not found in database provided
*City of London wells are backup wells

In Oxford County, there were no DWIS parameters above the ODWS in the Beachville-Loweville, Hickson-King, Innerkip or Tavistock well supply systems. The Embro, Thamesford, Woodstock and Ingersoll systems had wells that had sodium levels below the drinking water standard of 200 mg/L but over the Health Unit notification level of 20 mg/L. The Ingersoll, Lakeside and Thamesford systems had wells that had instances of fluoride above the ODWS. The Thornton Well Field #3 (raw water sample) in the Woodstock system had an instance of nitrates being above the ODWS. There was no DWIS data available for the Mount Elgin well supply system at the time of writing of this report, from the organization that provided the data.

Table 3.3.2.4-5: DWIS Data Parameter Above ODWS in Oxford County

Well Supply	Sample Type	Parameter	No. of Instances			
			2003	2004	2005	2006
Beachville-Loweville	Treated water	*	0	0	0	0
Embro	Treated water	Sodium		2 (n=2)		
Hickson-King	Treated water	*	0	0	0	0
Ingersoll						
1) Merrit St. Pumphouse	Treated water	Sodium	1 (n=1)	2 (n=2)		1 (n=1)
		Fluoride	2 (n=2)			1 (n=1)
2) Canterbury St. Pumphouse	Treated water	Sodium	1 (n=1)	2 (n=2)		1 (n=1)
		Fluoride	2 (n=2)			
3) Dunn's Road Pumphouse	Treated water	Sodium		2 (n=2)		1 (n=1)
		Fluoride	1 (n=1)			
4) Hamilton Road Pumphouse	Treated water	Sodium	1 (n=1)	2 (n=2)		
		Fluoride	0 (n=1)			
5) Thompson Road Pumphouse	Treated water	Sodium	1 (n=1)	2 (n=2)		1 (n=1)
		Fluoride	1 (n=2)			
6) Merrit St. Pumphouse	Treated water	Sodium	1 (n=1)			1 (n=1)
		Fluoride				
7) West St. Pumphouse	Treated water	Sodium			1 (n=1)	
		Fluoride	1 (n=1)		1 (n=1)	
Innerkip	Treated water	*	0	0	0	0
Lakeside	Treated water	Fluoride	2 (n=2)			1 (n=1)
Tavistock	Treated water	*	0	0	0	0
Thamesford						
1) Pumphouse 1	Treated water	Sodium		2 (n=2)		
		Fluoride	0 (n=1)			
2) Pumphouse 2	Treated water	Sodium		2 (n=2)		
		Fluoride	2 (n=3)			
Woodstock						
1) Sutherland WTP	Treated water	Sodium				2 (n=2)
2) Thornton Well Field #3	Raw Water	Nitrates		1 (n=3)		
Mount Elgin						

Note:
'n' is the number of times the parameter was analyzed in the year specified
Blank cells: No sample results found in database provided

Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)
*All tested parameters were within drinking water standards

In Perth County, there were no DWIS parameters above the ODWS in the Shakespeare and St. Marys well supply systems. In the Sebringville, St. Pauls and Stratford well systems, sodium levels above the 20 mg/L Health Unit notification level are observed but the sodium levels are below the drinking water standard of 200 mg/L. The Mitchell, Sebringville, St. Pauls and Stratford well systems had instances of fluoride levels above the ODWS. In the Sebringville and Stratford systems, fluoride levels are noticeably high, often above 2.0 mg/L.

Table 3.3.2.4-6: DWIS Data Parameter Above ODWS in Perth County

Well Supply	Sample Type	Parameter	No. of Instances			
			2003	2004	2005	2006
Mitchell	Treated water	Fluoride	1 (n=1)			
Sebringville	Treated water	Sodium				2 (n=2)
	Treated water	Fluoride	29 (n=29)	14 (n=14)	2 (n=2)	1 (n=1)
Shakespeare	Treated water	*	0	0	0	0
St. Marys	Raw and treated water	*	0	0	0	0
St. Paul's	Treated water	Sodium				2 (n=2)
		Fluoride				2 (n=2)
Stratford						
1) Chestnut	Treated water	Sodium	2 (n=2)	1 (n=1)	1 (n=1)	
		Fluoride	2 (n=2)	3 (n=4)	3 (n=3)	1 (n=1)
2) Dunn	Treated water	Sodium	1 (n=2)	0 (n=1)	1 (n=1)	
		Fluoride	2 (n=2)	4 (n=5)	4 (n=4)	1 (n=1)
3) Lorne	Treated water	Sodium	2 (n=2)	1 (n=1)	1 (n=1)	
		Fluoride	2 (n=2)	4 (n=4)	4 (n=4)	1 (n=1)
4) Mornington	Treated water	Sodium	2 (n=2)		1 (n=1)	
		Fluoride	2 (n=2)	2 (n=2)	3 (n=4)	1 (n=1)
5) O'Loane	Treated water	Sodium	1 (n=2)	0 (n=1)	0 (n=1)	
		Fluoride	2 (n=2)	4 (n=4)	4 (n=4)	1 (n=1)
6) Romeo	Treated water	Sodium			1 (n=1)	
		Fluoride			1 (n=4)	0 (n=1)

Note:
‘n’ is the number of times the parameter was analyzed in the year specified
Blank cells: No sample results found in database provided
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)
*All tested parameters were within drinking water standards

In Chatham-Kent, both the Highgate and Ridgetown well supply systems have sodium above the Health Unit notification level, and fluoride levels above the ODWS. In Highgate, the sodium levels are more than five times the 20 mg/L Health Unit notification level.

Table 3.3.2.4-7: DWIS Data Parameter Above ODWS in Chatham-Kent

Well Supply	Sample Type	Parameter	No. of Instances			
			2003	2004	2005	2006
Highgate	Treated water	Sodium	2 (n=2)	5 (n=5)	3 (n=3)	3 (n=3)
	Treated water	Fluoride	2 (n=2)	4 (n=4)	1 (n=3)	3 (n=3)
Ridgetown						
1) Erie St.	Treated water	Sodium		2 (n=2)		
	Treated water	Fluoride	1 (n=1)	2 (n=2)	1 (n=1)	
2) Scane Rd.	Treated water	Sodium		2 (n=2)		
	Treated water	Fluoride	1 (n=1)	2 (n=2)	1 (n=1)	

Note:
‘n’ is the number of times the parameter was analyzed in the year specified
Blank cells: No sample results found in database provided
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)

Across the Thames Watershed & Region, sodium and fluoride are the two chemical parameters that are above the Health Unit notification level and ODWS respectively.

In general, the concentrations of sodium are above the 20 mg/L level requiring notification to the local Health Unit but below the ODWS of 200 mg/L. Additional information on sodium concentrations in the wells is provided in **Table 3.3.2.4-8: Range of Sodium Concentrations in the Thames Watershed & Region.**

Naturally-occurring fluoride concentrations are often above the ODWS of 1.5 mg/L. Additional information on fluoride concentrations in the wells is provided in **Table 3.3.2.4-9: Range of Fluoride Concentrations in the Thames Watershed & Region**.

Table 3.3.2.4-8: Range of Sodium Concentrations in the Thames Watershed & Region
(Based on DWIS Data 2003-2006)

No.	Municipality/Drinking Water System Name	Sodium Concentrations mg/L
Middlesex		
1	Birr Well Supply	39.3 to 44
2	Dorchester Well Supply	29 to 50
3	Melrose Well Supply	25 to 29.6
4	Kilworth Heights Subdivision	42.9 to 51
5	Mount Brydges Well Supply	
6	Thorndale Well Supply	28 to 33
7	City of London Back Up Wells*	31.9 to 61.5
Oxford		
1	Beachville-Loweville Subdivision	<20 (15.7-16.4)
2	Embro Well Supply	20.8 to 21.3
3	Hickson-King Subdivision	< 20 (10.6-10.7)
4	Ingersoll Well Supply	25.8 to 97.1
5	Innerkip Well Supply	< 20 (16.2)
6	Lakeside Well Supply	< 20 (12.6-15)
7	Mount Elgin Well Supply	
8	Tavistock Well Supply	< 20 (15.9-16.6)
9	Thamesford Well Supply	26.6 to 51.5
10	Woodstock Well Supply*	36.2 to 35.8
Perth		
1	Mitchell Well Supply	
2	Sebringville Well Supply	26.9 to 30
3	Shakespeare Well Supply	
4	St. Marys Well Supply**	< 20 (1.01-1.23)
5	St. Pauls Well Supply	22.4 to 24.6
6	Stratford Well Supply	17 to 32
Chatham-Kent		
1	Highgate Pure Water Well Supply	102 to 120
2	Ridgetown Well Supply	75.3 to 76.4

*Raw Water Samples for City of London back up wells
** Raw and treated water samples for St. Marys Wells
Blank cells: No sample results found in database provided

Table 3.3.2.4-9: Range of Fluoride Concentrations in the Thames Watershed & Region
(Based on DWIS Data 2003-2006)

No.	Municipality/Drinking Water System Name	Fluoride Concentrations mg/L
Middlesex		
1	Birr Well Supply	< 1.5 (1.1-1.31)
2	Dorchester Well Supply	< 1.5 (0.2-0.3)
3	Melrose Well Supply	< 1.5 (0.8-0.97)
4	Kilworth Heights Subdivision	< 1.5 (0.59)
5	Mount Brydges Well Supply	
6	Thorndale Well Supply	1.5-1.6
7	City of London Back Up Wells*	< 1.5 (0.07-0.56)
Oxford		
1	Beachville-Loweville Subdivision	< 1.5 (0.69-0.76)
2	Embro Well Supply	< 1.5 (1.29)
3	Hickson-King Subdivision	< 1.5 (1.37-1.39)
4	Ingersoll Well Supply	0.77 to 2.36
5	Innerkip Well Supply	
6	Lakeside Well Supply	1.54 to 1.64
7	Mount Elgin Well Supply	
8	Tavistock Well Supply	< 1.5 (0.76-0.78)
9	Thamesford Well Supply	0.18 to 2.16
10	Woodstock Well Supply*	< 1.5 (0.2-0.68)
Perth		
1	Mitchell Well Supply	1.6
2	Sebringville Well Supply	2.06 to 2.74
3	Shakespeare Well Supply	< 1.5 (0.83)
4	St. Marys Well Supply**	< 1.5 (1.01-1.23)
5	St. Pauls Well Supply	1.61 to 1.69
6	Stratford Well Supply	0.1 to 2.6
Chatham-Kent		
1	Highgate Pure Water Well Supply	1.6 to 1.97
2	Ridgetown Well Supply	1.8 to 2.05

*Raw Water Samples for City of London back up wells
** Raw and treated water samples for St. Marys Wells
Blank cells: No sample results found in database provided

DWS and OMOE Reports

The DWS and OMOE annual reports typically provide data for a single treated water sample per year. They are provided here for information purposes only and are not considered conclusive review.

Summaries of parameters above ODWS (sodium is compared to the Health Unit notification level of 20 mg/L; its ODWS is 200 mg/L) from information in annual DWS reports for 2004, 2005 and 2006 are shown in the following tables:

- **Table 3.3.2.4-10: Parameters Above ODWS in Middlesex County Annual DWS Reports**
- **Table 3.3.2.4-11: Parameters Above ODWS in Oxford County Annual DWS Reports**
- **Table 3.3.2.4-12: Parameters Above ODWS in Perth County and Chatham-Kent Annual DWS Reports**

Sodium and fluoride are above the health unit notification and ODWS respectively in many well supplies across the Thames watershed. In addition, in Middlesex County, iron is above the ODWS in the Kilworth Heights and Melrose systems, with manganese above ODWS also in the former. In the City of London back up wells, extra parameters were analyzed and organic nitrogen and phosphorus also are above ODWS and IPWQO, respectively. Hardness and TDS are seen in City of London and St. Marys wells.

Table 3.3.2.4-10: Parameters Above ODWS in Middlesex County Annual DWS Reports

Well Supply System	Information From Annual DWS Report (n=1 per year)			Sample Type
	2004	2005	2006	
Birr	None	None	Iron	Treated water
Dorchester		Sodium	Sodium	Treated water
Melrose				
1) Well specified	Iron (Well #1)	Hardness, Iron (Well #2)	Hardness, Iron (Well #2)	Raw Water
2) Well specified	Iron (Well #2)	Hardness, Iron (Well #3)	Hardness, Iron (Well #3)	Raw Water
3) Treated water	None	None		Treated water
Kilworth Heights				
1) Well #1	Iron, Manganese	Iron, Manganese	o/s (out of service)	Raw Water
2) Well #2	Iron, Manganese	Manganese	Manganese	Raw Water
3) Well #3	Iron, Manganese	Manganese	Manganese	Raw Water
4) Treated (1,2,3 combined)	None	None	Sodium	Treated water
Mount Brydges	Sodium (Well #1)	None	None	Treated water
Thorndale		Sodium, Fluoride	Sodium, Fluoride	Treated water

Well Supply System	Information From Annual DWS Report (n=1 per year)			Sample Type
	2004	2005	2006	
City of London Back Up Wells				
1) Fanshawe 1		Hardness, Organic Nitrogen, Total Dissolved Solids, Total Phosphorus	Hardness, Organic Nitrogen, Total Phosphorus	Raw Water
2) Fanshawe 2		Hardness, Organic Nitrogen, Total Phosphorus	Hardness, Total Phosphorus	Raw Water
3) Fanshawe 3		Hardness, Manganese, Organic Nitrogen, Total Phosphorus	Hardness, Manganese, Organic Nitrogen, Total Phosphorus	Raw Water
4) Fanshawe 4		Hardness, Manganese, Organic Nitrogen, Total Phosphorus	Hardness, Manganese, Organic Nitrogen, Total Phosphorus	Raw Water
5) Fanshawe 5		Hardness, Organic Nitrogen, Total Dissolved Solids, Total Phosphorus, Sodium	Hardness, Manganese, Organic Nitrogen, Total Dissolved Solids, Total Phosphorus, Sodium	Raw Water
6) Fanshawe 6		Hardness, Organic Nitrogen, Total Phosphorus	Hardness, Organic Nitrogen, Total Phosphorus	Raw Water
7) Hyde Park		Hardness, Total Dissolved Solids, Total Phosphorus, Sodium	Hardness, Organic Nitrogen, Total Dissolved Solids, Total Phosphorus, Sodium	Raw Water

Blank cells are data gaps
Note: Results are reported for the year of the report but sampling may have been done in previous year
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)

Table 3.3.2.4-11: Parameters Above ODWS in Oxford County Annual DWS Reports

Oxford County Well Supply System	Information From Annual DWS Report (n=1 per year)			Sample Type
	2004	2005	2006	
Beachville-Loweville	None	None	None	Treated water
Embro	Sodium	Sodium	None	Treated water
Hickson-King	None	None	None	Treated water
Ingersoll (1 to 6)				
1) Merritt St.	Sodium (2004), Fluoride (2003)		None	Treated water
2) Canterbury St.	Sodium (2004), Fluoride (2003)		None	Treated water
3) Hamilton	Sodium (2004)		None	Treated water
4) Dunn's Rd	Sodium (2004), Fluoride (2003)		None	Treated water
5) Thomson Rd.	Sodium (2004), Fluoride (2003)		None	Treated water
6) West St.	None	Sodium, Fluoride	None	Treated water
Innerkip	None	None	None	Treated water
Lakeside	Fluoride (2003)		None	Treated water
Mount Elgin	Sodium (2004)		Sodium	Treated water
Tavistock	None	None	None	Treated water
Thamesford (1 and 2)				
1) #1 Pumphouse (River Well #1)	Sodium (2004)		Sodium	Treated water
2) #2 Pumphouse (Stanley St. Well #3)	Sodium (2004), Fluoride (2003)	Sodium (2004), Fluoride	Sodium, Fluoride	Treated water
Woodstock (1 and 2)				
1) Thornton	None	None	None	Treated water
2) Sutherland Park	None	None	Sodium	Treated water

Note: Years in brackets are when sample was taken for that parameter (some parameters are not required to be tested every year)
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)

Table 3.3.2.4-12: **Parameters Above ODWS in Perth County and Chatham-Kent Annual DWS Reports**

Well Supply System	Information From Annual DWS Reports (n=1 per year)			Sample Type
	2004	2005	2006	
Perth County				
Mitchell				
Sebringville				
Shakespeare	Sodium	None		Treated water
St. Marys				
1) Well #1		Hardness, Total Dissolved Solids, Sodium (source of data*)	None	Raw Water
2) Well #3		Hardness, Total Dissolved Solids, Sodium (source of data*)	None	Raw Water
St. Paul's				
Stratford				
1) Chestnut St.		Sodium, Fluoride	Sodium, Fluoride	Treated water
2) Lorne Ave		Sodium, Fluoride	Sodium, Fluoride	Treated water
3) O'Loane Ave		Fluoride	Fluoride	Treated water
4) Dunn Rd		Sodium, Fluoride	Fluoride	Treated water
5) Mornington St.		Sodium, Fluoride	Sodium, Fluoride	Treated water
6) Romeo St. Pumphouse		Sodium	None	Treated water
Chatham-Kent				
Highgate	Sodium	Fluoride, Sodium	Fluoride, Sodium	Treated water
Ridgetown				
1) Erie pumphouse	Sodium	Fluoride	Fluoride	Treated water
2) Scane pumphouse	Sodium	Fluoride	Fluoride	Treated water

*Source of data: lab analysis sheets, not DWS
Blank cells are data gaps
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)

The parameters above ODWS (sodium is compared to the Health Unit notification level of 20 mg/L, ODWS is 200 mg/L) in OMOE inspection samples for 2005 and 2006 are shown in the following tables:

- **Table 3.3.2.4-13: Parameters Above ODWS in Middlesex and Oxford Counties Annual OMOE Inspection Reports**
- **Table 3.3.2.4-14: Parameters Above ODWS in Perth County and Chatham-Kent Annual OMOE Inspection Reports**

Iron and manganese levels above the ODWS are observed in a few Middlesex and Oxford County wells. In Perth, fluoride and iron levels above the ODWS are observed. In Chatham Kent, fluoride is above the drinking water standard.

Systems No Longer in Use

The Sweaburg-Oxford Heights Subdivision well supply system was discontinued from use in August 2006. Information on water quality samples from this system is available from the DWIS data set, annual DWS Reports and annual OMOE Inspection Reports. Data available is reviewed and described below.

There were no parameters above the ODWS in treated water samples of the Sweaburg-Oxford well supply system from 2003 to 2006 from the Drinking Water Information System (DWIS) data set. Sodium was also below the Health Unit notification level of 20 mg/L.

In the Annual Drinking Water System reports for 2004-2006 and the annual OMOE Inspection Report information for 2005-2006, the treated water samples for the Sweaburg-Oxford system showed no parameters above the ODWS. The sample size is one per year.

Table 3.3.2.4-13: Parameters Above ODWS in Middlesex and Oxford Counties Annual OMOE Inspection Reports

Well Supply System	Annual OMOE Inspection Report Information (n=1 per year, treated water samples)	
	2005	2006
Middlesex		
Birr	Iron (386 +/- 64 ug/L)	Iron (403 +/- 66 ug/L)
Dorchester	Manganese (66.4 +/- 5.2 ug/L)	None
Melrose	None	Iron (440 +/- 72 ug/L)
Kilworth Heights	None	
Mount Brydges	None	None
Thorndale	Fluoride (1.5, 1.6 mg/L), Iron (502+/-82, 1030+/-170 ug/L)	
City of London Back up Wells*	None	None
Oxford		
Beachville-Loweville	None	None
Embro	None	None
Hickson-King	None	None
Ingersoll		
1) Well 2	Fluoride (1.71 mg/L)	Fluoride (1.96 mg/L)
2) Well 5	Fluoride (1.89 mg/L)	Fluoride (2.11 mg/L)
3) Well 7	(none)	Fluoride (2.3 mg/L)
4) Well 8	Fluoride (1.92 mg/L)	(none)
5) Well 10	Fluoride (1.61 mg/L)	Fluoride (1.81 mg/L)
Innerkip	None	None
Lakeside	None	Fluoride (1.5 mg/L), Iron (400 ug/L)
Mount Elgin	None	None
Tavistock	Iron (644+/-105 ug/L)	Iron (649+/-106 ug/L)
Thamesford		Manganese (144+/-12 ug/L) (at River well treated pumphouse)
Woodstock	None	None

Note: Blank cells: information unavailable at time of writing of report
*Raw water samples for this system only
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)

Table 3.3.2.4-14: Parameters Above ODWS in Perth County and Chatham-Kent Annual OMOE Inspection Reports

Well Supply System	Annual OMOE Inspection Report Information (n=1 per year, treated water samples)	
	2005	2006
Perth		
Mitchell	Fluoride (1.78 mg/L), Iron (440 +/-72 ug/L)	Fluoride (1.93 mg/L), Iron (502+/-82 ug/L)
Sebringville	Fluoride (2.14 mg/L), Iron (358+/-51 ug/L)	
Shakespeare	Iron (1040+/-170 ug/L)	Iron (515+/-84 ug/L)
St. Marys	None	None
St. Paul's	Iron (495+/-81 ug/L)	Fluoride (1.59 mg/L), Iron (584+/-95 ug/L)
Stratford	Fluoride, Iron (see below)	Fluoride, Iron (see below)
1) Dunn Road Facility	Fluoride (1.74 mg/L)	Fluoride (1.87 mg/L)
2) O'Loane Ave Facility	Fluoride (2.13 mg/L)	Fluoride (2.16 mg/L), Iron (245+/-41 ug/L)
3) Mornington St. Facility	Fluoride (1.74 mg/L), Iron (288+/-48 ug/L)	Fluoride (1.96 mg/L), Iron (263+/-44 ug/L)
4) Romeo St. Facility	Fluoride (1.34 mg/L), Iron (358+/-59 ug/L)	Fluoride (1.59 mg/L), Iron (344 +/-57 ug/L)
5) Lorne Ave Facility	Fluoride (2.17 mg/L), Iron (225+/-38 ug/L)	Fluoride (2.4 mg/L), Iron (253+/-43 ug/L)
6) Chestnut St. Facility		Fluoride (2.2 mg/L), Iron (423+/-70 ug/L)
Chatham-Kent		
Highgate	Fluoride (1.56 mg/L)	Fluoride (1.5 mg/L)
Ridgetown	Fluoride (1.81 at Erie St., 1.72 mg/L at Scane Rd.)	Fluoride (1.7 at Erie St., 1.69 at Scane Rd)

Blank cells: information unavailable at time of writing of report
Sodium is compared to the Health Unit notification level of 20 mg/L (the ODWS is 200 mg/L)

3.3.2.5 Data Gaps

At the time of writing of this report, the following data gaps are being identified.

PGMN Monitoring

Data gaps in sampling (sample size is zero, or no samples taken) for PGMN wells are given in **Tables 3.3.2.5-1: Sample Size of PGMN Wells in the UTRCA Watershed** and **Table 3.3.2.5-2: Sample Size of PGMN Wells in the LTVCA Watershed**.

Table 3.3.2.5-1: Sample Size of PGMN Wells in the UTRCA Watershed

Well No.	Year			
	2003	2004	2005	2006
53	0	1	0	1
54	1	1	1	1
55	2	1	2	1
56	1	1	2	1
76	1	1	2	1
107	1	1	0	0
180	1	1	0	1
201	1	1	2	2
217	1	1	0	0
218-3	1	1	0	0
218-4	1	1	0	0
218-5	1	1	0	1
219	1	1	2	1
368	1	1	3	2
369-2	1	1	2	0
369-3	1	1	1	1
370	1	1	0	0
371-2	1	1	1	1
371-3	1	1	2	1
437	0	0	1	1

Note:
One sample was taken for Well #53 in 2002
One sample was taken for Well #180 in 2000

Table 3.3.2.5-2: Sample Size of PGMN Wells in the LTVCA Watershed

Well No.	Year			
	2003	2004	2005	2006
181	0	0	0	0
182	1	0	0	0
184	1	1	0	0
211	1	1	0	0
236	1	0	0	0
237	1	1	0	0
247	1	1	0	1
248	1	1	0	0
249	1	1	0	1
250	1	1	0	0
438	0	0	0	1
445	0	0	0	1

Drinking Water Monitoring

Our review of the water quality data obtained, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water. Differences in the period of the data sets reviewed are identified as 'data gaps.' The specific reasons for these gaps in data are not ascertained and are not relevant to the characterizing of the water source. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these 'data gaps.' The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

From the provided DWSP and DWIS data sets, very little information on raw (untreated) water quality was obtained.

The OMOE Inspection report parameters analyzed vary by year and by well supply system. The report information as well as the Annual Drinking Water System information provide limited (treated water samples, typically once a year only) water quality data as well.

Recently, the community of Mount Brydges in Strathroy-Caradoc has been reported in the media for drinking water with high nitrate levels and a Class Environmental Assessment[75] has been initiated to find a long-term water supply. Past data sets do not show nitrate levels above the ODWS and more up-to-date information may be needed.

Other Sources

Prior to 1995, a groundwater monitoring network similar to the PGMN existed throughout Ontario. However, this legacy data is often difficult to obtain and it can be difficult to establish the exact location of the wells, as the information is often missing and/or is not centrally filed.

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[75] Dillon Consulting. Municipality of Strathroy-Caradoc Mount Brydges and Area Long-term Water Supply System Municipal Class Environmental Assessment.

Another source of information can be sporadic water level data and water quality information that may be found in old reports in areas where there is a dispute over a Permit to Take Water or in environmental assessments. This data may have been collected over long periods of time (10-15 years) but is usually located in hard copy files. This type of data would be identified as a data gap.

3.3.3 Ambient Water Quality Study

Historically, groundwater quality monitoring has been sporadic and various monitoring programs throughout the province were suspended in 1995 or earlier. Long-term groundwater quality and quantity trends are difficult to determine at this time, as the data is intermittent, missing or difficult to locate. However, there is a great deal of water quality data that exists in both electronic and paper formats.

Waterloo Hydrogeologic, Inc. (WHI), A Schlumberger Company, had a contract to conduct an Ambient Water Quality Study to gather and consolidate groundwater information throughout southwestern and central Ontario. The goal of the study was to better understand the ambient quality of groundwater from overburden and bedrock aquifers in southwestern Ontario. The establishment of a central database for water quality was identified as being necessary to provide the required information for groundwater management. This study covered an area from Lake Simcoe in the east to the Detroit River in the west, and from Lake Erie in the south to Georgian Bay in the north. The information was submitted by Schlumberger in August 2007 as the Ambient Chemical Characterization of Regional Aquifers Within Southwestern and Central Ontario.

WHI/ Schlumberger also has a contract to complete a local study to characterize and understand the state of the water quality within the Thames-Sydenham & Region. This work is focused on chemical water quality parameters and does not include review of microbiological data. This study is based on the information compiled for the original report with the addition of information from the Provincial Groundwater Monitoring Network (PGMN) wells in the region.

In November 2007, only a draft of the WHI Report for the Thames-Sydenham & Region was available. A final report is expected to be available early in 2008. However, some of the findings in the draft report have been used to provide information on ambient groundwater quality for the Thames Watershed & Region.

WHI compiled information from four existing digital data sets into a common database. Water quality data from the Provincial Groundwater Monitoring network (PGMN), from a recent OMOE hydrochemistry data compilation and interpretation covering southwestern Ontario (SOWAQ), and from the Drinking Water Information System (DWIS), were integrated with geological data from the EarthFX database. The final data set includes 676 stations and 1,929 water chemistry analysis for the Thames-Sydenham & Region Source Protection Region. The location of the wells is shown in **Figure 3.3.3-1: Schlumberger Plate 3.1 Location of Water Quality Wells.**

The location, depth, lithology and water level information for water quality wells was extracted from the OMOE Water Well Information System. This database does not contain chemical analysis of water samples; however, it contains a qualitative description of whether the water encountered was fresh, salty, or gaseous or whether hydrogen sulphide was noted. This information can be valuable on a regional scale, and was compiled as part of this project. The location of wells is depicted in **Figure 3.3.3-2: Schlumberger Plate 3.3 Location of Sulphide and Saline Waters Reported in WWIS Data Set**. Plate 3.3 shows the location where well records noted the presence of saline waters or waters with hydrogen sulphide.

The Major Ion Composition Expression (Facies) summarizes its major constituents in a text expression according to a standardized process. The major ion composition of a groundwater is controlled by the availability of reactive minerals in the aquifer along the flow path, as well as by the time of contact with the mineral.

In general, highly soluble minerals have been flushed from shallow aquifers and can be found in deeper and less permeable formations. Ions provided by the dissolution of less soluble minerals form the composition for surface and young groundwater, whereas mature groundwater is dominated by the ions of the more soluble minerals.

The typical maturity succession for anions and cations in pristine groundwater can be used to estimate the maturity of water:

- Cations: Ca> Mg > Na
- Anions: HCO_3 > SO4 > Cl

The classic sequence of water composition a groundwater will undergo on its subsurface journey is: Ca-HCO_3 > Ca-Mg-HCO_3, Ca-Mg-HCO_3-SO_4> Ca-SO_4> Ca-Na-SO_4-Cl, Na-Ca-Cl-SO_4>Na-Cl.

The amount of Ca and HCO_3, as well as the ratios of Ca/Mg, Ca/SO_4 and Na/Cl expressed in mol/L reflect how much of the minerals calcite, dolomite, gypsum or anhydrite or halite have been dissolved. In lower permeable systems with high rock volume and residence time, the time available for reaction is much higher. In such systems, gypsum and halite can survive for a longer time and the elements composing these salts can accumulate in the groundwater. Typical waters for low permeability and/or long residence time aquifers are thus of type Ca-SO_4 and Na-Cl in most cases.

While mineral dissolution is responsible for the initial chemical composition of a groundwater, this composition can be altered by ion exchange processes between the groundwater and the aquifer material. Clay minerals and organic material have the ability to absorb ions from the solution in exchange of ions sorbed on the mineral. Similar to the dissolution process, an equilibrium state can be reached at which no further reaction between the mineral and the solution will occur.

The ion exchange process, therefore, requires disequilibrium between the solution and the aquifer material. This typically occurs when a saline groundwater intrudes a freshwater aquifer or when freshwater intrudes an aquifer that was previously in contact with a saline groundwater. Depending on the composition of the aquifer material and the intruding water, typical ion exchange waters will be of the following water types: sodium-bicarbonate (Na-HCO_3), sodium sulfate (Na-SO_4) or calcium chloride (Ca-Cl). These waters no longer reflect the composition of a dissolved mineral.

The major ion composition for wells in the study area is depicted in the Piper diagram in **Figure 3.3.3-3: Schlumberger Figure 3.2 Piper Diagram Showing Major Ion Composition**. This diagram confirms that bedrock and overburden wells fall into similar facies fields and, in most cases, are comprised of similar constituents. Samples cover the entire area of the diamond shaped projection area.

The classic evolution paths are depicted with blue arrows[76]. The anion triangles indicate that there are waters where the anion composition is dominated by bicarbonate, sulphate, bicarbonate and chloride; however, no waters are dominated by chloride and sulphate simultaneously. This is interpreted to reflect the facies transition in the underlying Salina formation, with halite in the southwest and sulphate in the northwest.

An unusual transition zone of waters ranging from the Ca-HCO_3 to the calcium-chloride facies is also noted. This cannot be attributed to ion exchange, since Ca-Cl type water always originates from the Na-Cl pole. The only water type that may be generated from an initial Ca-HCO_3 water is the Na-HCO_3 type. A

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[76] Appelo, C.A.J., and D. Postma. 2005. Geochemistry, groundwater and pollution (2nd ed.).

possible explanation for the observed transition between the Ca-HCO_3 and the Ca-Cl in Figure 3.2 is mixing of an ascending Ca-Cl brine with freshwater in shallow aquifers.

The chemical facies requires a complete analysis of all major ions (calcium, magnesium, sodium. chloride, bicarbonate, and sulphate). These parameters are available in most PGMN samples. However, many samples from the SOWAQ data set and all samples from the DWIS data set were incomplete. The available samples that had sufficient data to calculate the water facies expressions are shown on **Figure 3.3.3-4: Schlumberger Plate 3-4 Water Facies in Bedrock Aquifers** and **Figure 3.3.3-5: Schlumberger Plate 3.5 Water Facies in Overburden Aquifers.**

Table 3.3.3-1: WHI (Schlumberger) Report - Water Facies - Plate 3.4 Bedrock & Plate 3.5 Overburden provides a summary of water facies across the Source Protection Region.

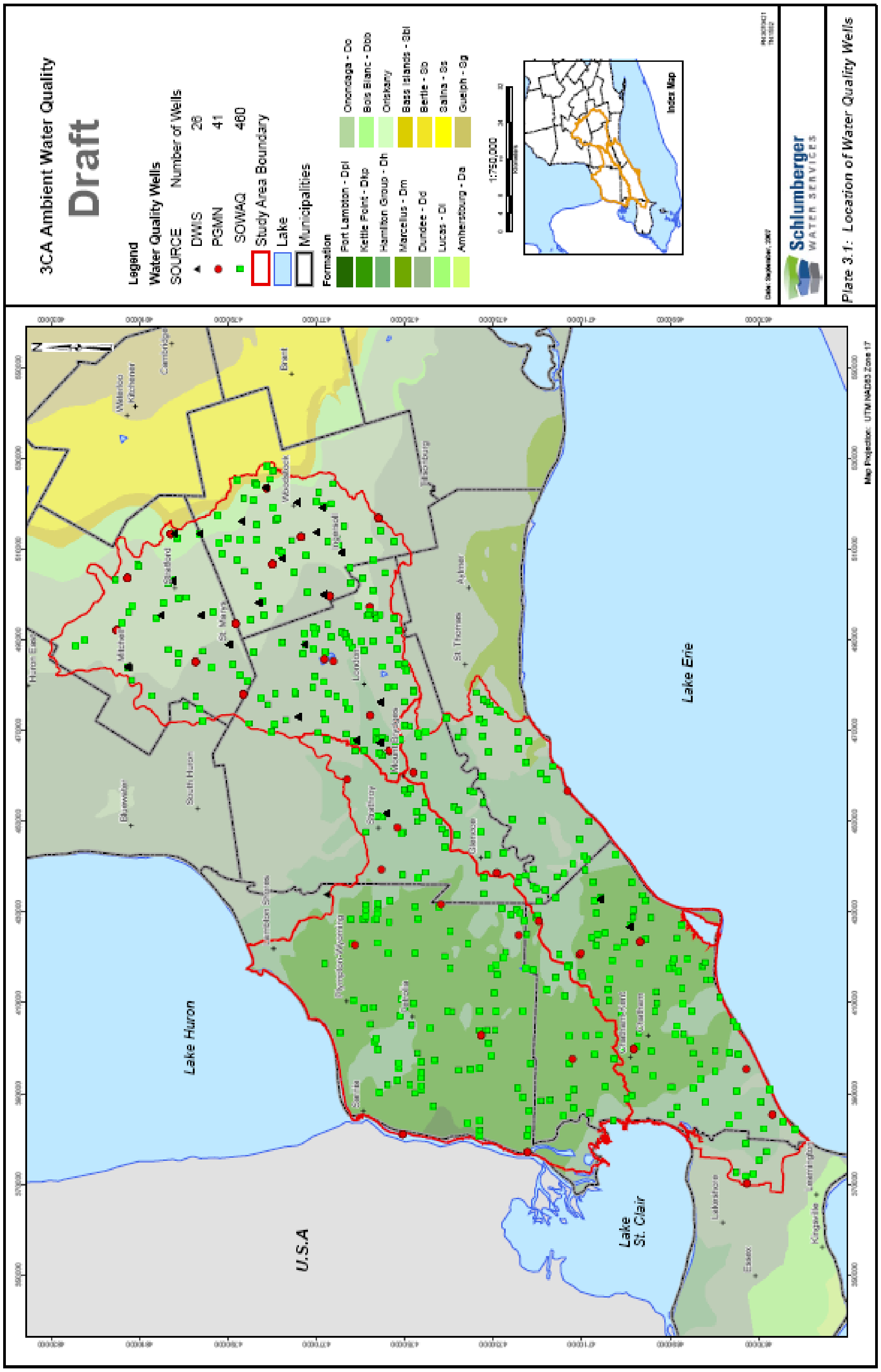

Figure 3.3.3-1: Schlumberger Plate 3.1 Location of Water Quality Wells

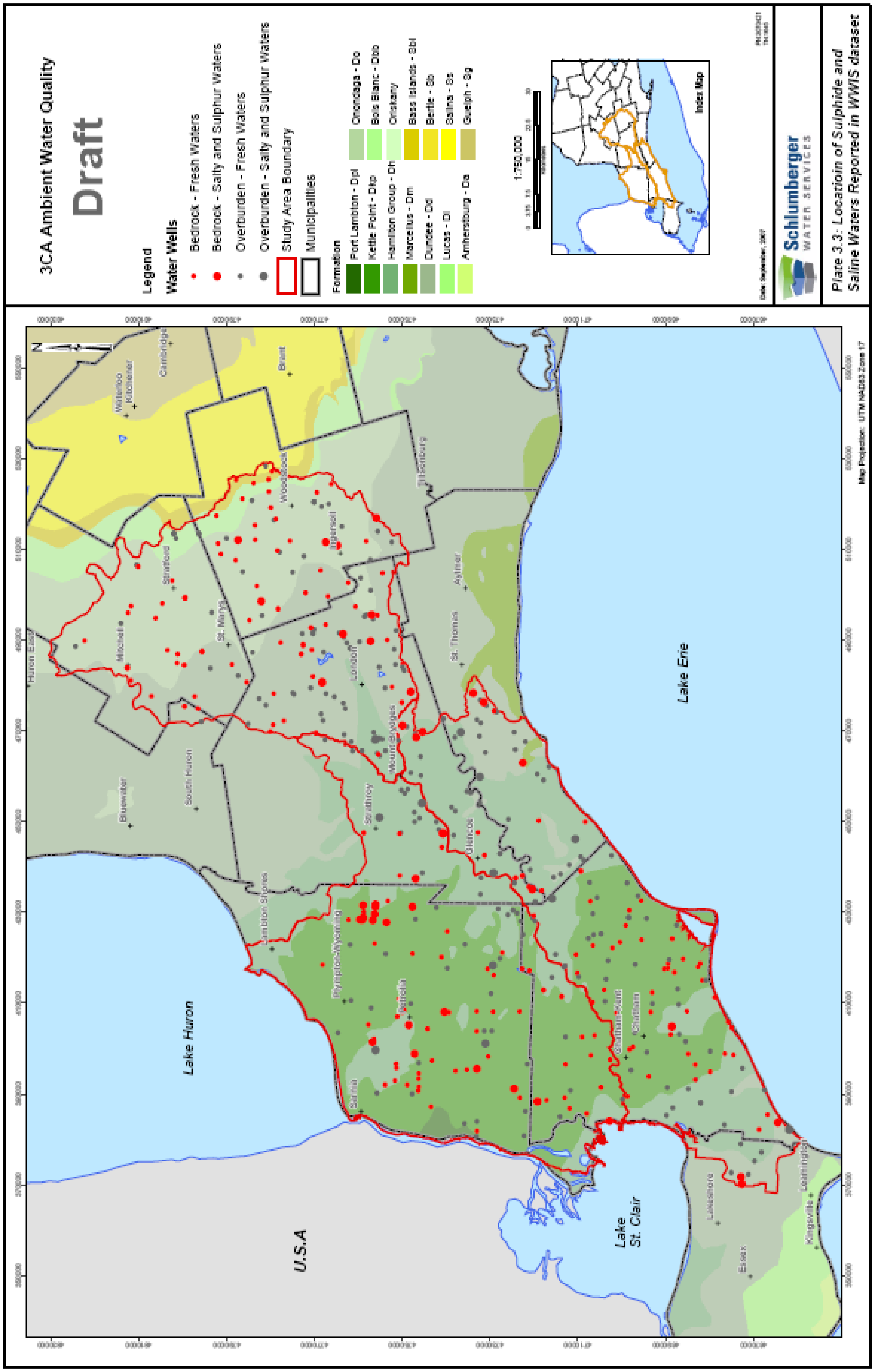

Figure 3.3.3-2: Schlumberger Plate 3.3 Location of Sulphide and Saline Waters Reported in WWIS Data set

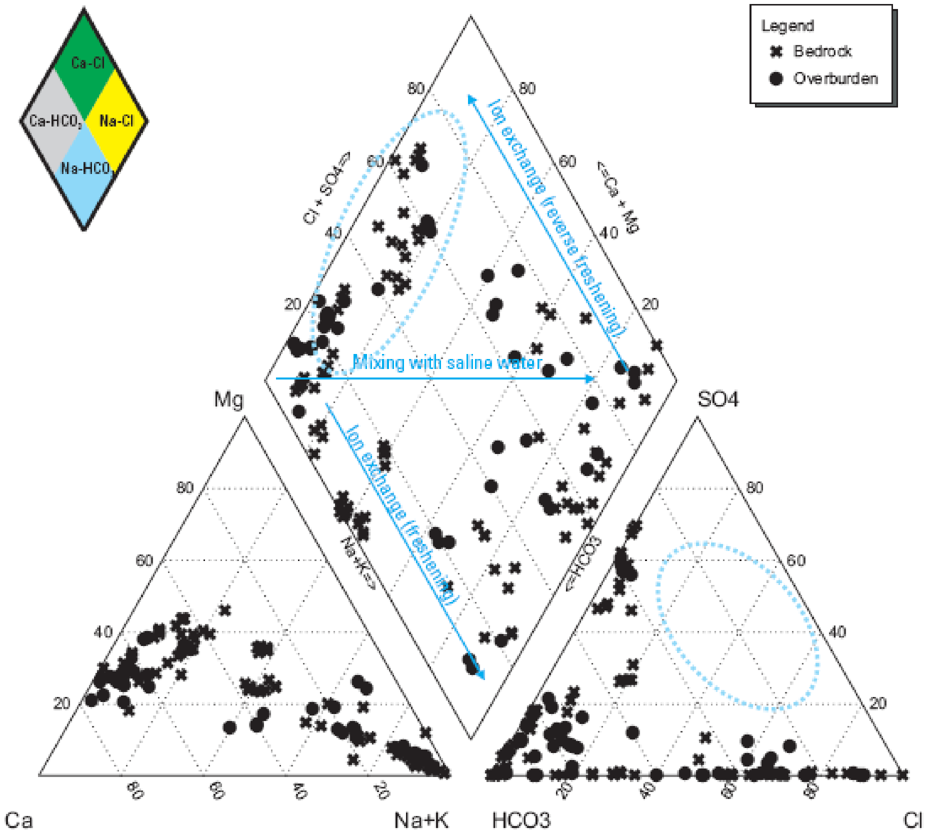

Figure 3-2: Piper diagram showing major ion composition and water facies of bedrock and overburden Wells. Data from PGMN and SOWAQ dataset.

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TN: 1982

Figure 3.3.3-3: **Schlumberger Figure 3.2 Piper Diagram Showing Major Ion Composition**

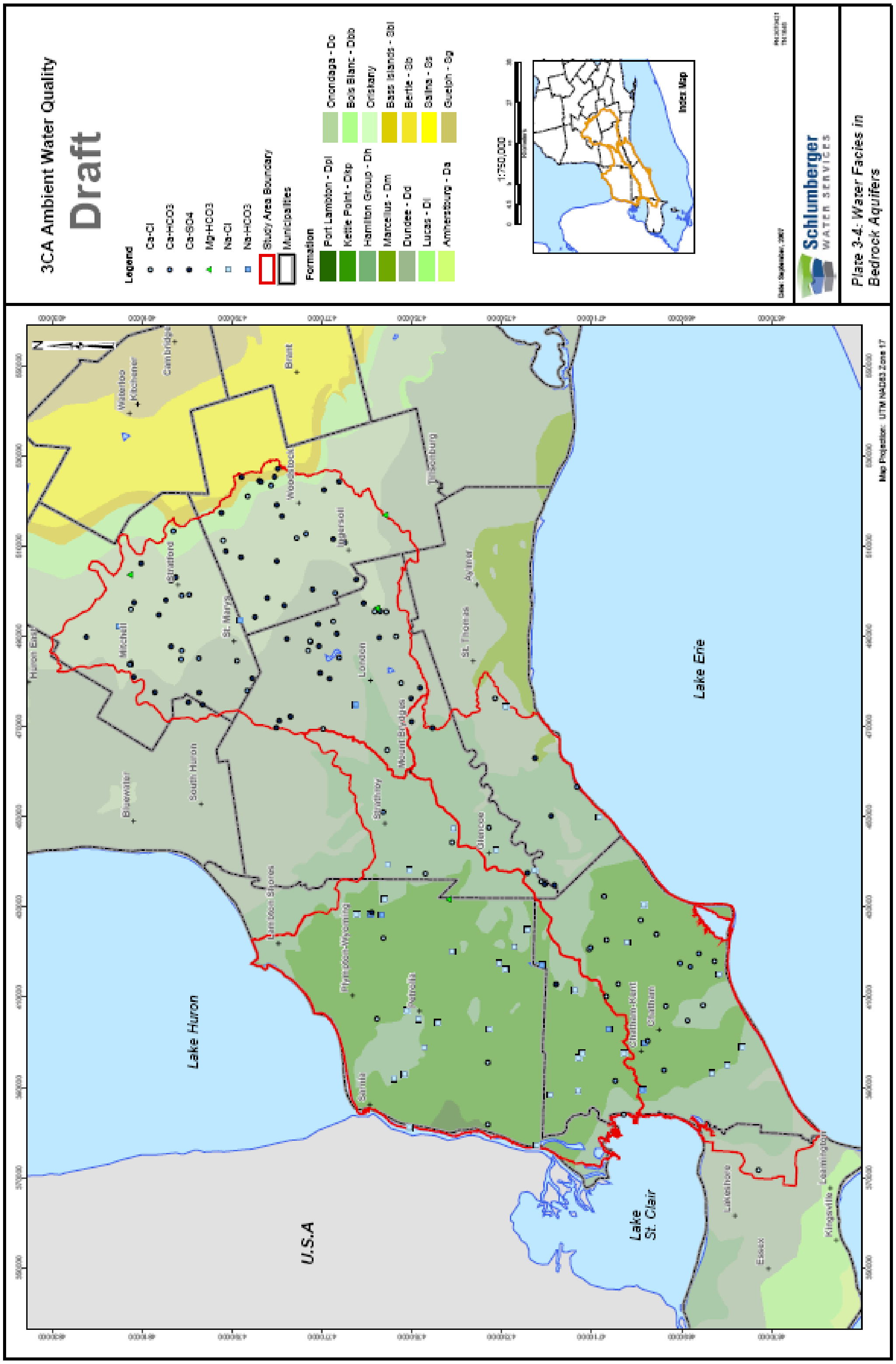

Figure 3.3.3-4: **Schlumberger Plate 3-4 Water Facies in Bedrock Aquifers**

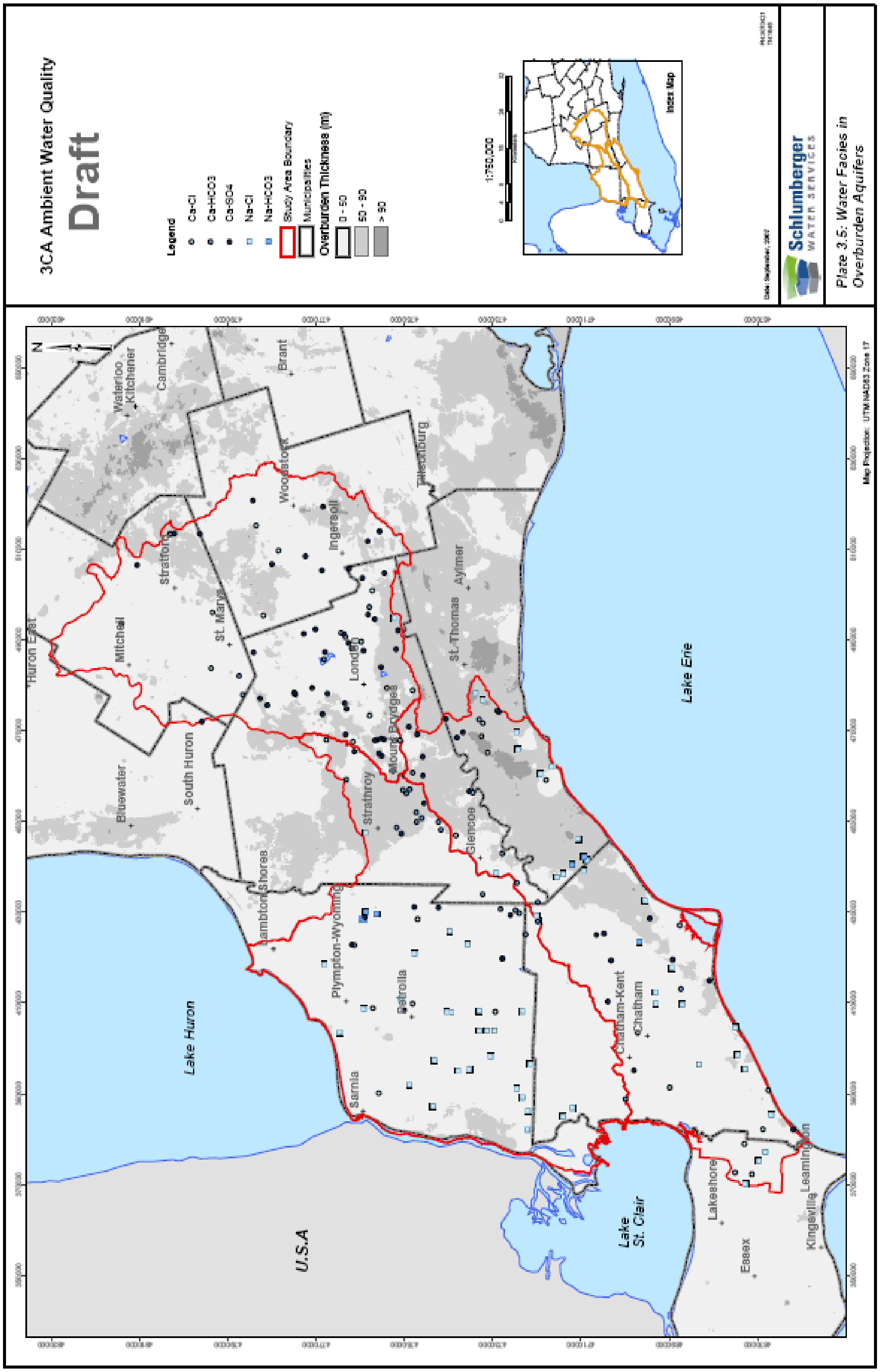

Figure 3.3.3-5: Schlumberger Plate 3.5 Water Facies in Overburden Aquifers

Table 3.3.3-1: WHI (Schlumberger) Report - Water Facies – Plate 3.4 Bedrock & Plate 3.5 Overburden

Facies Type	SCRCA		LTVCA		UTRCA	
	Number	Percentage	Number	Percentage	Number	Percentage
Bedrock						
Ca-Cl	8	**20**	15	**36**	14	**17**
Ca-HCO_3	2	**5**	7	**17**	12	**15**
Ca-SO4	2	**5**	7	**17**	48	**59**
Mg-HCO_3	0	**0**	0	**0**	4	**5**
Na-Cl	25	**60**	10	**25**	0	**0**
Na-HCo_3	4	**10**	2	**5**	3	**4**
Total	41	**100**	41	**100**	81	**100**
Overburden						
Ca-Cl	7	**11**	15	**22**	16	**24**
Ca-HCO_3	17	**26**	6	**9**	6	**9**
Ca-SO_4	10	**15**	18	**26**	43	**65**
Mg-HCO_3	0	**0**	0	**0**	0	**0**
Na-Cl	28	**42**	27	**39**	1	**2**
Na-HCo_3	4	**6**	3	**4**	0	**0**
Total	66	**100**	69	**100**	66	**100**

Note: The numbers in this table are based on a review of the Water Facies types shown on Plates 3.4 & 3.5 in the November 2007 Draft Schlumberger Report

The following discussion is based on Table 3.3.3-1, which was prepared based on the initial information in the November draft Schlumberger report and may be subject to change when the final report is completed.

In the UTRCA, both the bedrock and overburden water is predominately calcium sulphate (Ca-SO_4) type water. Calcium chloride (Ca-Cl) and sodium-bicarbonate (Na-HCO_3) are the other significant water type present in both bedrock and overburden.

In the LTVCA, calcium chloride (Ca-Cl) and sodium chloride (Na-Cl) type waters make up 60% of the water facies in both bedrock and overburden. Calcium sulphate (Ca-SO_4) and calcium carbonate (Ca-HCO_3) are the other significant water type present.

Ca-SO_4 waters may achieve their mineralization from an anhydrite layer in the Lucas Formation. Alternatively, they may indicate ascending waters from the underlying Salina Formation, with its well-documented presence of evaporites. The overburden sampling points characterized by calcium sulphate water are located close to the bedrock surface, and are strongly imprinted by bedrock groundwater composition. Ca-SO_4 type water is considered poor in quality due to its typically high salinity and hardness.

Na-Cl water facies indicate aquifers of low permeability and/or long residence time. Na-Cl type waters are mainly located in the LTVCA watershed. This location coincides with the proximity of evaporates in the Salina Formation and likely indicates ascending fluids from this formation.

Ca-Cl type waters usually form in deep (bedrock) conditions, for example, in oil fields. When Ca-Cl type waters are encountered at the overburden they may indicate contamination with oil brines, uprising of deep basin waters along fault plains, or analysis error.

Sodium-bicarbonate ($Na\text{-}HCO_3$) is another significant groundwater type that is found in both bedrock and overburden wells. This water type indicates a mixing or intrusion of saline groundwater into a freshwater aquifer or freshwater into an aquifer containing a saline groundwater. The Hamilton Group and Kettle Point Formation are the most probable origin of these waters, as these formations have high organic carbon content that provides excellent ion exchange capabilities. $Na\text{-}HCO_3$ type waters are vulnerable to certain water quality issues due to the high pH that frequently accompanies these waters.

Aquifer Characterization

Bedrock

The bedrock formations that outcrop under the St. Clair Region are shown on **Figure 3.3.3-1: Schlumberger Plate 3.1 Location of Water Quality Wells** and **Map 4: Bedrock Geology**. The bedrock outcropping in the UTRCA watershed consists mainly of the Detroit River Group and Dundee Formation with some Hamilton Group. In the LTVCA, the bedrock that outcrops is mainly Hamilton Group and Kettle Point Formation, with some Dundee Formation.

The Detroit River Group (aquifer) consists of the Sylvanian Formation, an orthoquartzitic sandstone restricted to the subsurface in the Windsor area; the Lucas Formation, a microcrystalline limestone; and the Amherstburg Formation, a crinoidal limestone and dolostone (Karrow, 1993). The Lucas Formation is a good water bearing aquifer and several communities in the study area extract water from the Lucas and the Amherstburg bedrock aquifers for their municipal and domestic groundwater needs.

All waters from the Detroit River Group have a similar major ion composition, except for sulphate, which can range from 0.1 to 404 mg/L. It is interesting to note that high sulphate gradients can exist over a short distance, e.g. Huitema and Ellis or Golspie and Embro. Each of these couples shares a similar major ion composition but have very different sulphate levels. Since this formation does not include sulphate minerals, sulphate rich water is likely to ascend in discrete zones. These waters have high fluoride values of up to 2.1 mg/L with an average of 1.4 mg/L.

The Dundee Formation (aquifer for the most part) is a grey to brown fossiliferous limestone. Most samples in the southern part are incomplete and include major ions. They include the most saline water with electrical conductivities of 7800 belonging to the Na-Cl facies. This demonstrates the connectivity with other bedrock formations (Kettle Point or Salina).

The Hamilton Group (aquitard for the most part) includes interbedded mudstones, shales and thin carbonate horizons overlying the Dundee Formation. Due to its aquitard character, few wells are completed in the Hamilton group. The dominant water facies are Na-Cl and $Na\text{-}HCO_3$. As may be expected, the median salinity is high (480 mg/L) and the highest values are reached in the southern most part of the study area. The reason for the high frequency of $Na\text{-}HCO_3$ waters may be explained by the organic rich shales, which provide an excellent ion exchange capacity.

The Kettle Point Formation (shales are normally aquitards; however, fracture porosity can provide aquifer properties) is comprised of a black, organic-rich (up to 15% by weight organic carbon), siliciclastic, non-calcareous shale with minor beds of silty shale. The Kettle Point Formation contains large (up to 1.2 m) spherical or subspherical calcite concretions locally referred to as ‘kettles.’ A major unconformity separates the Hamilton Group from the Kettle Point Formation. The waters from the Kettle Point formations are in many respects similar to the Hamilton Group waters. Most wells produce water belonging to the Na-Cl or Na-HCO_3 facies. The salinity is the highest of all formations.

Overburden

Fifteen monitoring wells in the St. Clair Region watershed collect water from the overburden. The composition of these waters seems to be controlled mostly by the presence or absence of interaction with bedrock waters. Waters that are not mixed with bedrock groundwater are generally of type Ca-HCO_3.

Parameters of Interest

Several parameters were reviewed because they represent a potential concern or because they may contribute to a better understanding of processes that control the observed water quality. The WHI report indicates that among the health related parameters, fluoride is the primary parameter of concern. Another health related parameter of potential concern is nitrate. Non-health related parameters that are above the aesthetic objectives include: sodium, chloride and iron.

Fluoride

Figure 3.3.3-6: Schlumberger Plate 3.20 Fluoride Concentration in Bedrock Aquifers and **Figure 3.3.3-7: Schlumberger Plate 3.21 Fluoride Concentration in Overburden Aquifers** provide an overview of fluoride levels. Among the studied water quality related parameters, fluoride is above the drinking water standard most frequently. Over 25% of samples from bedrock wells are higher than the ODWS MCL of 1.5 mg/L, and about 20% of samples in overburden wells. It is believed that fluoride is natural in origin. Fluorite dissolution and ion exchange of sorbed fluoride in the Kettle Point Formation are the most likely processes leading to the observed elevated concentrations.

Nitrate

Figure 3.3.3-8: Schlumberger Plate 3.18 Nitrate Concentration in Bedrock Aquifers and **Figure 3.3.2.3-9: Schlumberger Plate 3.19 Nitrate Concentration in Overburden Aquifers** provide an overview of nitrate levels. Overburden wells have higher nitrate values and are above the Ontario Drinking Water Standard (ODWS) of 10 mg/L more frequently than bedrock wells.

Sodium

Figure 3.3.3-10: Schlumberger Plate 3.14 Sodium Concentration in Bedrock Aquifers and **Figure 3.3.3-11: Schlumberger Plate 3.15 Sodium Concentration in Overburden Aquifers** provide an overview of sodium levels. In general, most of the wells have sodium levels higher than the 20 mg/L concentration that requires notification to local Health Units, and many wells have levels that are above the ODWS of 200 mg/L. Waters with high sodium values are concentrated in the area with Na-Cl and Na-HCO_3 type waters in the southernmost part of the study area. All waters with low sodium levels are encountered in bedrock wells in the northeastern portion of the area.

The combined effect of low calcium with high sodium in Na-HO_3 type waters leads to sodium adsorption ratios (SAR) of up to 28, which makes this water unsuitable for the irrigation of sodium sensitive crops. The sodium hazard may be intensified by the high boron levels encountered in many of the sodium rich waters.

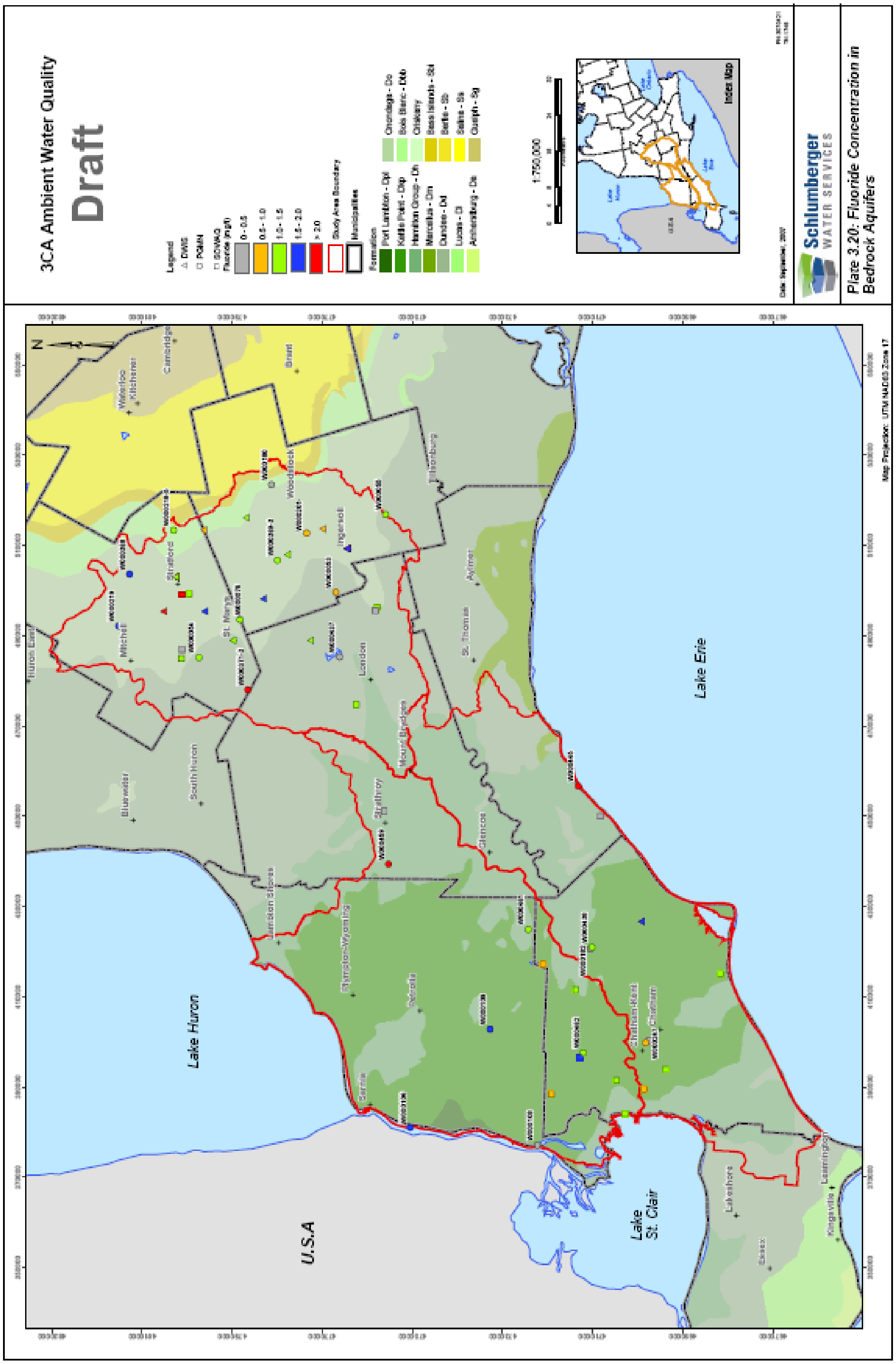

Figure 3.3.3-6: **Schlumberger Plate 3.20 Fluoride Concentration in Bedrock Aquifers**

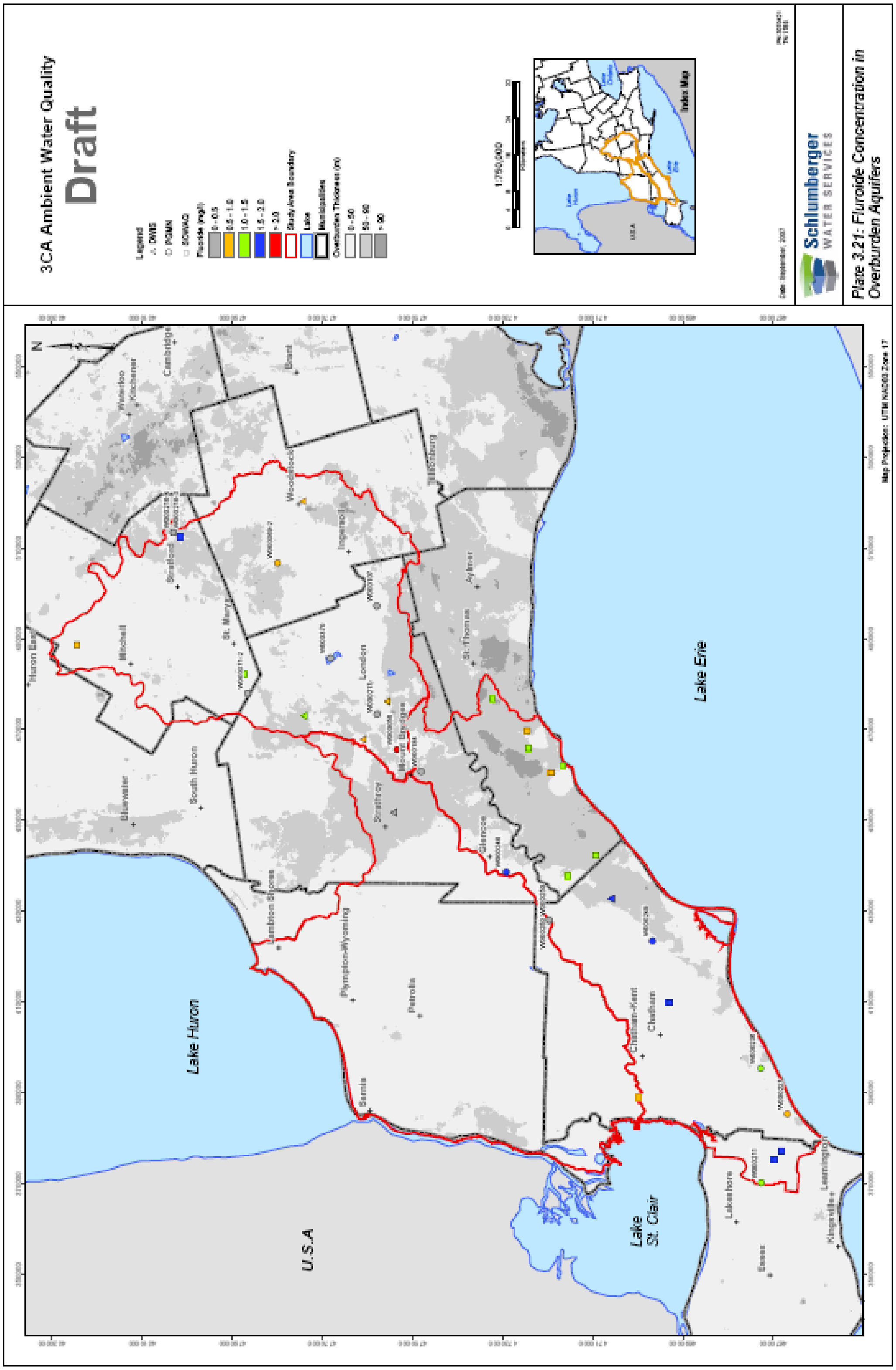

Figure 3.3.3-7: Schlumberger Plate 3.21 Fluoride Concentration in Overburden Aquifers

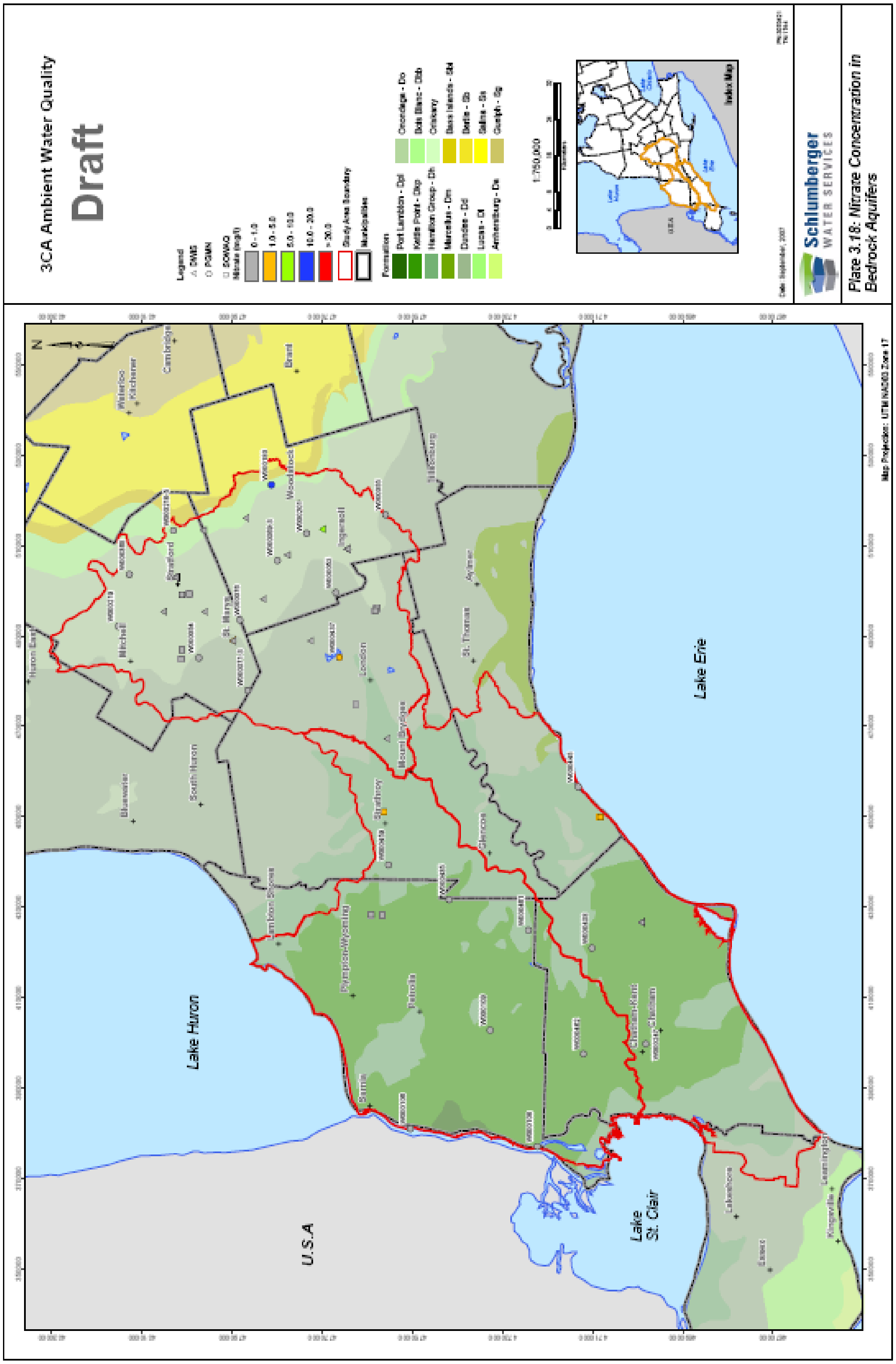

Figure 3.3.3-8: **Schlumberger Plate 3.18 Nitrate Concentration in Bedrock Aquifers**

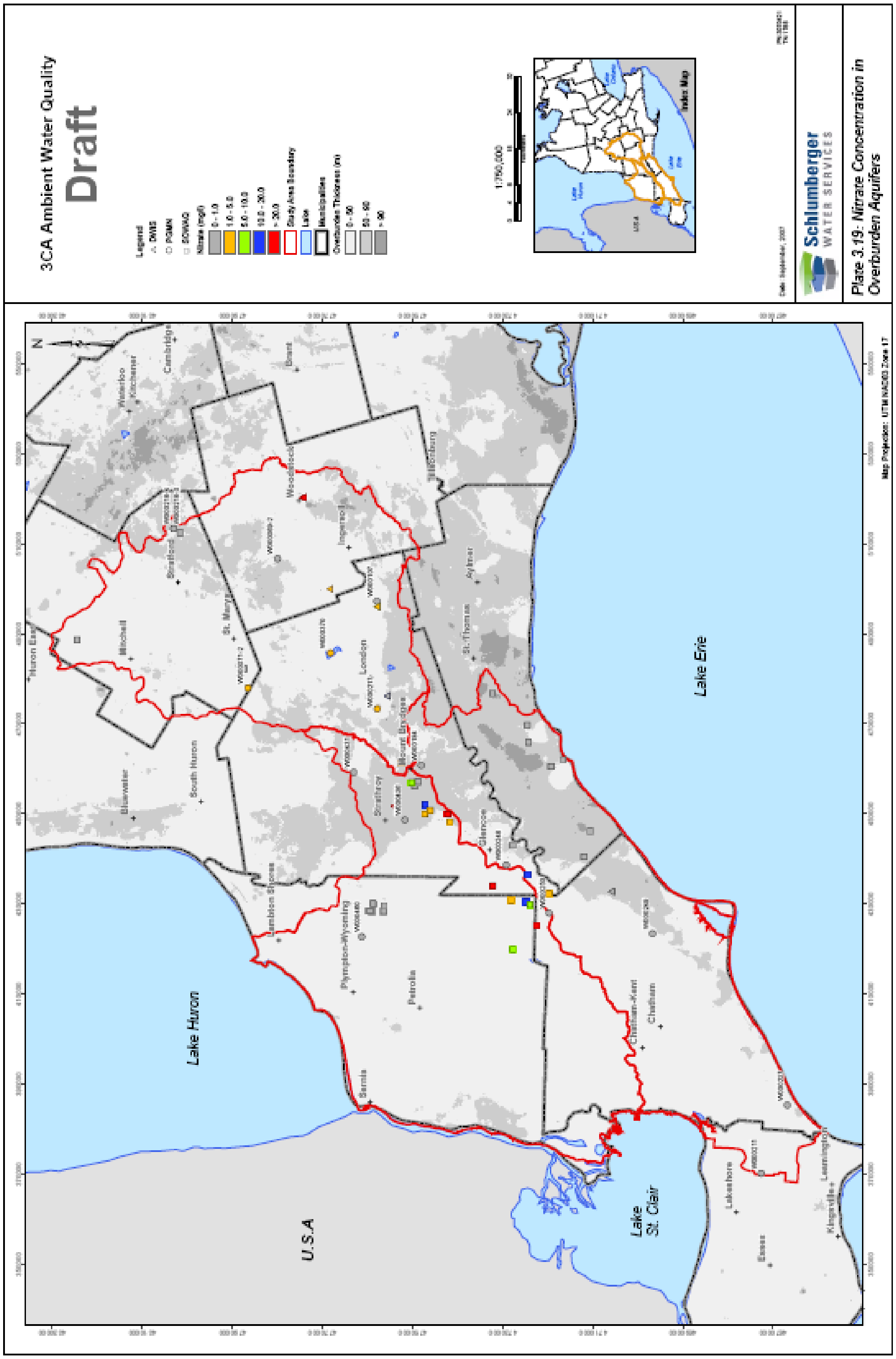

Figure 3.3.3-9: Schlumberger Plate 3.19 Nitrate Concentration in Overburden Aquifers

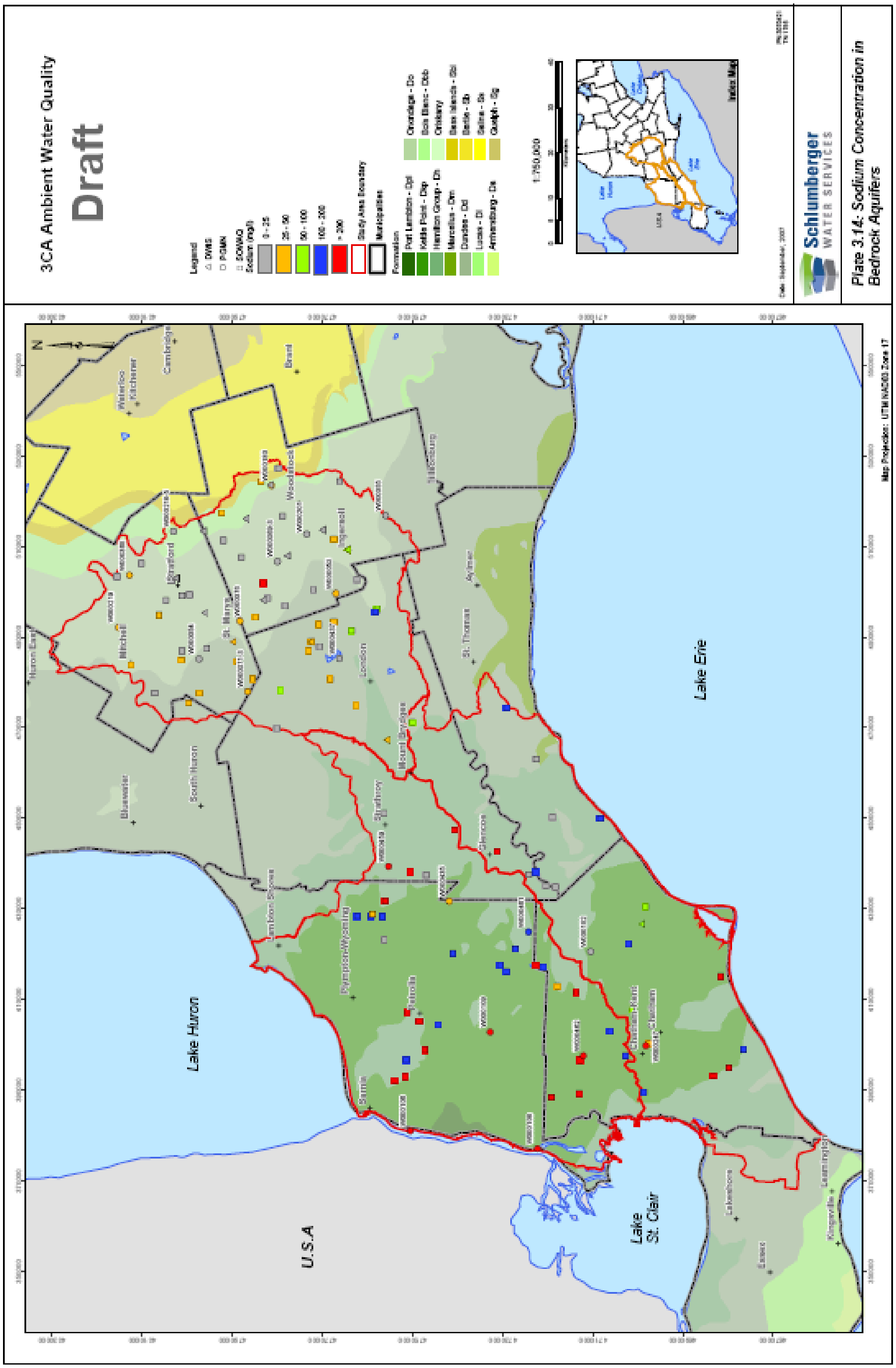

Figure 3.3.3-10: Schlumberger Plate 3.14 Sodium Concentration in Bedrock Aquifers

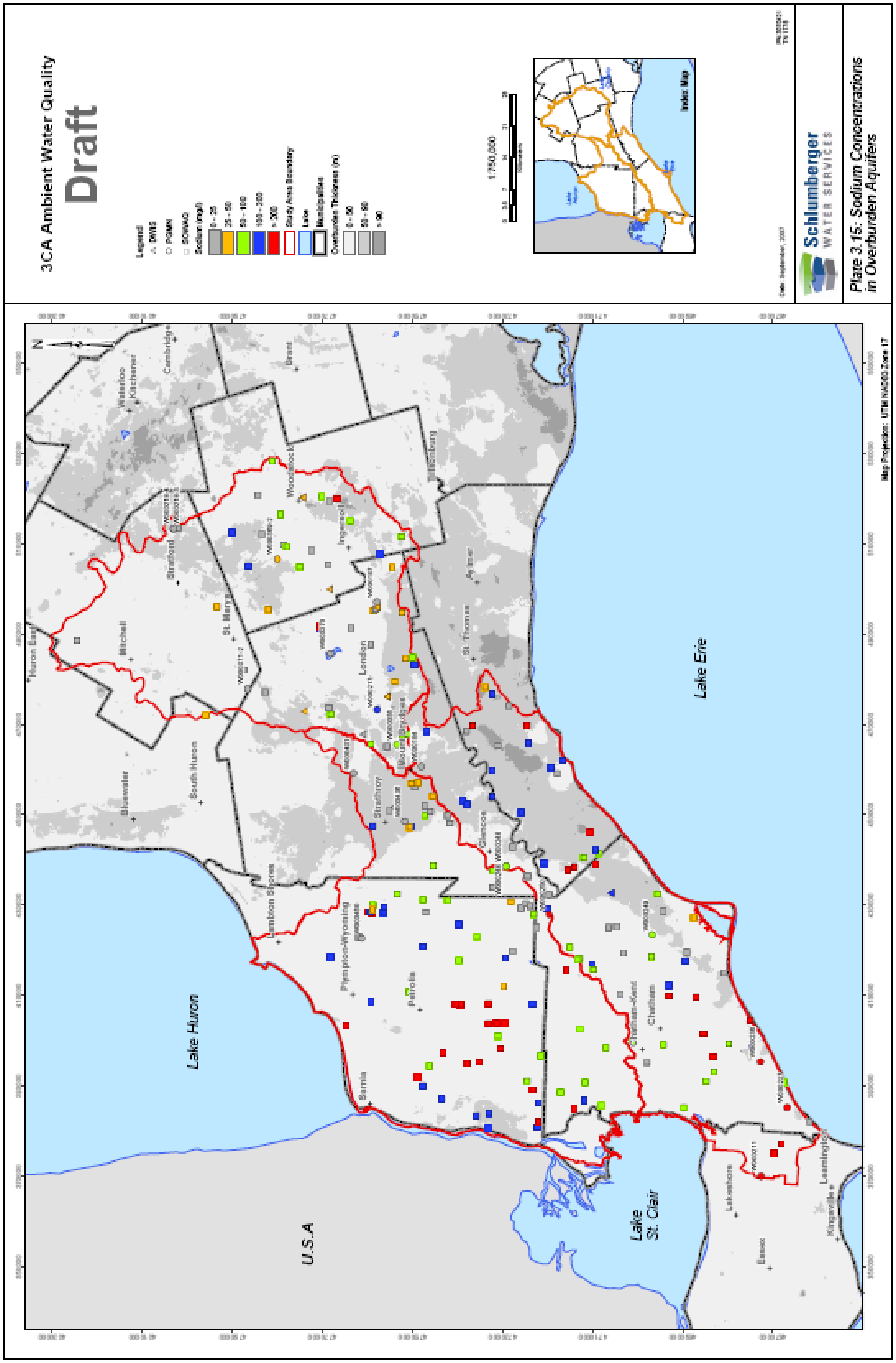

Figure 3.3.3-11: Schlumberger Plate 3.15 Sodium Concentration in Overburden

3.3.4 Groundwater Quality – Microbiological Characterization

This section discusses the characterization of the microbiological quality of groundwater sources used for municipal (public) water supply systems in the Thames Watershed & Region. There is also a brief review of the microbiological data available for wells that are part of the Provincial Groundwater Monitoring Network.

The microbiological quality of drinking water is the most important aspect of drinking water because of its association with waterborne diseases[77]. Incidents of microbiological contamination of municipal water supply systems can be dated to 1853 when more than 10,700 people died in London, England, due to severe dehydration caused by Asiatic cholera[78]. In March 1996, cryptosporidiosis occurred in Collingwood, Ontario due to *Cryptosporidium parvum* in the municipal water supply[79]. This outbreak affected more than 35 people[80]. In May 2000, in Walkerton, Ontario, seven people died and more than two thousand were affected due to contamination of drinking water, mainly by the fecal coliform *Escherichia coli* (*E. coli*) strain O157:H7 and by *Campylobacter jejuni.*[81]

Microbiological contamination of drinking water sources may be due to inadequately treated sewage wastewater, combined sewer overflow to a water source, or wildlife fecal matter. In an agricultural region, the contamination of groundwater by a pathogen may also be due to land application of manure and biosolids, or waste disposal systems, such as septic tanks and manure storage piles[82]. Groundwater can be affected in areas where the soils are permeable, underlain by fractured bedrock, or where the wells are uncapped or improperly capped[83].

3.3.4.1 Microbiological Parameters and Standards

Water can be contaminated by numerous pathogenic (disease-causing) micro-organisms. They include bacteria (such as *Escherichia coli* and Salmonella), protozoa (such as *Giardia* or *Cryptosporidium*) and viruses (like rotavirus). The microbiological contaminants in drinking water that originate from human and animal feces are the most dangerous to human health[84].

Figure 3.3.4.1-1: Coliform Bacteria Subgroups provides an overview of the relationship between groups of micro-organisms, and the types of coliforms relevant to the current report.

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[77] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf.

[78] Collins, C. November 2004. Cholera epidemics in 19th-century Britain. In The Biomedical Scientist. www.ibms.org/index.cfm?method=science.history_zone&subpage=history_cholera

[79] Ontario Ministry of the Environment and Energy. 1997. Executive Summaries Report for 1993, 1994 and 1995. Drinking Water Surveillance Program. www.ene.gov.on.ca/envision/techdocs/3554e.htm

[80] Frost, F. J., T. Muller, G.F. Craun, G. Fraser, D. Thompson, R. Notenboom and R.L. Calderon. Serological analysis of a cryptosporidiosis epidemic. In International Journal of Epidemiology 2000; 29:376-379. www.epidemichttp://ije.oxfordjournals.org/cgi/content/abstract/29/2/376

[81] Ontario Ministry of the Attorney General. 2002a. Part One. Report of the Walkerton Inquiry: The Events of May 2000 and Related Issues.

[82] CCME. CCME Linking Water Science to Policy Workshop Series: Groundwater Quality. Toronto, March 2002.

[83] Rosen, Barry H. February 2000. Waterborne Pathogens in Agricultural Watersheds. Watershed Science Institute Technical Note 2.

[84] Health Canada. *Escherichia coli*: Significance of *E. coli* in Drinking Water. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/escherichia_coli/significance-importance-eng.php

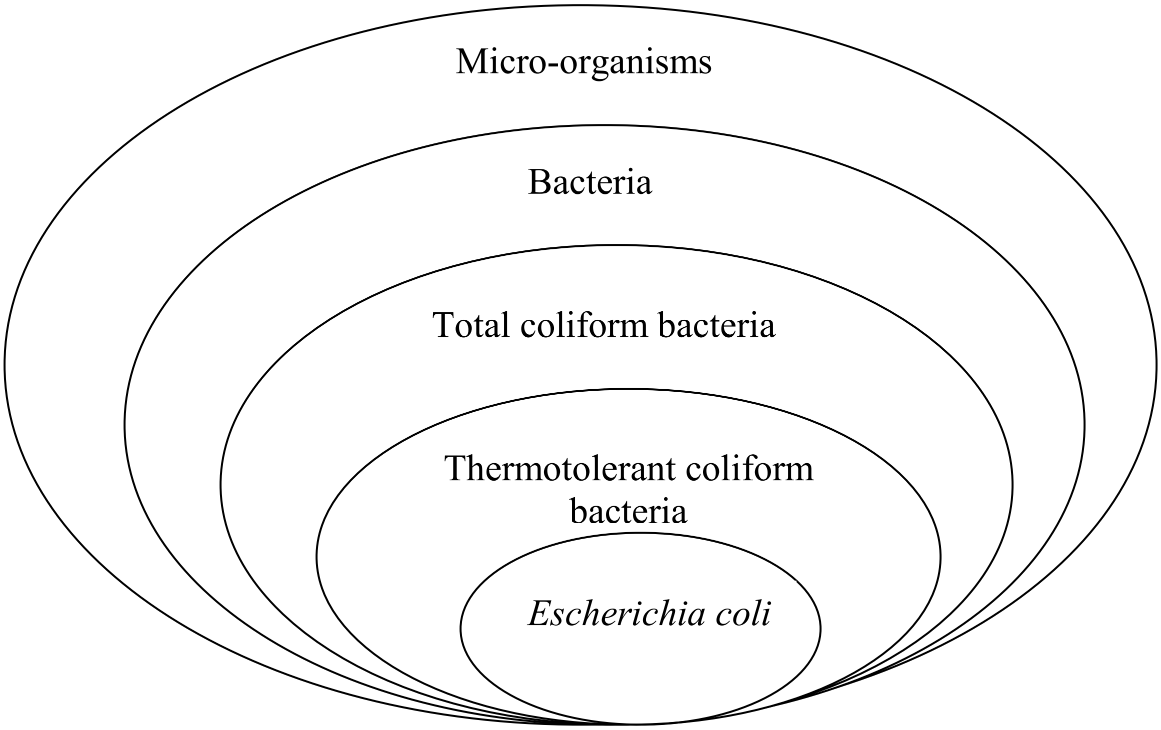

Figure 3.3.4.1-1: **Coliform Bacteria Subgroups**

Total coliform bacteria are rod shaped bacteria from the family Enterobacteriaceae[85]. They are widespread in nature being present in the soil and in the intestines and feces of animals including humans, livestock, poultry and wildlife[86].

Thermotolerant coliform bacteria, which were formerly known as fecal coliform bacteria, are a subset of the total coliform bacteria group. This group includes members of the genera *Escherichia*, *Klebsiella, Enterobacter* and *Citrobacter*[85]. It is important to note that *Klebsiella* may not necessarily be of fecal origin since they are also commonly found in textile and pulp and paper mill wastes[86].

Escherichia coli (*E. coli*) are a subgroup of thermotolerant (fecal) coliform bacteria. Certain strains of *E. coli*, such as *E. coli* O157:H7, are disease-causing.

In order to assess the microbiological quality of drinking water, indicator parameters are used. Historically in Ontario, fecal coliform bacteria were monitored by the Ministry of the Environment as an indicator of fecal contamination. In 1994, OMOE changed this indicator to *E. coli*. The need for testing thermotolerant (fecal) coliform in drinking water quality management is deemed unnecessary due to recent advances in *E. coli* detection methods[85].

The bacteria *Escherichia coli* is commonly used as an indicator of potentially dangerous contamination because:

- It can be readily cultured, identified and enumerated,
- It is found exclusively in the feces of humans and other animals,[87]

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[85] Health Canada. 2006. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - Total Coliforms, 4.0 Significance of total coliforms in drinking water. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/coliforms-coliformes/significance-importance_e.html

[86] USEPA. Monitoring and Assessing Water Quality: Fecal Bacteria. www.epa.gov/volunteer/stream/vms511.html

[87] Health Canada. *Escherichia coli*: Significance of *E. coli* in Drinking Water. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/escherichia_coli/significance-importance-eng.php

- Its presence indicates recent fecal contamination of the water,[87] and
- It indicates the possible presence of disease-causing bacteria, viruses or protozoa including those that are resistant to commonly used disinfectants.[87]

The parameters to be tested in "raw" (i.e. untreated), treated and distributed water of drinking water systems are specified under Schedules 10, 11, and 12 of Ontario Regulation 170/03 of the Safe Drinking Water Act of 2002. Prior to treatment the raw water must be tested for *E. coli* and total coliform bacteria in all drinking water systems, whether the source is surface water or groundwater. The treated water and the water in the distribution system must be tested for both of these microbiological parameters and, in addition, tested for heterotrophic plate count (HPC)[88] which provides a general bacteria population count. There is no drinking water standard for HPC. However, the HPC results are useful in judging the efficiency of various treatment processes[89] for drinking water and for checking the quality of the finished water in a distribution system[90]. In the past, HPC was also analyzed in raw water by water supply systems. It is no longer required to be reported for raw water.

The Conservation Ontario March 2003 Discussion Paper: 'Recommendations for Monitoring Ontario's Water Quality' recommends the use of certain parameters as the indicator parameters for watershed management. The microbiological water quality indicator parameter recommended for analysis in surface water and groundwater sources is *E. coli*. For groundwater, *E. coli* is the microbiological indicator monitored in the Provincial Groundwater Monitoring Network (PGMN) program. In general, surface water sources are more likely to contain micro-organisms than groundwater sources, unless the groundwater sources are under the direct influence of surface water[91].

In this report, the two microbiological indicator parameters used to assess groundwater well (raw water) quality in the SCRCA Watershed are *Escherichia coli* and total coliform.

Drinking water standards are established for treated drinking water supplied to communities. In this report, the data for raw (untreated) water are compared to the treated water standards since there are none specifically for raw water. The comparison with these treated water standards is only intended to provide a means of quality assessment using a reference number (the standard) and not to judge conformance of raw water to the treated water standards.

The OMOE published standards for drinking water, referred to as the Ontario Drinking Water Standards (ODWS), in 2003[92]. The ODWS for *Escherichia coli* and total coliform are a Maximum Acceptable Concentration (MAC) of 'not detectable', meaning zero tolerance in drinking water. The Maximum Acceptable Concentration (MAC) is established for parameters that, when present above a certain concentration, have known or suspected adverse health effects.

An additional source of drinking water standards is the 'Guidelines for Canadian Drinking Water Quality' published by Health Canada on behalf of the Federal-Provincial-Territorial Committee on Drinking Water

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[88] OMOE. 2002. Ontario Safe Drinking Water Act, 2002 - O. Reg. 170/03. Heterotrophic Plate Count. www.search.e-laws.gov.on.ca/en/isysquery/c94cd303-3652-454f-bfdd-f1e4c4e19d86/1/frame/?search=browseStatutes&context=

[89] Health Canada. Heterotrophic Plate Count. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/heterotrophic-heterotrophes/role_heterotroph-eng.php

[90] ProvLab Alberta website. Heterotrophic Plate Count. http://secure.provlab.ab.ca/bugs/webbug/envbug/hpc/hpcintro.htm

[91] Health Canada. 2006. Guidelines for Canadian Drinking Water Quality: Guideline Technical Document - *Escherichia coli*. 2.0 Executive summary for microbiological quality of drinking water. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/escherichia_coli/guideline-recommandation-eng.php#2

[92] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf

(CDW)[93]. The ODWS for *Escherichia coli* and total coliform are the same as the guidelines published by Health Canada.

3.3.4.2 Municipal Groundwater Wells Supply Systems Examined – Thames Watershed & Region

Of the 25 municipal well supply systems in the Thames Watershed & Region, 23 are located in the UTRCA watershed.

In Middlesex, there are six active municipal well supply systems serving populations within the UTRCA watershed including Birr, Dorchester, Melrose, Kilworth Heights Subdivision, Mount Brydges and Thorndale. The Mount Brydges well supply system also supplies residents living in the St. Clair Region watershed. The City of London system wells are for emergency backup only. The primary sources of drinking water to the City of London are the Elgin Area Primary Water Supply System (Lake Erie water) and the Lake Huron Primary Water Supply System (Lake Huron water).

In Oxford, the 10 municipal well supply systems in the UTRCA watershed are Beachville-Loweville Subdivision, Embro, Hickson-King Subdivision, Ingersoll, Innerkip, Lakeside, Mount Elgin, Tavistock, Thamesford and Woodstock.

In Perth, the six well supply systems in the UTRCA watershed are Mitchell, Sebringville (Black Creek Estates), Shakespeare (Miller Ave.), St. Marys, St. Pauls and Stratford.

In Chatham-Kent, the Highgate and Ridgetown well supplies are the only municipal systems located in the LTVCA watershed.

3.3.4.3 Sources of Data and Sample Size - Municipal Groundwater

The source of microbiological data to characterize groundwater quality for most of the municipal groundwater wells in the Thames Watershed & Region is the Drinking Water Information System (DWIS). This database provides total coliform and *E. coli* data on a weekly basis. The data provided to us contains data from May 2003 to September 2006 for most groundwater wells. The DWIS reporting of another parameter, total background coliform, was stopped in 2004 since it was no longer required to be analyzed by water supply systems[94]. Hence, this parameter was not studied in this report.

In addition to the DWIS, microbiological data from 2006 plant operational records for the St. Marys well supply system were obtained from the Town of St. Marys.

For the two well supply systems where DWIS data was unavailable (Mount Brydges and Mount Elgin), equivalent data was obtained from well monitoring reports and used to evaluate the systems. The Mount Elgin data was obtained from the Public Works Department, County of Oxford. The Mount Brydges data was obtained from the Environmental Services Department, Municipality of Strathroy-Caradoc.

The sample sizes (‘n’) of most wells range from around 32 to 52 samples per year (three to five samples per month). Noticeable exceptions to this sample size range, in the data set provided, are:

- City of London - all of the backup emergency wells have sample sizes of only one to four per year with some years’ data not in the data set provided
- Dorchester - three (one decommissioned well and two backup wells) of the eight wells have between only one and eight samples per year with some years’ data not in the data set provided
- Embro - one of the wells is a monitoring well with three to four samples per year for 2003 and 2004
- Shakespeare - one well has only seven to 14 samples per year

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[93] Health Canada. 2008. Guidelines for Canadian Drinking Water Quality Summary Table. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/sum_guide-res_recom/index_e.html

[94] OMOE staff. April 2007. Personal communication.

- St. Marys - two of the wells have large sample sizes from 104 to 247 for a few years
- Thamesford - one of the three wells was offline and, therefore, not tested[95]

Our review of the water quality data obtained, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water. Differences in the period of the data sets reviewed are identified as 'data gaps.' The specific reasons for these gaps in data are not ascertained and are not relevant to the characterization of the water source. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these 'data gaps.' The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

The most common period for which data is available from the provided DWIS data set is from May 2003 to September 2006. **Tables 3.3.4.3-1** to **3.3.4.3-30** show sample sizes per year of each analyzed groundwater well of the Thames Watershed & Region.

Sample Sizes and Data Gaps for the Thames Watershed & Region Municipal Wells

Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these 'data gaps.' The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

Data start and end dates are based on the period of data provided at the time of writing of this report.

Table 3.3.4.3-1: Sample Size and Data Gaps for Birr Well

Well	Year	Sample Size	Notes
#1	2003	33	Data starts from May 20
	2004	54	(data for all months)
	2005	52	(data for all months)
	2006	28	Data ends September 25

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[95] Oxford County Manager of Water Services. Personal communication.

Table 3.3.4.3-2: Sample Size and Data Gaps for Dorchester Wells

Well	Year	n	Data Gaps
2PW-1	2003	29	Data starts from May 20; no December data
	2004	39	No January, February and March data
	2005	52	(data for all months)
	2006	39	Data ends September 26
3PW-1	2003	32	Data starts from May 20
	2004	51	(data for all months)
	2005	52	(data for all months)
	2006	39	Data ends September 26
3PW-2A	2003		No data
	2004	1	One sample data only on Dec 21
	2005		No data
	2006	4	Data in May, Aug and Sept
3PW-3	2003	27	Data starts from May 20; no November data
	2004	52	(data for all months)
	2005	52	(data for all months)
	2006	39	Data ends September 26
3PW-4A	2003	39	Data starts from May 20
	2004	51	(data for all months)
	2005	52	(data for all months)
	2006	39	Data ends September 26
3PW-5	2003	8	May 27 to Dec 30; no data from July to November
	2004		No data
	2005		No data
	2006		No data
3PW-6	2003	5	Data starts Dec 2
	2004	1	One sample data only on June 22
	2005		No data
	2006		No data
3PW-7	2003	30	Data starts from May 20
	2004	50	(data for all months)
	2005	51	(data for all months)
	2006	39	Data ends September 26

Table 3.3.4.3-3: Sample Size and Data Gaps for Melrose Wells

Well	Year	n	Data Gaps
#2	2003	33	Data starts from May 20
	2004	57	(data for all months)
	2005	52	(data for all months)
	2006	29	Data ends Sept 25
#3	2003	33	Data starts from May 20
	2004	53	(data for all months)
	2005	52	(data for all months)
	2006	29	Data ends Sept 25

Table 3.3.4.3-4: Sample Size and Data Gaps for Kilworth Heights Subdivision Wells

Well	Year	n	Data Gaps
#1	2003	10	Data starts from May 20; no data in June, July, Sept, Oct
	2004	52	(data for all months)
	2005	44	(data for all months)
	2006	4	Data ends Sept 18; no data Jan to May
#2	2003	33	Data starts from May 20
	2004	54	(data for all months)
	2005	52	(data for all months)
	2006	38	Data ends Sept 25
#3	2003	33	Data starts from May 20
	2004	54	(data for all months)
	2005	52	(data for all months)
	2006	38	Data ends Sept 25

Table 3.3.4.3-5: Sample Size and Data Gaps for Mount Brydges Wells

Well	Year	n	Data Gaps
#1	2003	52	(data for all months)
	2004	27	Data starts from July 2
	2005	52	(data for all months)
	2006	53	(data for all months)
#2	2003	52	(data for all months)
	2004	27	Data starts from July 2
	2005	52	(data for all months)
	2006	53	(data for all months)

Table 3.3.4.3-6: Sample Size and Data Gaps for Thorndale Wells

Well	Year	n	Data Gaps
River Well #1	2003	32	Data starts May 20
	2004	48	(data for all months)
	2005	52	(data for all months)
	2006	39	Data ends Sept 26
River Well #2	2003	33	Data starts May 20
	2004	47	(data for all months)
	2005	52	(data for all months)
	2006	39	Data ends Sept 26

Table 3.3.4.3-7: Sample Size and Data Gaps for City of London Standby Wells

Well	Year	n	Data Gaps
Hyde Park	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	3	Data only in March, June, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept
Fanshawe Well #1	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	4	Data only in March, June, Sept, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept
Fanshawe Well #2	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	4	Data only in March, June, Sept, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept
Fanshawe Well #3	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	4	Data only in March, June, Sept, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept
Fanshawe Well #4	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	4	Data only in March, June, Sept, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept
Fanshawe Well #5	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	4	Data only in March, June, Sept, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept
Fanshawe Well #6	2003	3	Data starts June 16; data only in June, Sept, Dec
	2004	2	Data only in March and Dec
	2005	4	Data only in March, June, Sept, Dec
	2006	3	Data ends Sept 18; data only in March, June, Sept

Table 3.3.4.3-8: Sample Size and Data Gaps for Beachville-Loweville Subdivision Wells

Well	Year	Sample Size	Data Gaps
#1	2003	33	Data starts from May 20
	2004	46	No data in July
	2005	51	(data for all months)
	2006	10	Data ends September 11

Table 3.3.4.3-9: Sample Size and Data Gaps for Embro Wells

Well	Year	n	Data Gaps
#1	2003	33	Data starts from May 20
	2004	51	(data for all months)
	2005	52	(data for all months)
	2006	33	Data ends September 11; no February data
#3	2003	30	Data starts from May 20
	2004	47	(data for all months)
	2005	52	(data for all months)
	2006	33	Data ends September 11; no February data

Table 3.3.4.3-10: Sample Size and Data Gaps for Hickson-King Subdivision Wells

Well	Year	n	Data Gaps
#1	2003	33	Data starts from May 20
	2004	51	Data ends Dec. 29
	2005		No data
	2006		No data
2	2003		No data
	2004		No data
	2005	51	Data starts from Jan 4
	2006	10	Data ends September 11; no data in May

Table 3.3.4.3-11: Sample Size and Data Gaps for Ingersoll Wells

Well	Year	n	Data Gaps
#2	2003	30	Data starts from May 20
	2004	49	(data for all months)
	2005	53	(data for all months)
	2006	37	Data ends September 11
#3	2003	27	Data starts from May 20
	2004	14	No data in Jan, Feb, Jul, Aug, Sept, Nov, Dec
	2005	38	No data in Jan
	2006	35	Data ends August 28
#5	2003	35	Data starts from May 20
	2004	47	(data for all months)
	2005	51	(data for all months)
	2006	37	Data ends September 11
#7	2003	31	Data starts from May 20
	2004	23	Data ends October 26; no data in Aug and Sept
	2005		No data
	2006		No data
#8	2003	26	Data starts from May 26; no data in June
	2004	24	No data in Sept to Dec
	2005	49	(data for all months)
	2006	37	Data ends September 11
#10	2003	33	Data starts from May 20
	2004	46	(data for all months)
	2005	52	(data for all months)
	2006	37	Data ends September 11

Table 3.3.4.3-12: Sample Size and Data Gaps for Innerkip Wells

Well	Year	n	Data Gaps
#1	2003		No data
	2004		No data
	2005	43	Data starts from March 15
	2006	37	Data ends September 11
#2	2003		No data
	2004		No data
	2005	41	Data starts from March 15
	2006	37	Data ends September 11

Table 3.3.4.3-13: Sample Size and Data Gaps for Lakeside Wells

Well	Year	n	Data Gaps
#2-00	2003		No data
	2004	26	Data starts April 5
	2005	52*	(data for all months)
	2006	37	Data ends Sept. 11

*No sample April 5, 2005. Sample size adjusted accordingly.

Table 3.3.4.3-14: Sample Size and Data Gaps for Mount Elgin Well

Well	Year	n	Data Gaps
3	2003	54	Data starts from Jan 2
	2004	53	(data for all months)
	2005	52	(data for all months)
	2006	52	Data ends Dec 27

Table 3.3.4.3-15: Sample Size and Data Gaps for Tavistock Wells

Well	Year	n	Data Gaps
#W-1	2003	33	Data starts May 20
	2004	53	(data for all months)
	2005	52	(data for all months)
	2006	37	Data ends Sept 11
#W-2A	2003	33	Data starts May 20
	2004	53	(data for all months)
	2005	51	(data for all months)
	2006	37	Data ends Sept 11
#3	2003	33	Data starts May 20
	2004	53	(data for all months)
	2005	46	No data in Sept
	2006	37	Data ends Sept 11

Table 3.3.4.3-16: Sample Size and Data Gaps for Thamesford Wells

Well	Year	n	Data Gaps
River Well #1	2003	33	Data starts May 20
	2004	52	(data for all months)
	2005	53	(data for all months)
	2006	37	Data ends Sept 11
River Well #2	2003	1	Data starts July 21; no data Aug - Dec
	2004	3	No data in Jan-July, Sept-Oct and Dec
	2005	6	Data ends Aug 16; no data in Jan and July
	2006		No data
Stanley St. Well #3	2003	32	Data starts May 20
	2004	49	(data for all months)
	2005	46	(data for all months)
	2006	35	Data ends Sept 11

Table 3.3.4.3-17: Sample Size and Data Gaps for Woodstock Wells

Well	Year	n	Data Gaps
Thornton Well Field Well #1	2003	33	Data starts May 20
	2004	52	No data in Dec
	2005	39	No data Jan to March
	2006	37	Data ends Sept 11
Tabor Well Field Well #2	2003	33	Data starts May 20
	2004	51	(data for all months)
	2005	51	(data for all months)
	2006	35	Data ends Sept 11
Thornton Well Field Well #3	2003	33	Data starts May 20
	2004	51	(data for all months)
	2005	50	(data for all months)
	2006	38	Data ends Sept 11
Tabor Well Field Well #4	2003	33	Data starts May 20
	2004	50	(data for all months)
	2005	52	(data for all months)
	2006	37	Data ends Sept 11
Thornton Well Field Well #5	2003	33	Data starts May 20
	2004	51	(data for all months)
	2005	52	(data for all months)
	2006	7	Data ends Feb 13
Southside Park Well #6	2003	1	Data only on July 28 (no other data)
	2004		No data
	2005	23	No data Jan to April
	2006	37	Data ends Sept 11
Sutherland Well #7	2003	32	Data starts May 20
	2004	49	(data for all months)
	2005	45	(data for all months)
	2006	47	Data ends Sept 11
Thornton Well Field Well #8	2003	33	Data starts May 20
	2004	51	(data for all months)
	2005	46	No data in June
	2006	37	Data ends Sept 11

Well	Year	n	Data Gaps
Hart Springs Well #9	2003	19	Data starts May 20; no data in Oct and Dec
	2004	15	No data Jan to May and Nov to Dec
	2005	27	No data Jan to May
	2006	37	Data ends Sept 11
Thornton Well Field Well #11	2003	34	Data starts May 20
	2004	52	(data for all months)
	2005	52	(data for all months)
	2006	37	Data ends Sept 11

Table 3.3.4.3-18: Sample Size and Data Gaps for Mitchell Wells

Well	Year	n	Data Gaps
#1	2003	33	Data starts May 21
	2004	52	(data for all months)
	2005	56	(data for all months)
	2006	39	Data ends Sept 24
#2	2003	33	Data starts May 21
	2004	52	(data for all months)
	2005	50	(data for all months)
	2006	39	Data ends Sept 24
#3	2003	32	Data starts May 21
	2004	52	(data for all months)
	2005	50	(data for all months)
	2006	39	Data ends Sept 24

Table 3.3.4.3-19: Sample Size and Data Gaps for Sebringville Well

Well	Year	n	Data Gaps
Black Creek Estates Well	2003	32	Data starts from May 19
	2004	49	No data in July
	2005	51	(data for all months)
	2006	28	Data ends September 11

Table 3.3.4.3-20: Sample Size and Data Gaps for Shakespeare Well

Well	Year	n	Data Gaps
Shakespeare Well	2003	14	Data starts from May 27
	2004	7	No data from Jan to June
	2005	12	(data for all months)
	2006	7	Data ends September 6; no data in Feb and June

Table 3.3.4.3-21: Sample Size and Data Gaps for St. Marys Wells

Well	Year	n	Data Gaps
Well #1 - Timms Lane	2003	32	Data starts May 20
	2004	51	No data in Dec
	2005	55	No data in Feb
	2006	30	Data ends Aug 1
Well #3 - 209 Thomas St.	2003	66	Data starts May 20
	2004	104	(data for all months)
	2005	65	(data for all months)
	2006	30	Data ends Aug 1

Table 3.3.4.3-22: Sample Size and Data Gaps for St. Pauls Well

Year	n	Notes
2003	32	Data starts from May 19
2004	46	(data for all months)
2005	51	(data for all months)
2006	29	No data in August. Data ends September 11

Table 3.3.4.3-23: Sample Size and Data Gaps for Stratford Wells

Well	Year	n	Data Gaps
Romeo – Well #1	2003	32	Data starts May 26
	2004	56	(data for all months)
	2005	41	No data in May and June
	2006	40	Data ends Sept 25
Romeo – Well #2	2003	33	Data starts May 20
	2004	49	(data for all months)
	2005	43	No data in May and June
	2006	40	Data ends Sept 25
Romeo – Well #3	2003	33	Data starts May 20
	2004	52	(data for all months)
	2005	44	No data in May and June
	2006	40	Data ends Sept 25
Romeo – Well #4	2003	37	Data starts May 20
	2004	7	No data March to Dec
	2005	30	No data Jan to March, and May to June
	2006	42	Data ends Sept 25
Romeo – Well #6	2003	31	Data starts May 20
	2004	47	(data for all months)
	2005	52	(data for all months)
	2006	64	Data ends Sept 25
Romeo – Well #7	2003	33	Data starts May 20
	2004	54	(data for all months)
	2005	52	(data for all months)
	2006	14	Data ends July 24; no data in June
Chestnut Street Well	2003	32	Data starts May 20
	2004	55	(data for all months)
	2005	32	No data Sept to Dec
	2006	36	Data ends Sept 27; no data Jan to March
Dunn Road Well	2003	33	Data starts May 27
	2004	51	(data for all months)
	2005	52	(data for all months)
	2006	37	Data ends Sept 27

Well	Year	n	Data Gaps
Lorne Avenue Well	2003	33	Data starts May 20
	2004	51	(data for all months)
	2005	54	(data for all months)
	2006	39	Data ends Sept 27
Mornington Well	2003	34	Data starts May 20
	2004	38	No data in June to Aug
	2005	53	(data for all months)
	2006	35	Data ends Sept 27
O Loane Avenue Well	2003	33	Data starts May 20
	2004	53	(data for all months)
	2005	53	(data for all months)
	2006	27	Data ends Sept 27; no data in July

Table 3.3.4.3-24: Sample Size and Data Gaps for Highgate Wells

Well	Year	n	Notes
#1	2003	11	Data starts Oct 14
	2004	40	No data in July and Aug
	2005	37	No data in June
	2006	37	Data ends Sept 11
#2	2003	16	Data starts Sept 30
	2004	51	(data for all months)
	2005	44	(data for all months)
	2006	37	Data ends Sept 11

Table 3.3.4.3-25: Sample Size and Data Gaps for Ridgetown Wells

Well	Year	n	Notes
#1A	2003	33	Data starts May 20
	2004	58	(data for all months)
	2005	51	(data for all months)
	2006	37	Data ends Sept 11
#2	2003	33	Data starts May 20
	2004	46	No data in March
	2005	51	(data for all months)
	2006	37	Data ends Sept 11
#3	2003	33	Data starts May 20
	2004	39	No data in May
	2005	50	(data for all months)
	2006	37	Data ends Sept 11
#4	2003	2	Data starts Dec 22; data only in Dec
	2004	43	(data for all months)
	2005	51	(data for all months)
	2006	37	Data ends Sept 11
#5	2003	33	Data starts May 20
	2004	43	(data for all months)
	2005	51	(data for all months)
	2006	37	Data ends Sept 11
#6	2003	32	Data starts May 20
	2004	43	(data for all months)
	2005	51	(data for all months)
	2006	37	Data ends Sept 11

Table 3.3.4.3-26: Sample Size and Data Gaps for Decommissioned City of London Standby Wells

Well	Year	n	Data Gaps
Byron	2003		No data
	2004		No data
	2005		No data
	2006	1	Data only on July 29
Komoka Well #1	2003	2	Data only in June and Sept
	2004		No data
	2005		No data
	2006		No data
Komoka Well #2	2003	2	Data only in June and Sept
	2004		No data
	2005		No data
	2006		No data
Komoka Well #3	2003	2	Data only in June and Sept
	2004		No data
	2005		No data
	2006		No data

Table 3.3.4.3-27: Sample Size and Data Gaps for Embro Monitoring Well

Well	Year	n	Data Gaps
#2 (monitoring)	2003	3	Data starts July 28; data only in July, Aug, Oct
	2004	4	Data ends April 13; data only in Jan, Feb, April
	2005		No data
	2006		No data

Table 3.3.4.3-28: Sample Size and Data Gaps for Decommissioned Lakeside Well

Well	Year	n	Data Gaps
#1 (Decommissioned)	2003	37	Data starts from May 20
	2004	24	Data ends June 28
	2005		No data
	2006		No data

Table 3.3.4.3-29: Sample Size and Data Gaps for Decommissioned St. Marys Well

Well	Year	n	Data Gaps
Well #2 - 22 Wellington St. N.	2003	152	Data starts May 16
	2004	247	(data for all months)
	2005	125	No data from Aug to Nov
	2006	3	Data ends May 16; no data in Feb and April

Table 3.3.4.3-30: Sample Size and Data Gaps for Sweaburg-Oxford Heights Subdivision Wells

Well	Year	n	Data Gaps
#1	2003	33	Data starts May 20
	2004	56	(data for all months)
	2005	52	(data for all months)
	2006	31	Data ends July 31
#2	2003	33	Data starts May 20
	2004	50	(data for all months)
	2005	54	(data for all months)
	2006	31	Data ends July 31

As of August 3, 2006 the Sweaburg Well Supply was abandoned and customers are now served from the Woodstock Well Supply. (Source of info: Annual OMOE Drinking Water System Report for the Sweaburg Well Supply (Oxford Heights Subdivision) 2006)

Note: Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these 'data gaps'. The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist. Data start and end dates are based on the period of data provided to us at the time of writing of this report.

3.3.4.4. Method of Analysis - Municipal Groundwater

A total of 92 wells were analyzed using *E. coli* and total coliform data from 2003 to 2006. As noted in Section 3.3.4.3, data from some months or years is not available in the provided data set for a few wells. Of the 92 wells, 83 are actively in use, and nine wells are ‘extra’ wells that were decommissioned, sealed, abandoned, or used for monitoring purposes only (not considered to be a source of municipal drinking water in recent years). However, these ‘extra’ wells have partial data available for analysis. They are listed in the Special Cases section.

For each well, tables are provided in this report summarizing:

- Annual ranges (minimum to maximum counts),
- Number of exceedences of the ODWS, and
- Percent of exceedences of the ODWS.

Since the Ontario Drinking Water Standards (ODWS) for *E. coli* and total coliform is ‘not detectable’, exceedences are taken as any detects, or any coliform counts greater than zero (occurrences).

For wells in which the number of occurrences of *E. coli* (n1) is one or more ($n1\geq1$) and for wells in which the number of occurrences of total coliform (n2) is three or more ($n2\geq3$), scatter plot graphs were created using Microsoft Excel software to show the spread of total coliform and *E. coli* data over time. Monthly variations between different years' data can be seen from the graphs. (Where the number of occurrences of total coliform is less than three, and/or where *E. coli* is not detected, well data in the summary tables was not plotted as graphs.)

A logarithmic scale was employed where needed to present the spread of data over several orders of magnitude. For example, within one data set, the total coliform could range from 0 counts/100 mL to 210,000 counts/100 mL. Graphing on a logarithmic scale aids in displaying such an extreme variation in data values.

Special Cases

(A) Extra wells

Nine extra groundwater wells whose data was available in the DWIS database were analyzed. These wells are decommissioned, sealed, abandoned, or used for monitoring purposes only and are not considered to be a source of municipal drinking water. However, their coliform data aids in assessing groundwater quality in the vicinity of functioning source water supplying wells. They are described in detail in **Table 3.3.4.4.-1: Extra Wells Analyzed**.

Table 3.3.4.4-1: Extra Wells Analyzed

No.	Drinking Water System Name	No. of Extra Wells Analyzed	Notes on Extra Wells
1	City of London Distribution System Back Up Wells *	4	Byron Well and the Komoka Wells (# 1, 2 and 3) were decommissioned in 2003 and 2004 respectively[96]
2	Embro Well Supply	1	Well #2 became a monitoring well in May 1998[97]
3	Lakeside Well Supply	1	Well #1 was sealed in December 2005[97]
4	Sweaburg-Oxford Heights Subdivision Well Supply	2	Discontinued from use in August 2006[97]
5	St. Marys Well Supply	1	Well #2 (22 Wellington Street) was decommissioned in 2006[98] (probably May)

*The extra City of London wells were emergency backup wells only

(B) Wells not in regular use

There are wells typically not used regularly but kept ready for use if needed. For source protection study purposes, these wells are considered to be a part of the active municipal well supply systems. A few samples from each well are analyzed every year and the coliform results presented in this report.

All seven City of London distribution system wells (Hyde Park Well and Fanshawe Wells #1 to 6) are back up wells. They have not been used to supply water to the distribution system since 1988, but are operated once every three months.

Two of the Dorchester wells (Wells #3PW-5 and 3PW-6) are backup wells.

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[96] City of London Water and Sewer Operations Division staff. May 2007. Personal communication.

[97] Oxford County Water Operations Coordinator. May 2007. Personal communication.

[98] Town of St. Marys Supervisor of Water & Works. May 2007. Personal communication.

In the Ingersoll well supply system, Well #3 has been run occasionally since August 2003. Well #7 was not used regularly since May 2004, used only sporadically in 2002 and 2003 but has been in regular use since October 2006. Well #11 has not been in use since November 2000[97] .

The River Well #2 of the Thamesford well supply system had not been used since before 1997, but an iron and manganese removal system has been constructed and the well is now back into service[99].

(C) Incorrect and missing well names in DWIS database

There are instances of data being recorded under incorrect well names and instances of missing well names in the DWIS database. However, the discrepancies/anomalies are resolved with information provided by the operations staff from the respective municipality or county.

City of London Distribution Well

The Byron well 2006 sample in the DWIS data set is removed from the analysis in this report. This is due to the fact that the Byron well was decommissioned in 2003, and no samples were taken from the well thereafter[100].

Dorchester Well Supply

In the DWIS data obtained from OMOE, 2004 and 2006 coliform data for Dorchester Well #3PW-2A is provided. However, this well was decommissioned in October 2004.

It was confirmed that the December 2004 data is not of this well, and the December 2004 data for all other wells are accounted for. Hence, that DWIS data is not included in the analysis for this report.

It was also confirmed that the DWIS 2006 data for Well #3PW-2A belonged to a newer well. The new well, #3PW-2B started operating in August 2006 and also has a raw water sample taken in May 2006 after installation of the mechanical piping from the well head to the Treatment Facility. The 2006 data reported for #3PW-2A is analyzed and included in this report as being data for Well #3PW-2B[101].

Hickson King Subdivision Well Supply

In the OMOE DWIS database, the 2003 to 2004 data is reported to be for Well #1 while 2005 to 2006 data is for Well #2 of the Hickson King Subdivision. However, Well #1 was sealed and abandoned in January 2002. Well #2 has been operating since 1992 and is now the only well of this well supply system. It was confirmed that the 2003 to 2004 data for Well #1 is data from Well #2. After Well #1 was sealed, the Well #2 was called #1 for some time[99]. Hence, the OMOE coliform data reported under Well #1 is analyzed along with Well #2 data and included in this report as being 2003 to 2006 data for Well #2 only.

Ingersoll Well Supply

There is no data for Well #11 in the DWIS database. It has not been in use since November 2000 and is not included in the routine sampling program. However, it is still considered to be a part of the Ingersoll well supply system[99].

(D) Coliform data values with qualifiers

When the samples are taken for testing in the laboratory, there can be problems with shipping or analysis that may be noted by certain data qualifiers (or comments) within the DWIS database for the groundwater wells studied. These data are not shown in graphs but are noted below the summary tables. The details of these qualifiers and how the data was treated during the review for this report are shown below in **Table**

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[99] Oxford County Water Operations Coordinator. May 2007. Personal communication.

[100] City of London Water and Sewer Operations Division staff. May 2007. Personal communication.

[101] Municipality of Thames Center Superintendent of Environmental Services. May 2007. Personal communication.

3.3.4.4-2: Qualifiers in DWIS Data and Data Treatment. For example, with the Stratford wells, the data on June 22, 2005 for both total coliform and *E. coli* is unavailable owing to a power outage. Although remaining data for that month and year indicate zero counts of both total coliform and *E. coli*, it is unknown whether the counts may have been zero or not on June 22, 2005. Hence, this data point must be considered with caution for the five Stratford wells.

Table 3.3.4.4-2: Qualifiers in DWIS Data and Data Treatment

No.	Drinking Water System Name	Data Qualifier, Date and Well Name	Data Treatment
1	Kilworth Heights Subdivision Well Supply	NDOG on August 31, 2006 for Well #1	Sample is considered positive for total coliform
2	Lakeside Well Supply	NDMT on April 5, 2005 for Well #2-00	Sample is excluded from analysis
3	St. Marys Well Supply	NDSF October 13, 2004 for Well #2	Sample is excluded from analysis
4	Stratford Well Supply	URAPO on June 22, 2005 for Chestnut Street, Dunn Road, Lorne Avenue, Mornington and O'Loane Avenue Wells	Indeterminable analysis for these wells

NDOG - No data, total coliform plate overgrowth
NDMT - No data, missing in transit
NDSF - No data, sample frozen
URAPO - Unreliable results affected by power outage at Laboratory

Bias

Weather and event bias may be present in DWIS data where the number of samples per years is typically low or where several months' data is not in the data set provided to us.

3.3.4.5 Results and Discussion - Municipal Groundwater - Microbiological Data

The municipal groundwater well supply systems that service various areas of the Thames Watershed & Region are discussed in this section. The well systems are grouped based on their location in the municipalities of Middlesex, Oxford, Perth and Chatham-Kent. The data for each individual well within a system is reviewed and summarized in tables. In addition, wells with one or more occurrences of *E. coli* or three or more occurrences of total coliform are graphed as scatter plots. All results discussed are only for the period for which data was provided.

Our review of the water quality data obtained, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water. Differences in the period of the data sets reviewed are identified as 'data gaps.' The specific reasons for these gaps in data are not ascertained and are not relevant to the characterizing of the water source. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these 'data gaps.' The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

(A) Municipal Groundwater Well Supply Systems in Middlesex County

There are six active well supply systems in the County of Middlesex servicing populations within the Thames watershed: Birr, Dorchester, Melrose, Kilworth Heights Subdivision, Mount Brydges and Thorndale. In addition, the City of London maintains a seven well system that consists of emergency backup wells only.

(1) Birr Well Supply

Table 3.3.4.5-1 summarizes the raw water coliform data for the single well in the Birr supply system. The data available is from May 2003 to September 2006. There was no *E. coli* detected. The well had 25 instances of total coliform presence between May 2003 and December 2005 and none in 2006. Data is graphed as a scatter plot and discussed in detail below.

Figure 3.3.4.5-1 shows the spread of total coliform data. All counts are below 10 per 100 mL with the exception of a maximum of 70 counts/100 mL in October 2003. Most of the total coliform occurrences appear to be in the months of July to December, with a few occurrences in March to June.

Table 3.3.4.5-1: Summary Data for Birr Well Supply

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	33	0	0	9 (27%)	0-70
	2004	54			11 (20%)	0-9
	2005	52			5 (9.6%)	0-5
	2006	28			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

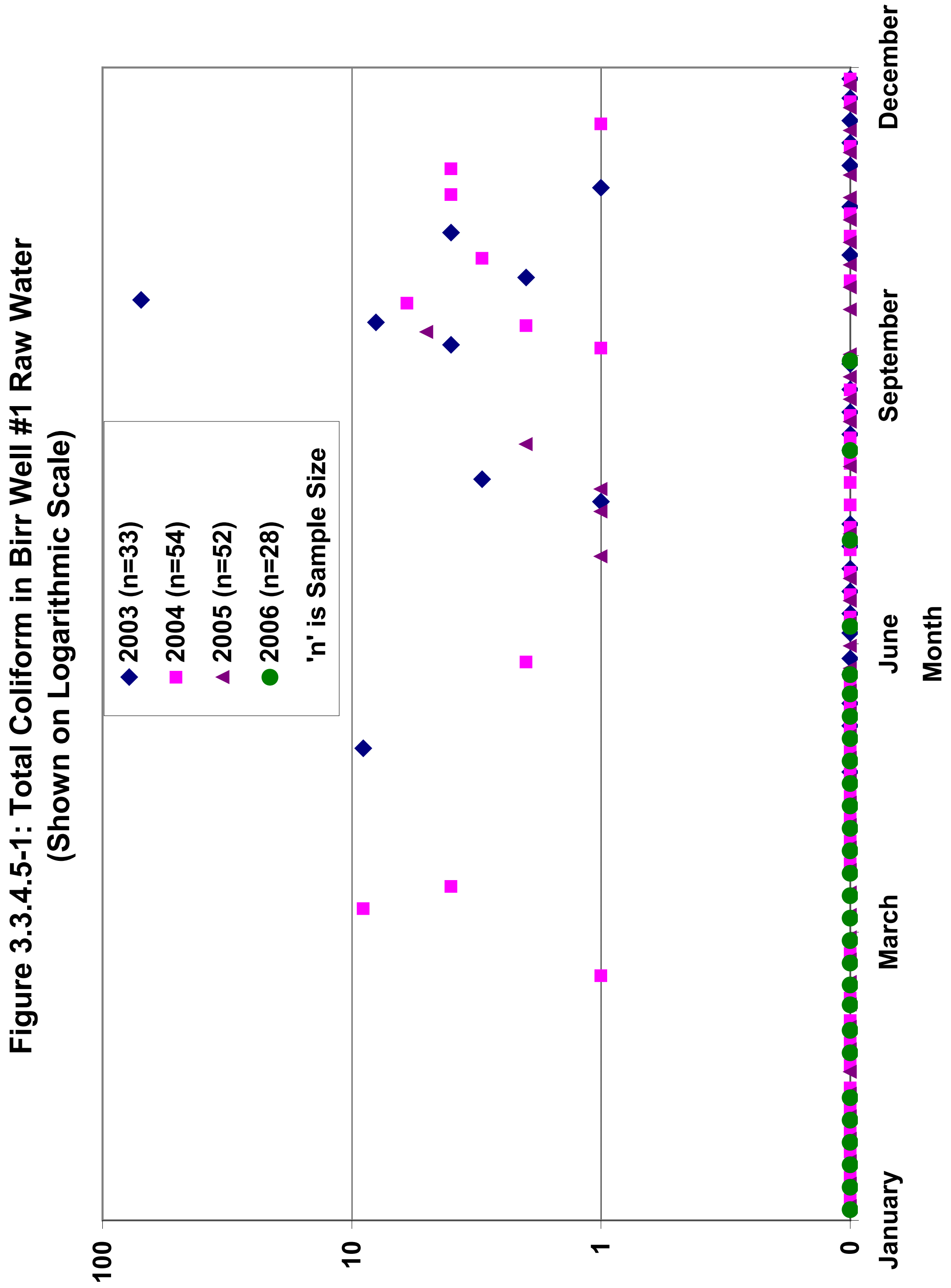

Figure 3.3.4.5-1: **Total Coliform in Birr Well #1 Raw Water**

(2) Dorchester Well Supply

Table 3.3.4.5-2 summarizes the raw water coliform data for the eight wells of the Dorchester supply system. Five of the wells have data from May 2003 to September 2006. Wells 3PW-5 and 3PW-6 are backup wells that have small sample sizes (one to eight per year) and one to two years data only. Another well, 3PW-2B started to operate in late 2006 and only has four samples.

One well, Well #3PW-1 had three instances of *E. coli* in 2006. No other well had *E. coli*.

All eight wells had total coliform detected with a maximum count of 24 per 100 mL in 2003 in Well #3PW-7. Well #2PW-1 had eight instances of total coliform detection in 2003 to 2006. Well #3PW-1 had seven instances of total coliform in three years (2003, 2005 and 2006). Well #3PW-4A had nine instances of total coliform in two years (2003 and 2006). The Wells #3PW-3 and 3PW-7 had one and two instances respectively of total coliform occurrences in 2003 only.

Wells with one or more occurrences of *E. coli* and three or more occurrences of total coliform are graphed as scatter plots.

Figure 3.3.4.5-2 shows total coliform occurrences in Well #2PW-1. Total coliform was detected in June 2003, September 2004, January and February 2005 (maximum of 3 counts per 100 mL) and April 2006.

Figure 3.3.4.5-3 shows the coliform present in Well #3PW-1. There was one instance of *E. coli* in August 2006 (maximum count of 3 per 100 mL) and two in September 2006. The total coliform in 2003, 2005 and 2006 appear to occur in August to December, with a maximum of 5 counts per 100 mL in August 2006.

Figure 3.3.4.5-4 shows the coliform present in Well #3PW-4A. Total coliform in 2003 occurs in December (data starts May 2003). In 2006 total coliform appears to occur in June to September (data is up to September 2006 only) with a maximum of 10 counts per 100 mL in September.

Table 3.3.4.5-2: Summary Data for Dorchester Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
2PW-1	2003	29	0	0	1 (3.4%)	0-1
	2004	39			2 (5%)	0-1
	2005	52			4 (7.7%)	0-3
	2006	39			1 (2.6%)	0-1
3PW-1	2003	32	0	0	2 (6.3%)	0-4
	2004	51	0	0	0	0
	2005	52	0	0	2 (3.8%)	0-2
	2006	39	3 (7.7%)	0-3	3 (7.7%)	0-5
3PW-2A	2003					
	2004	1	0	0	0	0
	2005					
	2006	4	0	0	1 (25%)	0-1
3PW-3	2003	27	0	0	1 (3.7%)	0-8
	2004	52			0	0
	2005	52			0	0
	2006	39			0	0
3PW-4A	2003	39	0	0	1 (2.6%)	0-2
	2004	51			0	0
	2005	52			0	0
	2006	39			8 (20%)	0-10
3PW-5	2003	8	0	0	2 (25%)	0-2
	2004					
	2005					
	2006					
3PW-6	2003	5	0	0	1 (20%)	0-1
	2004	1	0	0	0	0
	2005					
	2006					
3PW-7	2003	30	0	0	2 (6.6%)	0-24
	2004	50			0	0
	2005	51			0	0
	2006	39			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

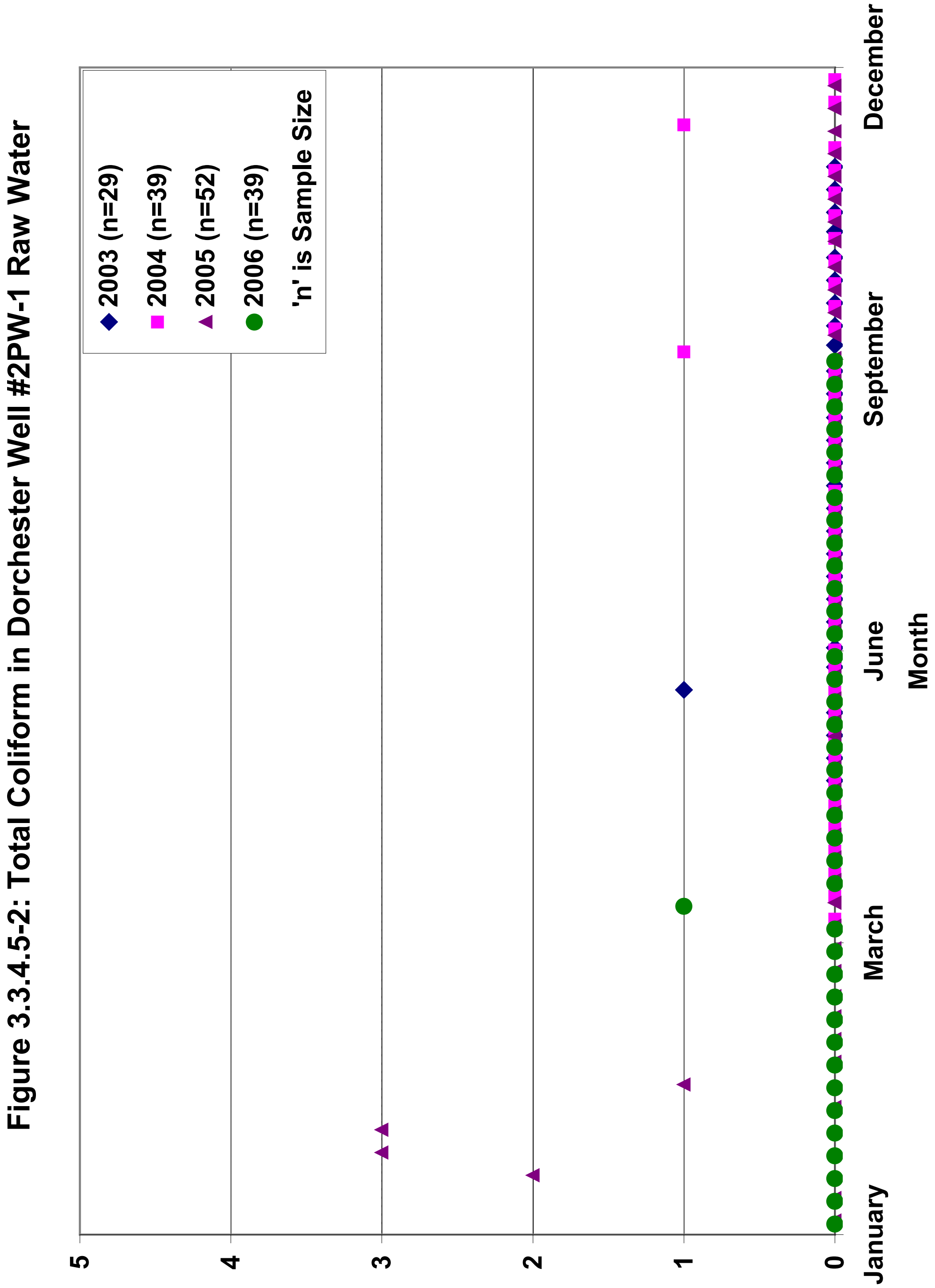

Figure 3.3.4.5-2: **Total Coliform in Dorchester Well #2PW-1 Raw Water**

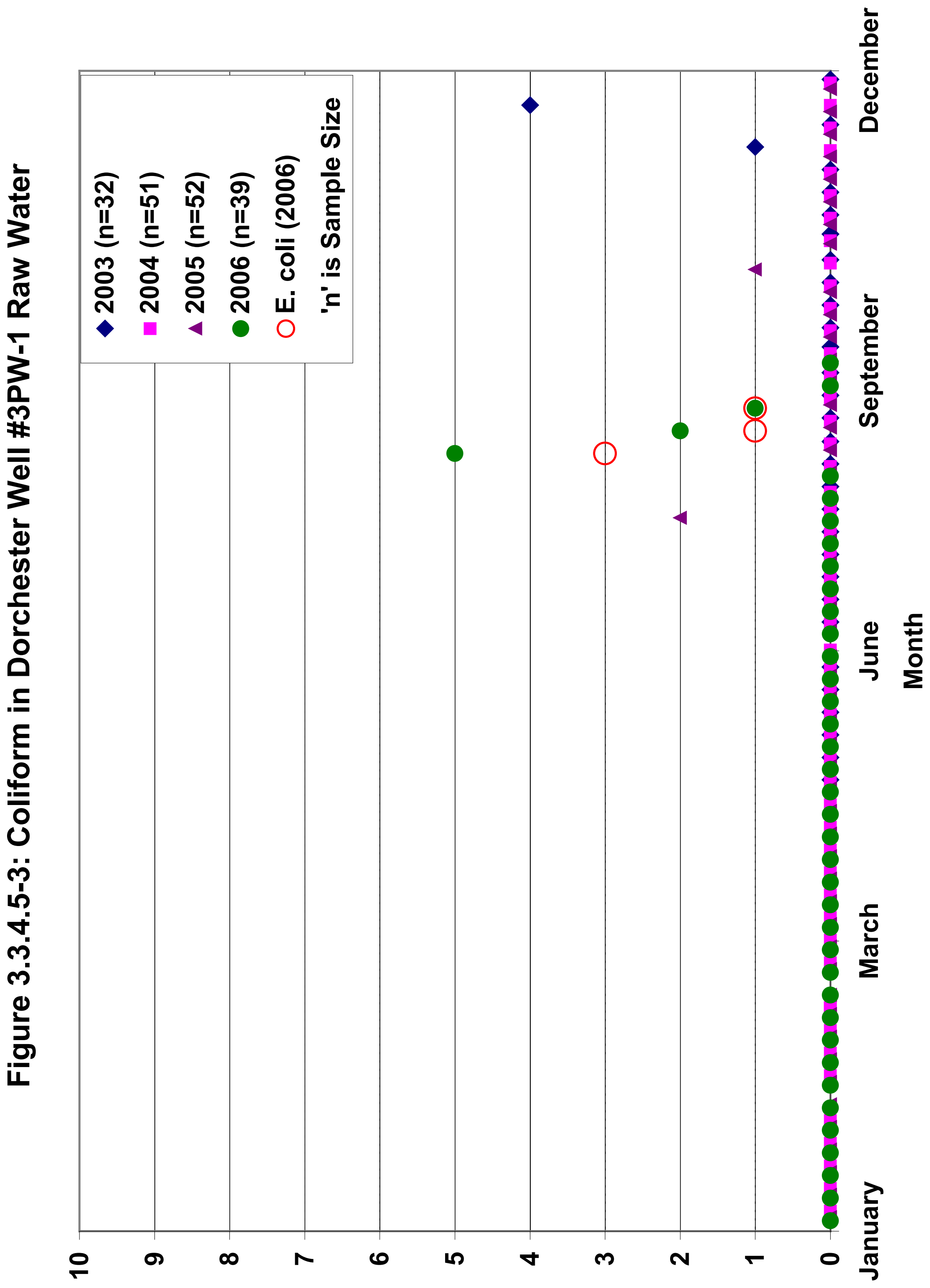

Figure 3.3.4.5-3: Coliform in Dorchester Well #3PW-1 Raw Water

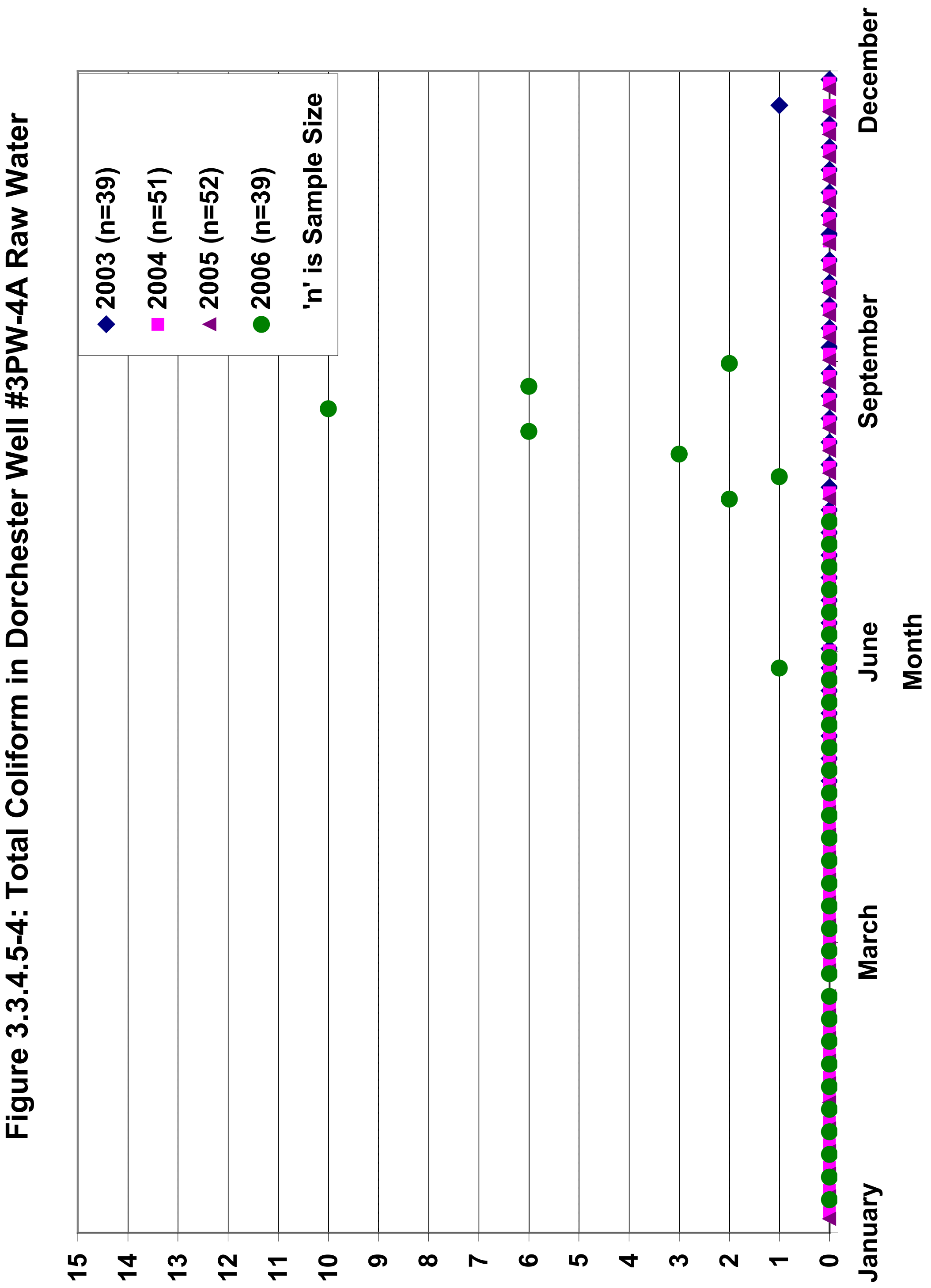

Figure 3.3.4.5-4: Total Coliform in Dorchester Well #3PW-4A Raw Water

(3) Melrose Well Supply

Table 3.3.4.5-3 summarizes the raw water coliform data for the two wells of the Melrose supply system. There was no *E. coli* detected in either well from May 2003 to September 2006 (period of data available). However, both wells had total coliform. Well #2 had two instances each of total coliform in 2003 and 2004. Well #3 had one to five instances of total coliform occurrence in each year (2003 to 2006). Data for both wells is graphed as scatter plots and discussed in detail below.

Figure 3.3.4.5-5 shows the few occurrences of total coliform in Well #2 with a maximum of 5 counts per 100 mL in August 2005. The only other occurrences are in March and August 2004, and in September 2005.

Figure 3.3.4.5-6 shows total coliform detected in Well #3 with a maximum of 630 counts per 100 mL in December 2004. In 2005, most counts occur in the months of January to February. The remaining 2005 total coliform instance as well as those in 2003, 2004 and 2006 occur in the months of September to December.

Table 3.3.4.5-3: Summary Data for Melrose Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#2	2003	33	0	0	0	0
	2004	57			2 (3.5%)	0-2
	2005	52			2 (3.8%)	0-5
	2006	29			0	0
#3	2003	33	0	0	1 (3%)	0-1
	2004	53			2 (3.8%)	0-630
	2005	52			5 (10%)	0-83
	2006	29			1 (3.4%)	0-2

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

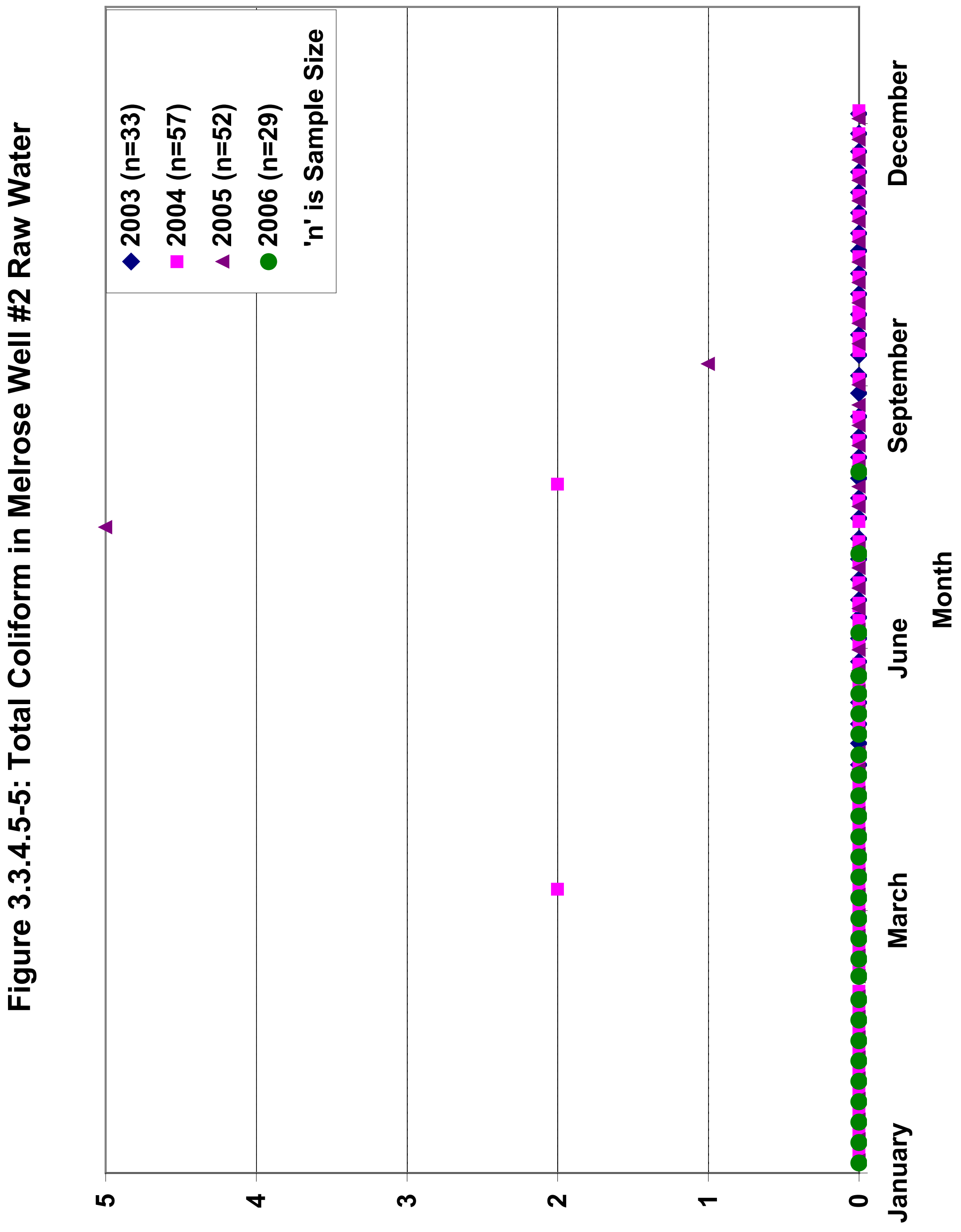

Figure 3.3.4.5-5: Total Coliform in Melrose Well #2 Raw Water

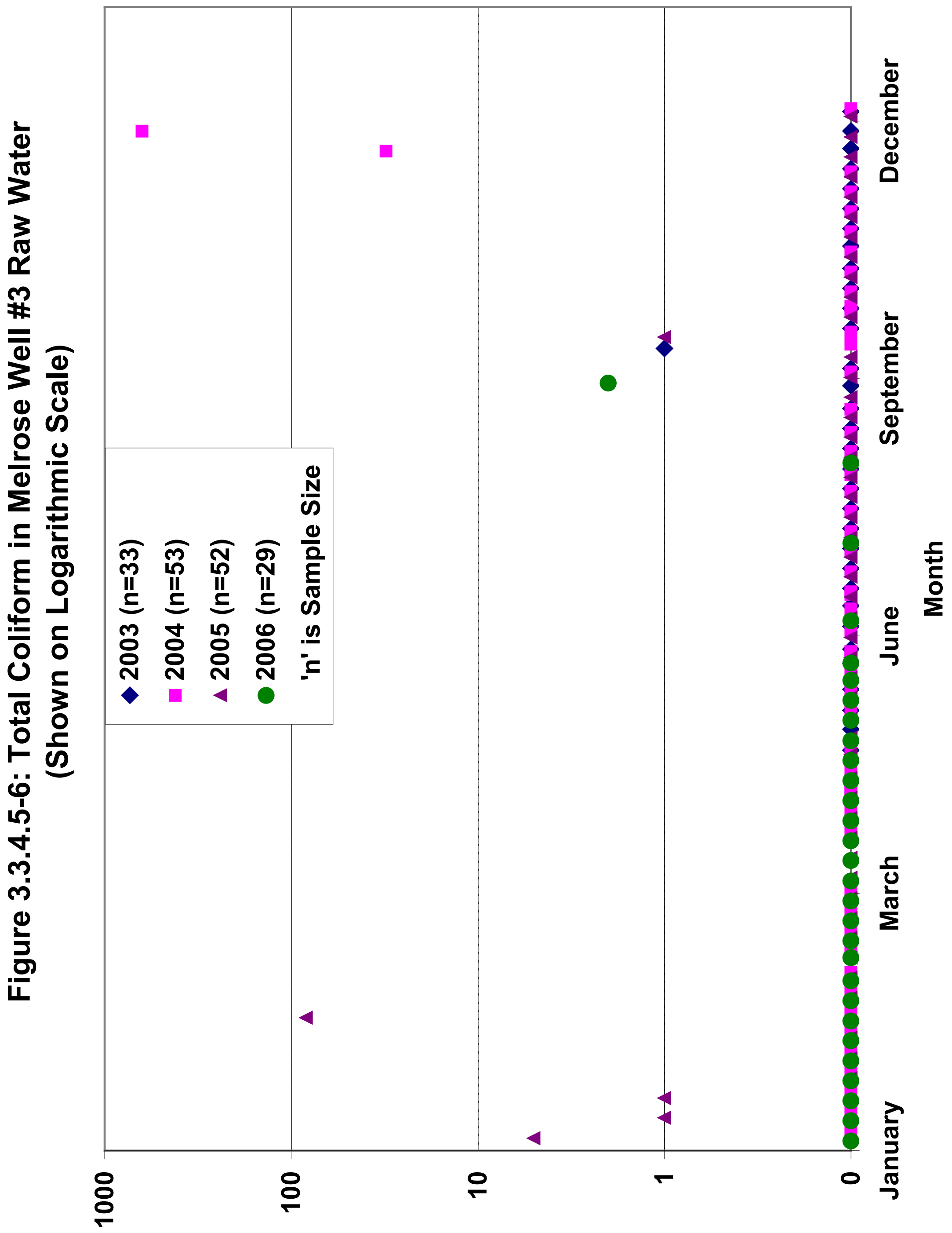

Figure 3.3.4.5-6: **Total Coliform in Melrose Well #3 Raw Water**

(4) Kilworth Heights Subdivision Well Supply

Table 3.3.4.5-4 summarizes the raw water coliform data for the three wells of the Kilworth Heights Subdivision supply system. There was no *E. coli* detected in any of the wells from May 2003 to September 2006 (period of data available with a few months' data gaps for Well #1).

Total coliform was detected in all three wells. Well #1 had one instance of total coliform plate overgrowth in August 2006; in this report, it is considered to be a positive result for total coliform with the count unknown (indeterminable). Well #3 had two instances of total coliform in May and July (maximum count of 17 per 100 mL) 2003 and none thereafter. Well #2 had three instances of total coliform between 2004 and 2005. The data is graphed as a scatter plot and discussed in detail below.

Figure 3.3.4.5-7 shows total coliform in Well #2, with a maximum count of 6 per 100 mL in January 2005 and the remaining two total coliform counts, each of 1 per 100 mL, occurring in December 2004.

Table 3.3.4.5-4: Summary Data for Kilworth Heights Subdivision Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	10	0	0	0	0
	2004	52			0	0
	2005	44			0	0
	2006	4			1*	*
#2	2003	33	0	0	0	0
	2004	54			2 (3.7%)	0-1
	2005	52			1 (2%)	0-6
	2006	38			0	0
#3	2003	33	0	0	2 (6%)	0-17
	2004	54			0	0
	2005	52			0	0
	2006	38			0	0

*NDOG (No Data, Total Coliform plate Overgrowth) on August 31, 2006
Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

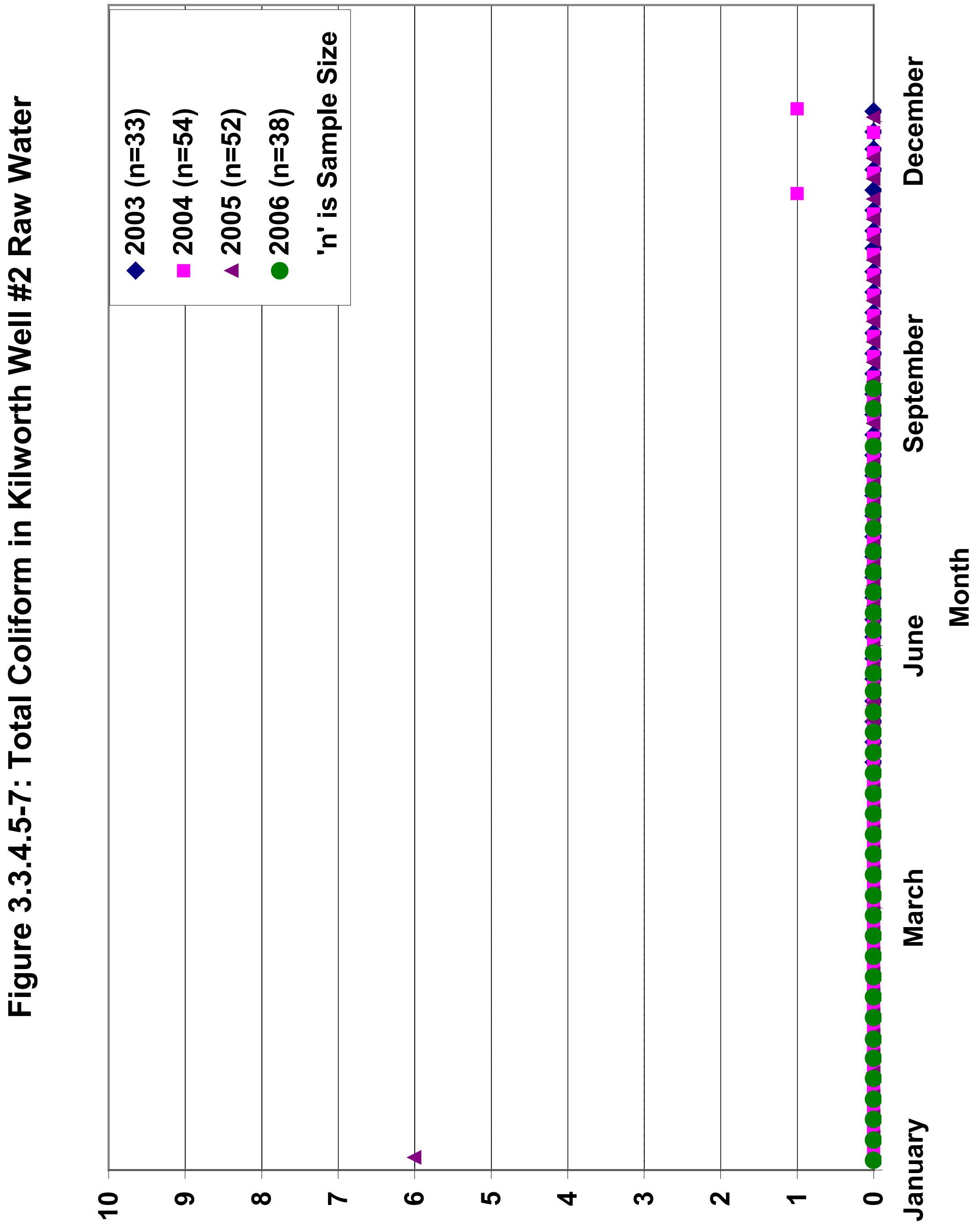

Figure 3.3.4.5-7: **Total Coliform in Kilworth Well #2 Raw Water**

(5) Mount Brydges Well Supply

Table 3.3.4.5-5 summarizes the raw water coliform data for the two wells of the Mount Brydges supply system. There were no total coliform or *E. coli* detected in either well during the period for which data is available (January 2003 to December 2006, with a data gap from January to June 2004).

Table 3.3.4.5-5: Summary Data for Mount Brydges Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	52	0	0	0	0
	2004	27				
	2005	52				
	2006	53				
#2	2003	52	0	0	0	0
	2004	27				
	2005	52				
	2006	53				

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(6) Thorndale Well Supply

Table 3.3.4.5-6 summarizes the raw water coliform data for the two wells of the Thorndale supply system (data available for May 2003 to September 2006). River Well #2 had one occurrence of *E. coli* in 2005 and one occurrence of total coliform in 2004. River Well #1 had three occurrences of total coliform in 2004 and one in 2005. Data for both wells is graphed as scatter plots and discussed in detail below.

Figure 3.3.4.5-8 shows the total coliform in River Well #1, with a maximum count of 6 per 100 mL in May 2004. The other instances in 2004 and 2005 occur between January and March.

Figure 3.3.4.5-9 shows the coliform in River Well #2, with an *E. coli* count of 1 per 100 mL, detected in January 2005. Total coliform counts of 1 per 100 mL each were detected in May 2004 and January 2005.

Table 3.3.4.5-6: Summary Data for Thorndale Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
River Well #1	2003	32	0	0	0	0
	2004	48			3 (6.3%)	0-6
	2005	52			1 (2%)	0-1
	2006	39			0	0
River Well #2	2003	33	0	0	0	0
	2004	47	0	0	1 (2.1%)	0-1
	2005	52	1	1	1 (2%)	0-1
	2006	39	0	0	0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

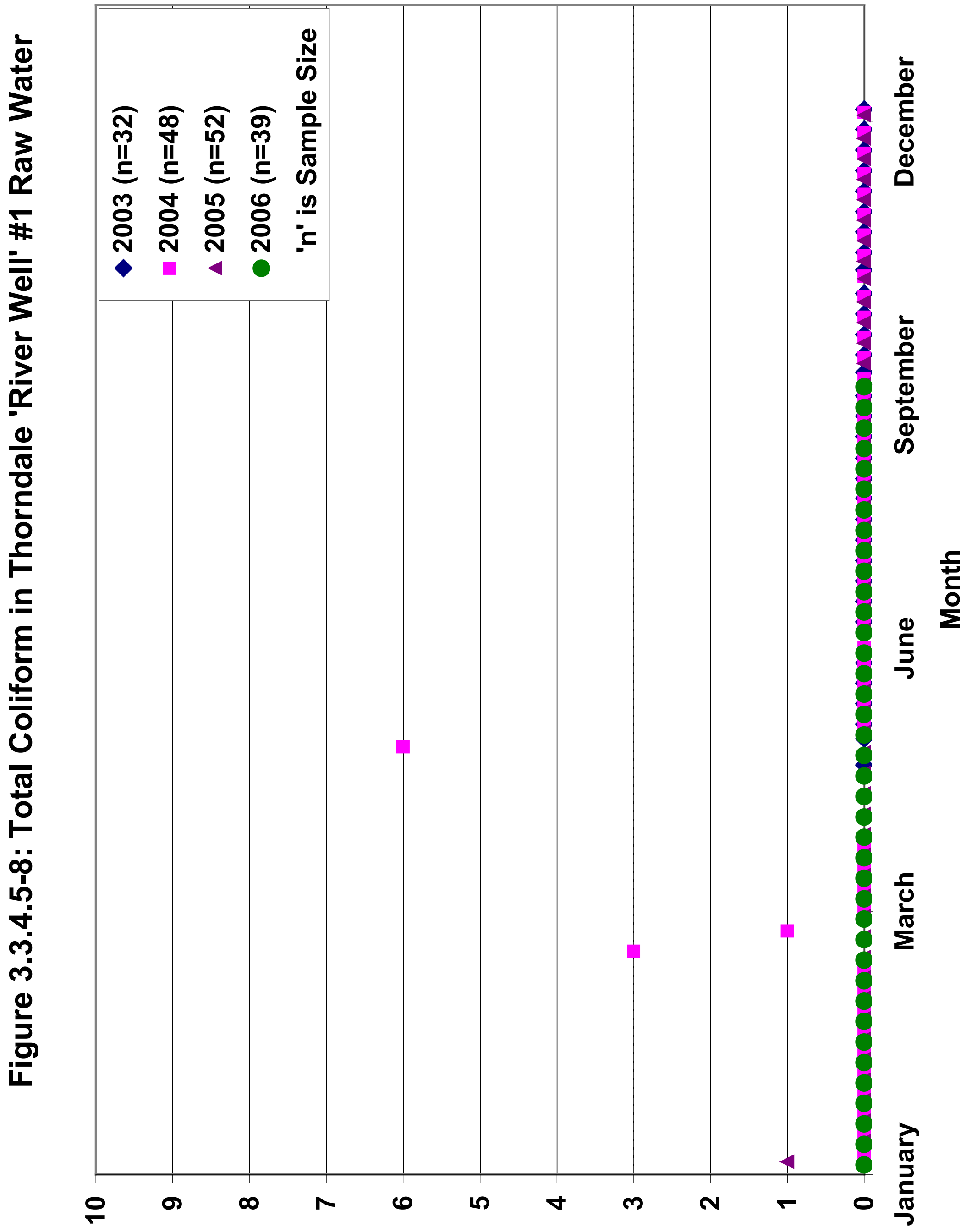

Figure 3.3.4.5-8: **Total Coliform in Thorndale 'River Well' #1 Raw Water**

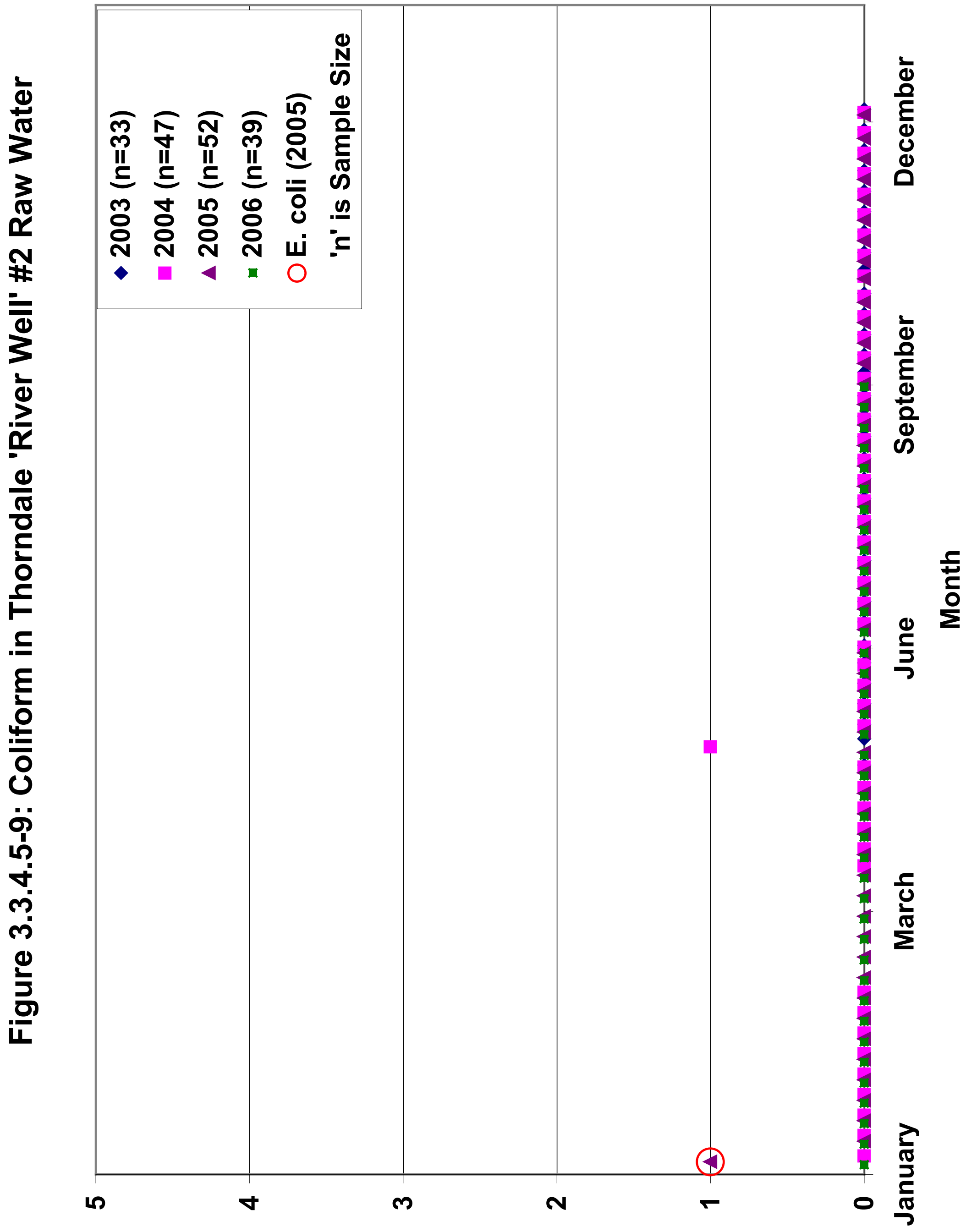

Figure 3.3.4.5-9: **Coliform in Thorndale ‘River Well’ #2 Raw Water**

(7) City of London Back Up Wells

Table 3.3.4.5-7 summarizes the raw water coliform data for the seven City of London back up wells: Hyde Park and Fanshawe Wells #1 to 6. Sample sizes are small and range from two to four per year for data from June 2003 to September 2006. One well (Fanshawe Well #5) tested positive for *E. coli* in 2005. The data is graphed as a scatter plot and discussed below. No other wells had *E. coli*. No coliform were detected at Fanshawe Wells #1, 3 and 4. Four wells (Hyde Park, and Fanshawe Wells #2, 5 and 6) tested positive for total coliform at least once during the period of 2003 to 2006.

Figure 3.3.4.5-10 shows the total coliform and *E. coli* counts of Fanshawe Well #5. The *E. coli* occurred in September 2006 with one instance of a count of 1 per 100 mL. Total coliform was detected in December 2004 (maximum count of 3 per 100 mL), and in June and September 2006.

Table 3.3.4.5-7: Summary Data for City of London Standby Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Hyde Park	2003	3	0	0	1 (33.3%)	0-1
	2004	2			0	0
	2005	3			0	0
	2006	3			1 (33.3%)	0-1
Fanshawe Well #1	2003	3	0	0	0	0
	2004	2				
	2005	4				
	2006	3				
Fanshawe Well #2	2003	3	0	0	0	0
	2004	2			0	0
	2005	4			0	0
	2006	3			1 (33.3%)	0-1
Fanshawe Well #3	2003	3	0	0	0	0
	2004	2				
	2005	4				
	2006	3				
Fanshawe Well #4	2003	3	0	0	0	0
	2004	2				
	2005	4				
	2006	3				
Fanshawe Well #5	2003	3	0	0	0	0
	2004	2	0	0	1	0-3
	2005	4	0	0	0	0
	2006	3	1 (33%)	0-1	2 (67%)	0-2
Fanshawe Well #6	2003	3	0	0	0	0
	2004	2			0	0
	2005	4			1 (25%)	0-1
	2006	3			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

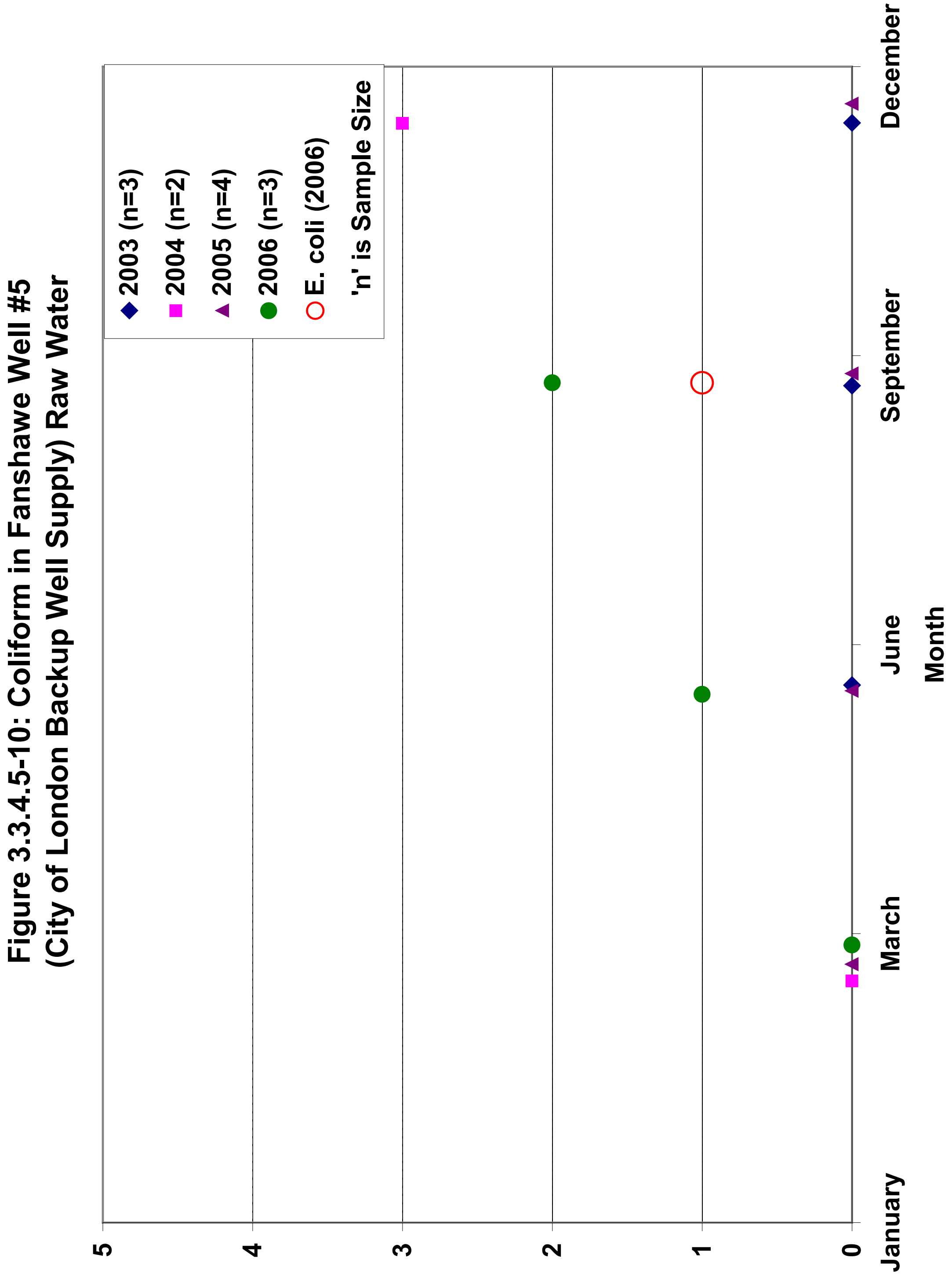

Figure 3.3.4.5-10: **Coliform in Fanshawe Well #5 (City of London Backup Well Supply) Raw Water**

(B) Municipal Groundwater Well Supply Systems in Oxford County

There are 10 well supply systems servicing populations within the Thames Watershed at Beachville-Loweville Subdivision, Embro, Hickson-King Subdivision, Ingersoll, Innerkip, Lakeside, Mount Elgin, Tavistock, Thamesford and Woodstock in the County of Oxford.

(1) Beachville-Loweville Subdivision Well Supply

Table 3.3.4.5-8 summarizes the raw (untreated) water coliform data for the one well, Well #1, of the Beachville-Loweville Subdivision supply system. There was no *E. coli* detected in the well from May 2003 to September 2006 (period of data provided to us). However, nine instances of total coliform detection occurred in 2003 and one in 2004. There were none in 2005 and 2006 (note: small sample size of 10 only in 2006). The data is graphed as a scatter plot and discussed below.

Figure 3.3.4.5-11 shows the total coliform in Well #1, with a maximum count of 15 per 100 mL in July 2003. The other instances in 2003 and 2004 occur between June and December.

Table 3.3.4.5-8: Summary Data for Beachville-Loweville Subdivision Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	33	0	0	9 (27%)	0-15
	2004	46			1 (2%)	0-1
	2005	51			0	0
	2006	10			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

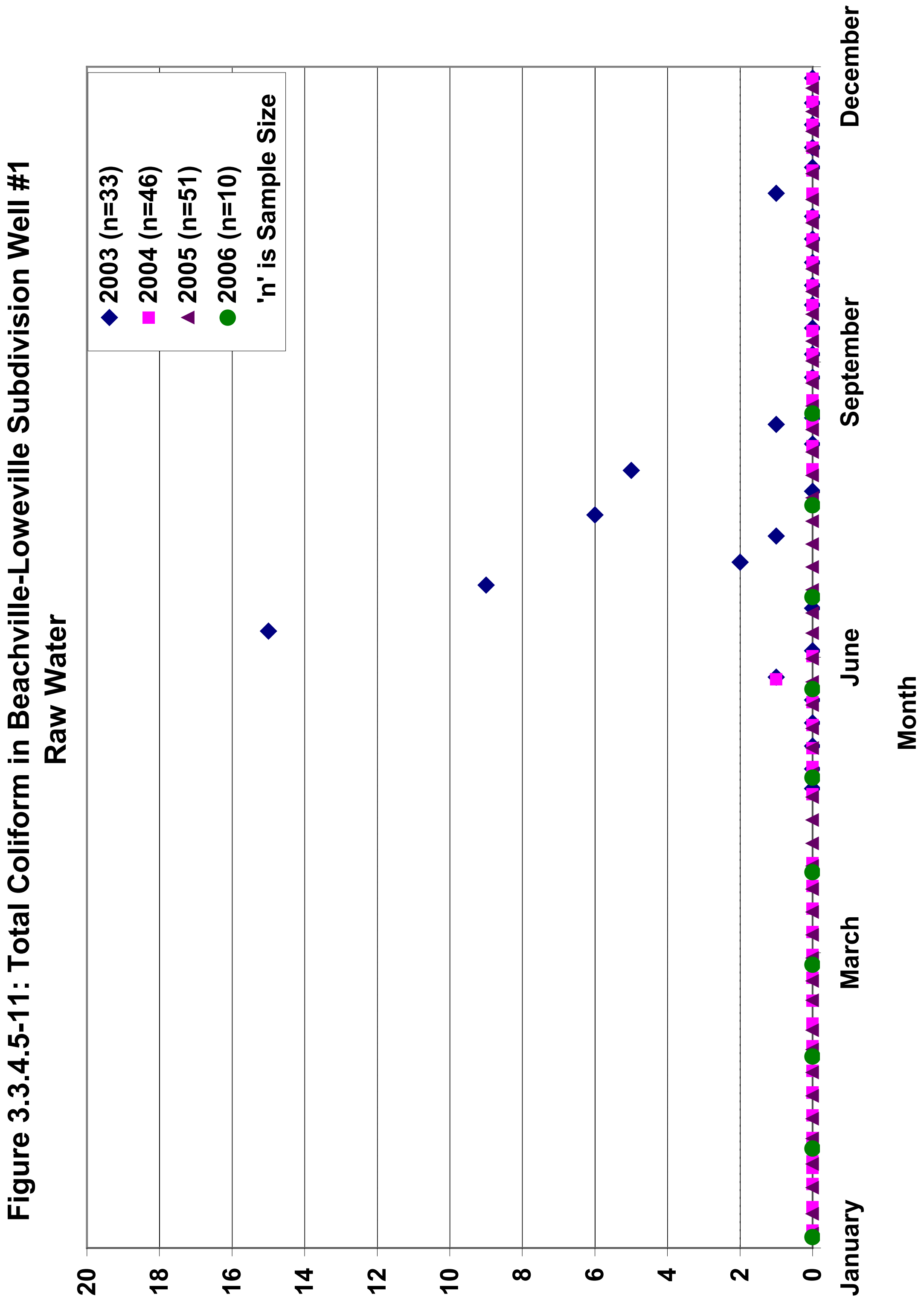

Figure 3.3.4.5-11: **Total Coliform in Beachville-Loweville Subdivision Well #1 Raw Water**

(2) Embro Well Supply

Of the three Embro wells, only two (Well #1 and 3) are source supply wells while Well #2 has been a monitoring well since 1998. For Wells #1 and 3, DWIS data provided to us was for the period of May 2003 to September 2006. For the monitoring Well #2, sample sizes are small (three to four per year) and DWIS data is available for the years 2003 and 2004.

Table 3.3.4.5-9 summarizes the raw water coliform data for the Embro Wells #1 and 3. There was no *E. coli* detected in either well. However, total coliform was detected in both wells. In Well #1, there were 15 occurrences of total coliform in 2003, 2004 and 2006 but none in 2005. In Well #3, there were 29 occurrences of total coliform in 2003 to 2005 but no detects in 2006. The data sets for Well #1 and Well #3 are graphed as scatter plots and discussed in detail below.

Figure 3.3.4.5-12 shows the total coliform in Well #1, with a maximum count of 15 per 100 mL in July 2004. The other instances in 2003, 2004 and 2006 occur between the months of May and November.

Figure 3.3.4.5-13 shows the total coliform in Well #3, with a maximum count of 530 counts/100 mL in June 2004. The other occurrences were mostly in June to November (2003 to 2005) with a few in February 2005.

Table 3.3.4.5-9: Summary Data for Embro Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	33	0	0	8 (24%)	0-12
	2004	51			6 (11%)	0-15
	2005	52			0	0
	2006	33			1 (3%)	0-1
#3	2003	30	0	0	14 (47%)	0-260
	2004	47			9 (19%)	0-530
	2005	52			6 (11.5%)	0-13
	2006	33			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

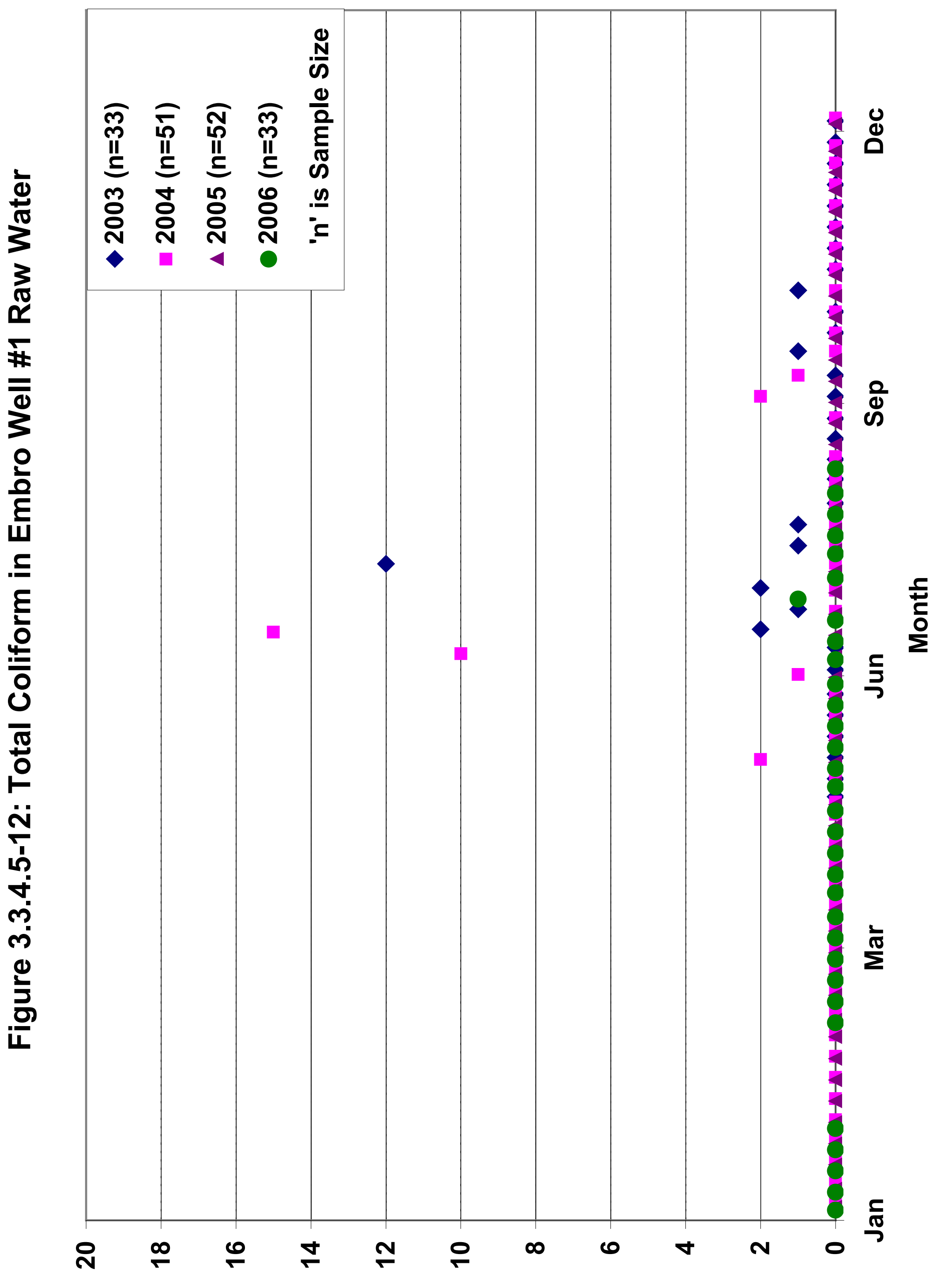

Figure 3.3.4.5-12: **Total Coliform in Embro Well #1 Raw Water**

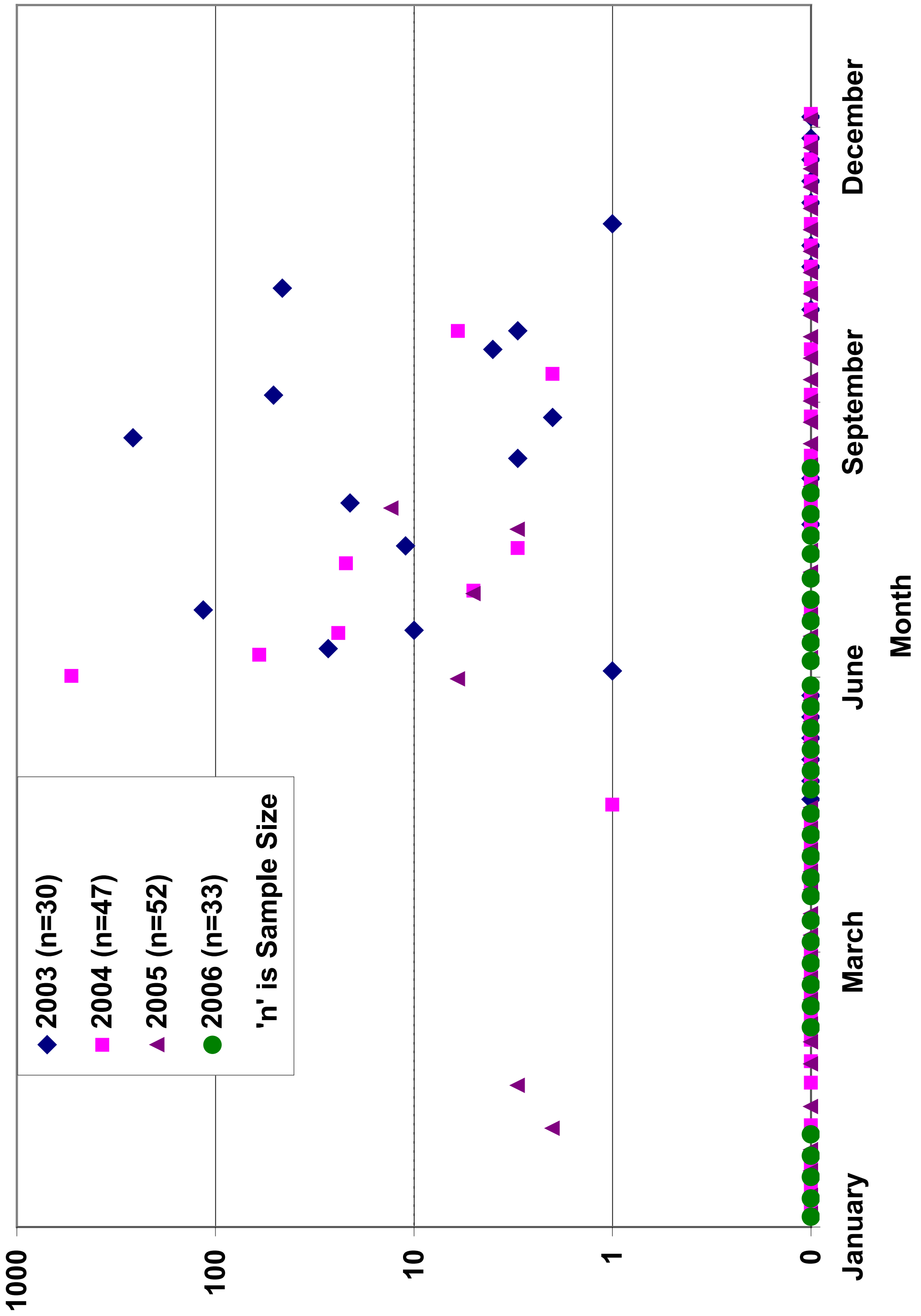

Figure 3.3.4.5-13: Total Coliform in Embro Well #3 Raw Water
(Shown on Logarithmic Scale)

Figure 3.3.4.5-13: **Total Coliform in Embro Well #3 Raw Water**

(3) Hickson-King Subdivision Well Supply

Well #2 is the only well used as drinking water source in the Hickson-King Subdivision well supply. Raw water data from May 2003 to September 2006 is available.

Table 3.3.4.5-10 summarizes the raw water coliform data for the Hickson-King Subdivision Well #2. There was no *E. coli* detected. Total coliform was detected in 2003 to 2005. No total coliform was detected in 2006 but the sample size in 2006 is small (n=10). Data is graphed as a scatter plot and discussed below.

Figure 3.3.4.5-14 shows the total coliform occurrences in Well #2, with most detects in the months of July to December and a maximum of 183 counts per 100 mL in September 2005.

Table 3.3.4.5-10: Summary Data for Hickson-King Subdivision Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
2	2003	33	0	0	1 (3%)	0-1
	2004	51	0	0	9 (17%)	0-24
	2005	51	0	0	7 (13.7%)	0-183
	2006	10	0	0	0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

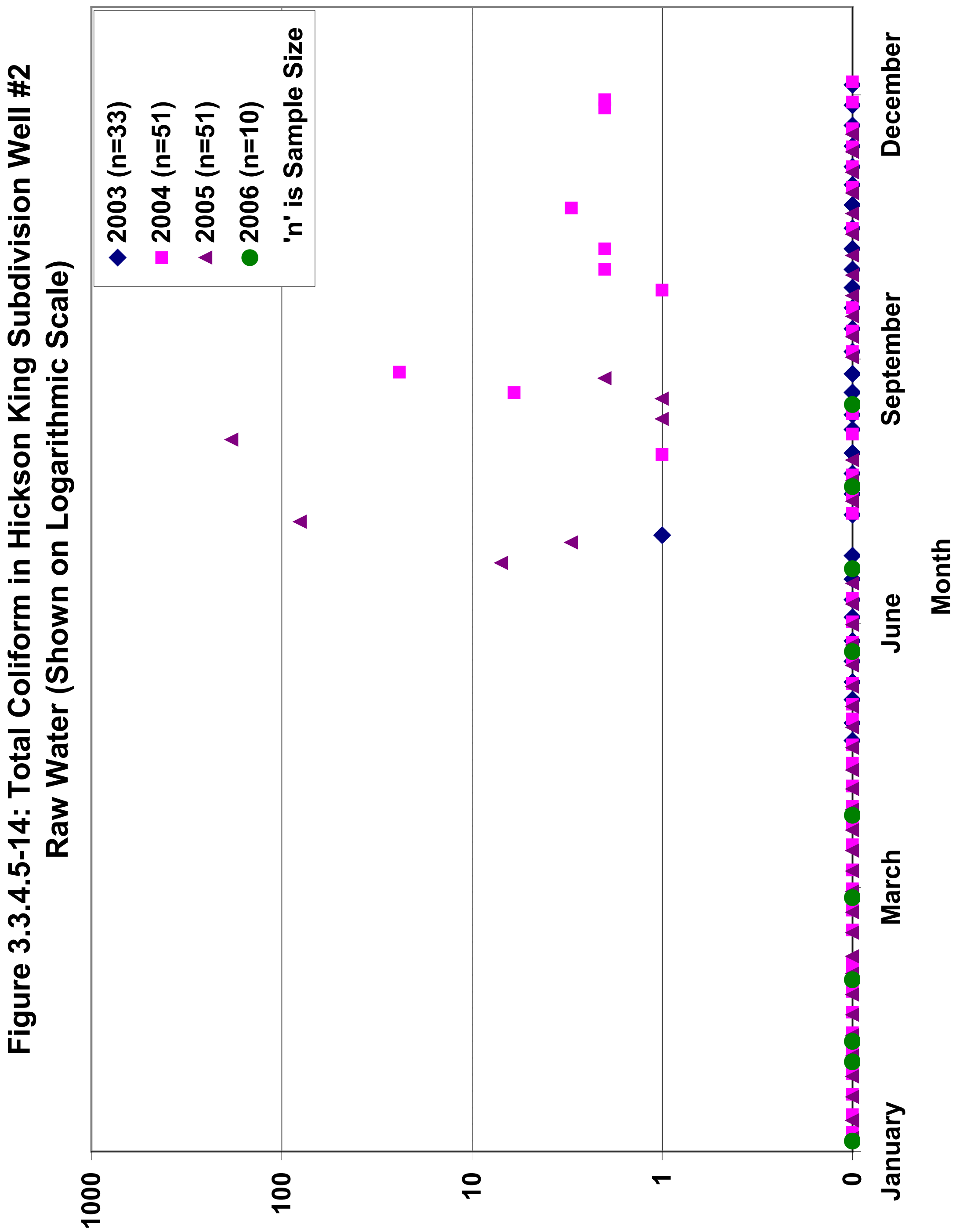

Figure 3.3.4.5-14: Total Coliform in Hickson-King Subdivision Well #2 Raw Water

(4) Ingersoll Well Supply

There are seven individual wells in the Ingersoll well supply system. Well #11 has not been in use since 2000 and does not have any coliform data. Well #7 has not been used regularly since May 2004 and does not have data for 2005 and 2006. For the five active wells, data provided to us is for the period of May 2003 to September 2006. Wells are not tested when they are offline for maintenance and, hence, there may be data gaps.

Table 3.3.4.5-11 summarizes the raw water coliform data for the Ingersoll wells. There was no *E. coli* detected in any of the six wells with DWIS data. No coliform was detected in Wells #2, 3 and 7. However, total coliform was detected in the three other wells. Well #5 has one instance of total coliform (1 count per 100 mL) in May 2006 only. Well #8 has three instances between 2004 and 2005, and Well #10 has three instances in 2004 only. Wells with three or more occurrences of total coliform are graphed as scatter plots.

Figure 3.3.4.5-15 shows the total coliform occurrences in Well #8. The total coliform was detected in June and July 2004 and July 2005 (maximum of 6 counts per 100 mL).

Figure 3.3.4.5-16 shows the total coliform occurrences in Well #10. The total coliform was detected in January (maximum of 2 counts per 100 mL), May and July 2004.

Table 3.3.4.5-11: Summary Data for Ingersoll Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#2	2003	30	0	0	0	0
	2004	49				
	2005	53				
	2006	37				
#3	2003	27	0	0	0	0
	2004	14				
	2005	38				
	2006	35				
#5	2003	35	0	0	0	0
	2004	47			0	0
	2005	51			0	0
	2006	37			1 (2.7%)	0-1
#7	2003	31	0	0	0	0
	2004	23	0	0	0	0
	2005					
	2006					
#8	2003	26	0	0	0	0
	2004	24			2 (8.3%)	0-2
	2005	49			1 (2%)	0-6
	2006	37			0	0
#10	2003	33	0	0	0	0
	2004	46			3 (6.5%)	0-2
	2005	52			0	0
	2006	37			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

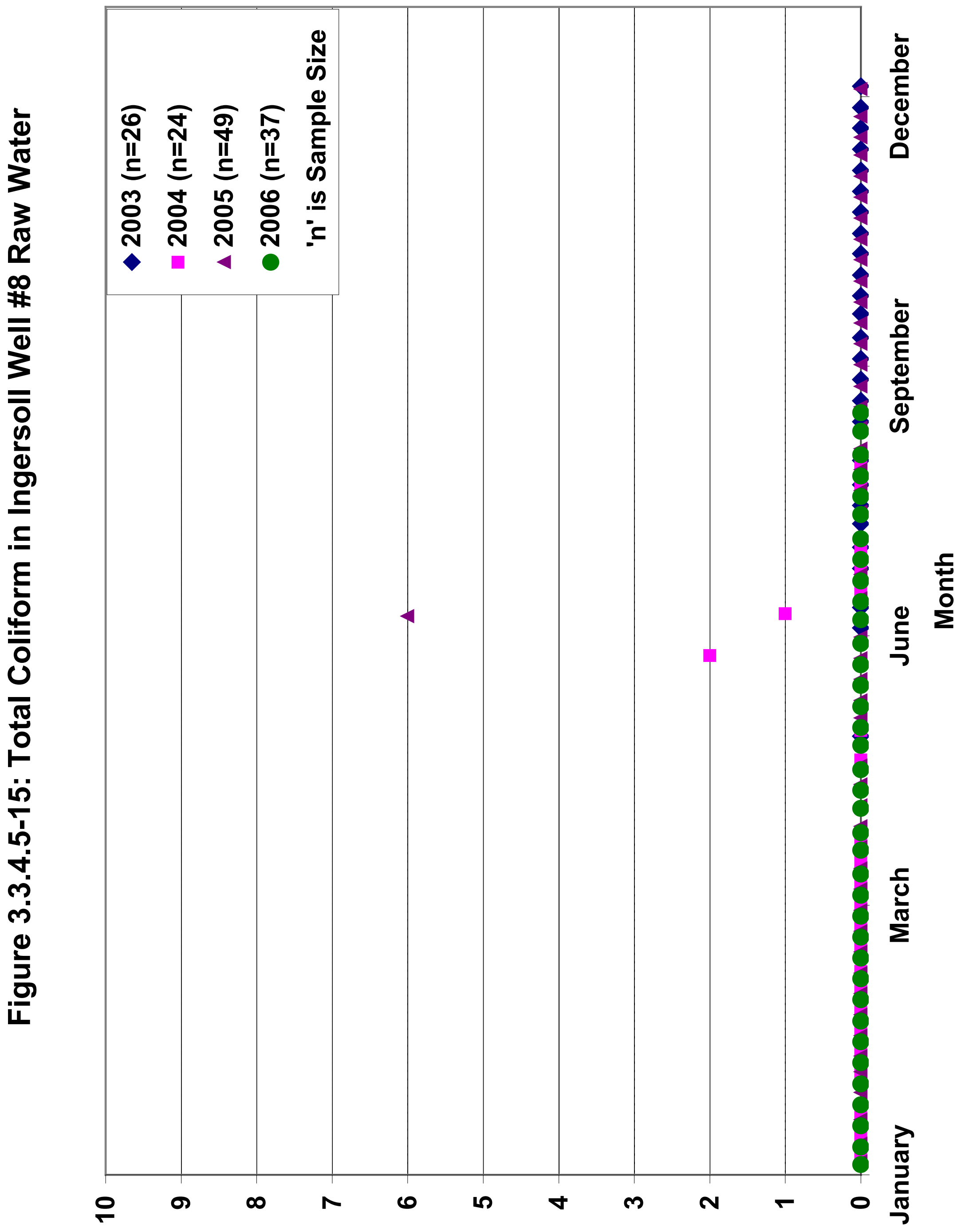

Figure 3.3.4.5-15: **Total Coliform in Ingersoll Well #8 Raw Water**

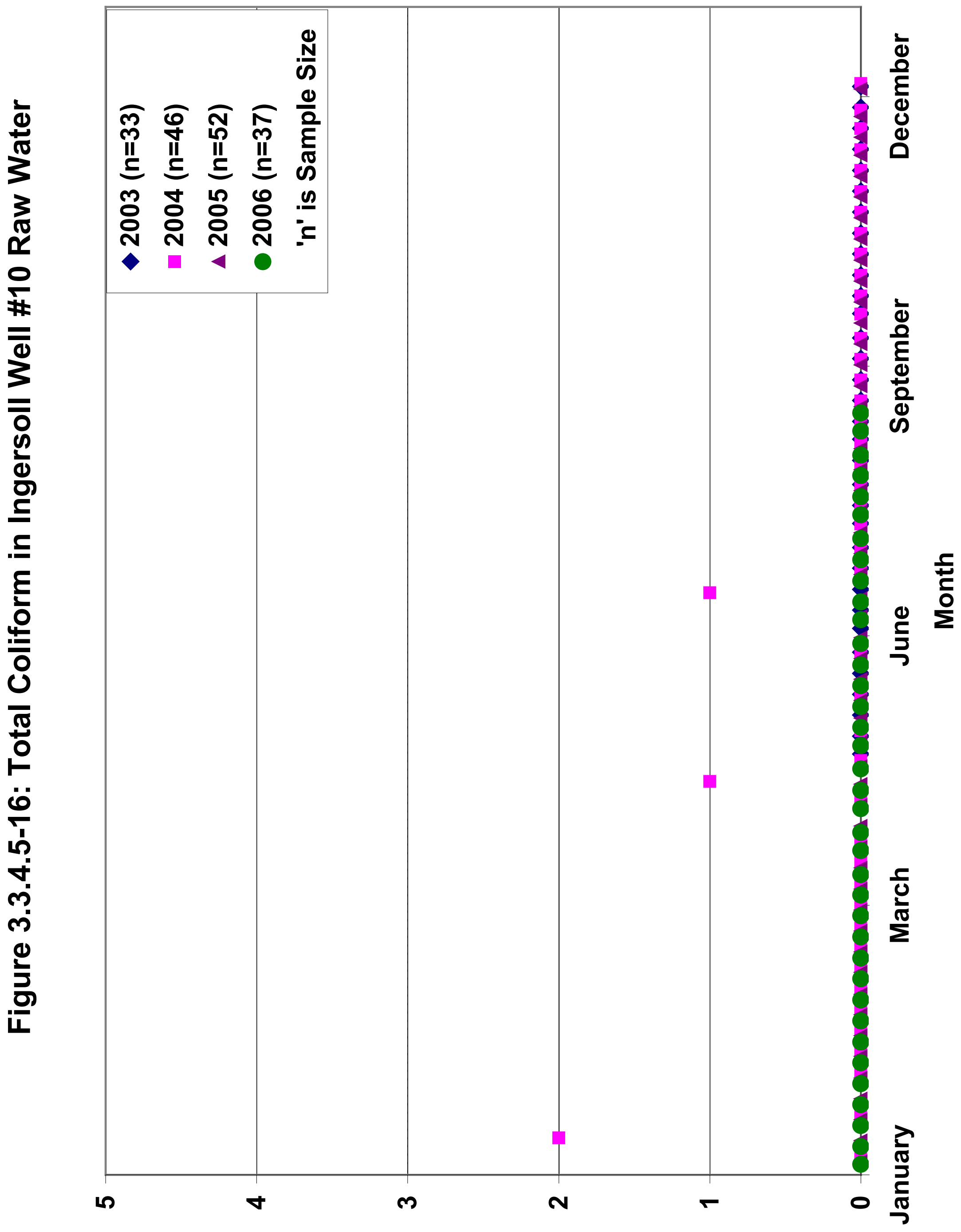

Figure 3.3.4.5-16: **Total Coliform in Ingersoll Well #10 Raw Water**

(5) Innerkip Well Supply

The two wells of the Innerkip well supply system were started in December 2004. DWIS data is available from March 2005 to September 2006.

Table 3.3.4.5-12 summarizes the raw water coliform data for the Innerkip wells. There was no *E. coli* detected in either well. Total coliform was not detected in Well #1 but was present in Well #2 for a total of eight times in 2005 to 2006. The data for Well #2 is graphed as a scatter plot and discussed below.

Figure 3.3.4.5-17 shows the total coliform occurrences in Well #2. The total coliform was detected between June (maximum of 18 counts per 100 mL) and November 2005, as well as in January and April of 2006.

Table 3.3.4.5-12: Summary Data for Innerkip Wells (In use since Dec. 2004)

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003					
	2004					
	2005	43	0	0	0	0
	2006	37	0	0	0	0
#2	2003					
	2004					
	2005	41	0	0	6 (14.6%)	0-18
	2006	37	0	0	2 (16%)	0-2

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

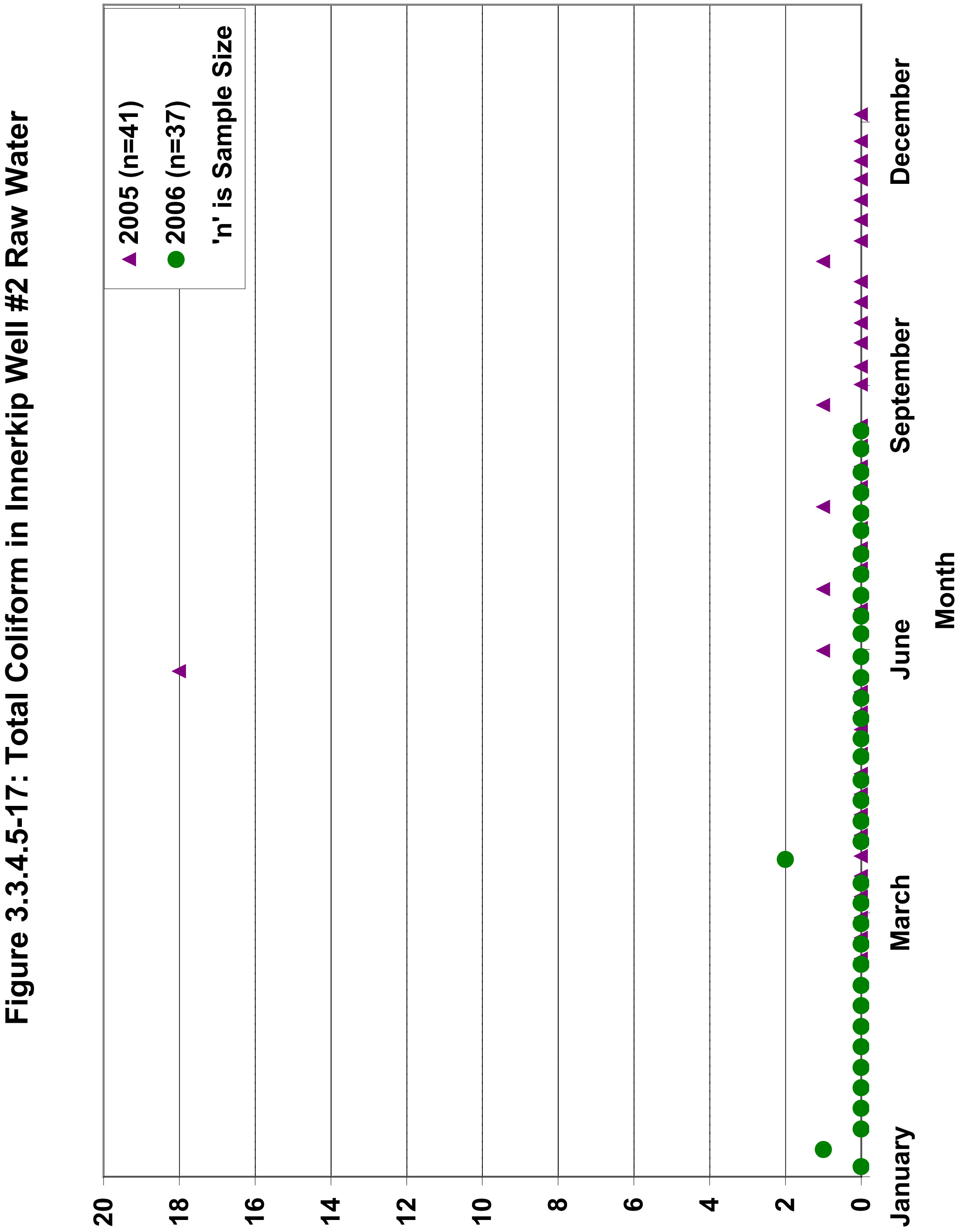

Figure 3.3.4.5-17: **Total Coliform in Innerkip Well #2 Raw Water**

(6) Lakeside Well Supply

The Lakeside well supply system is currently comprised of one well, Well #2-00, with DWIS data from April 2004 to September 2006 available.

Table 3.3.4.5-13 summarizes the raw water coliform data for the Lakeside well #2-00. There was no *E. coli* detected. However, total coliform was detected, with a total of five occurrences in 2004 and 2005. No coliform was detected in 2006. The total coliform occurrence is graphed as scatter plots and shown in **Figure 3.3.4.5-18**. The total coliform was detected in 2004 and 2005, between the months of May and August, with a maximum of 107 counts per 100 mL in July 2005.

Table 3.3.4.5-13: Summary Data for Lakeside Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#2-00	2003					
	2004	26	0	0	1 (3.8%)	0-1
	2005	52*	0	0	4 (7.7%)	0-107
	2006	37	0	0	0	0

*NDMT (No Data, Missing in Transit) on April 5, 2005
Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

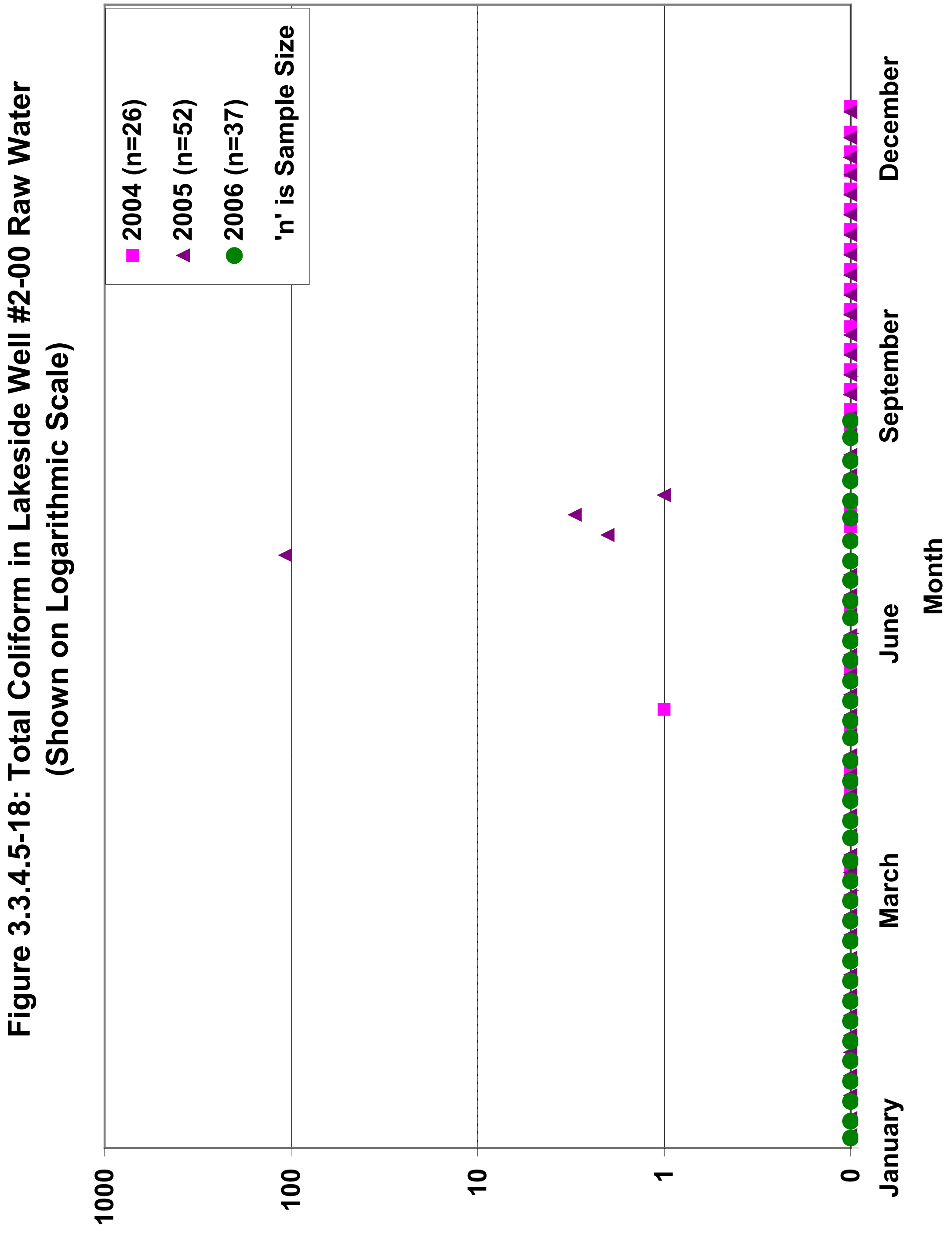

Figure 3.3.4.5-18: **Total Coliform in Lakeside Well #2-00 Raw Water**

(7) Mount Elgin Well Supply

The Mount Elgin supply system is comprised of one well, Well #3. The coliform data is available from January 2003 to December 2006.

Table 3.3.4.5-14 summarizes the raw water coliform data for the Mount Elgin well. There was no *E. coli* detected in the well. One instance of total coliform of 1 count per 100 mL occurred in May 2003.

Table 3.3.4.5-14: Summary Data for Mount Elgin Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
3	2003	54	0	0	1 (2%)	0-1
	2004	53			0	0
	2005	52			0	0
	2006	52			0	0

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(8) Tavistock Well Supply

Table 3.3.4.5-15 summarizes the raw water coliform data for the three wells of the Tavistock well supply. Data is available for May 2003 to September 2006. No *E. coli* was detected in any of the three wells. There was no coliform detected in Well #1. Total coliform was detected in Well #W-2A and Well #3. In Well #3, there were two instances of total coliform detected in November 2004 (maximum of 2 counts per 100 mL) but none in 2003, 2005 and 2006. In Well #W-2A, there were 11 occurrences of total coliform in 2003 to 2005, but none in 2006. The data for Well # W-2A is graphed as a scatter plot and discussed below.

Figure 3.3.4.5-19 shows the total coliform occurrences in Well #W-2A. The total coliform counts appear to occur in the months of June to September with a maximum of 24 counts per 100 mL reported in June 2004. In 2003, total coliform was detected in August and September. In 2004, total coliform occurred in June, July and August. In 2005, coliform was detected in September.

Table 3.3.4.5-15: Summary Data for Tavistock Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#W-1	2003	33	0	0	0	0
	2004	53				
	2005	52				
	2006	37				
#W-2A	2003	33	0	0	2 (6%)	0-1
	2004	53			8 (15%)	0-24
	2005	51			1 (2%)	0-1
	2006	37			0	0
#3	2003	33	0	0	0	0
	2004	53			2 (3.8%)	0-2
	2005	46			0	0
	2006	37			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

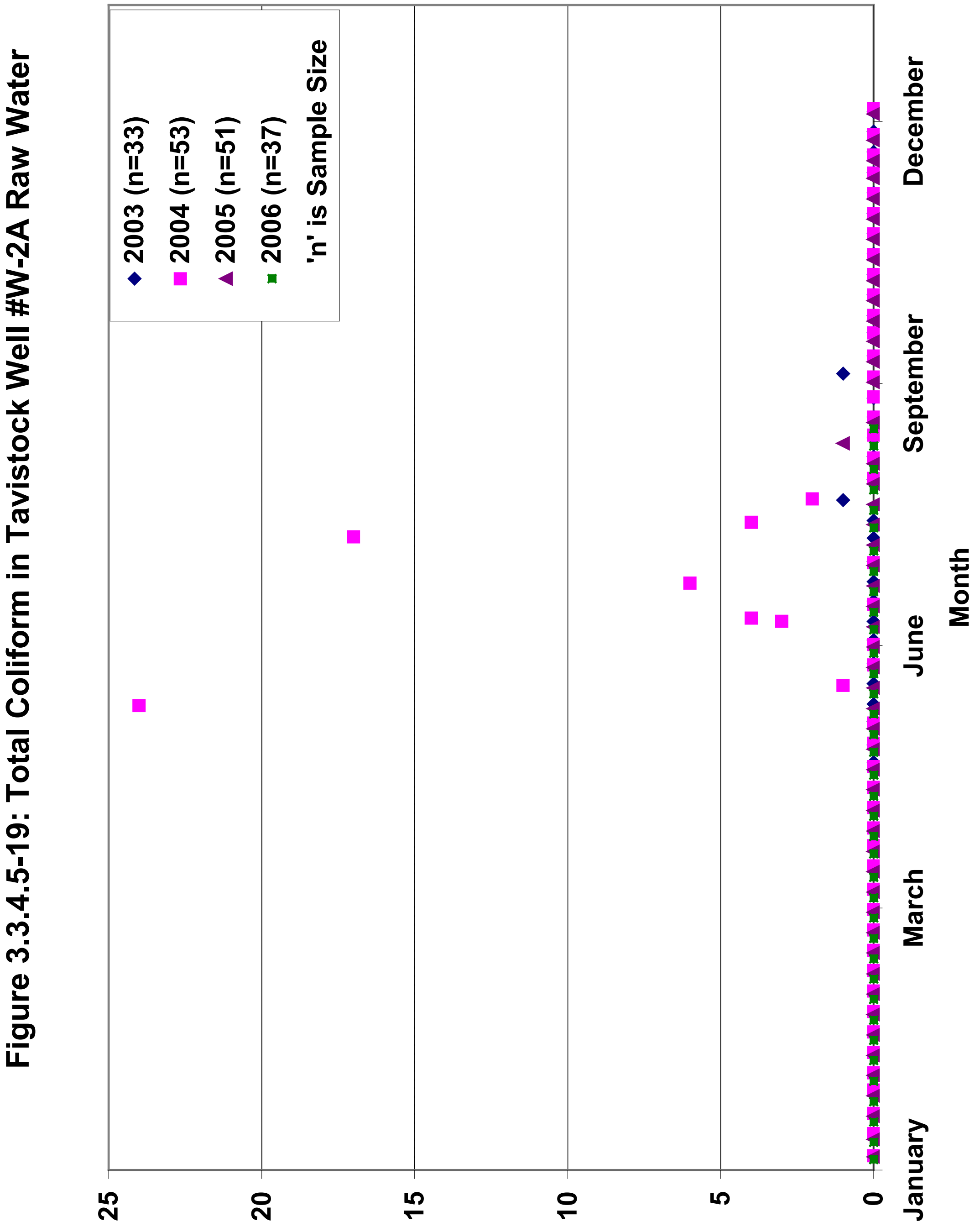

Figure 3.3.4.5-19: **Total Coliform in Tavistock Well #W-2A Raw Water**

(9) Thamesford Well Supply

In the DWIS database, data is available for three Thamesford wells. For the River Well #1 and Stanley Street Well #3, data is available from May 2003 to September 2006. The River Well #2 has not been used since before 1997 but coliform data is available from 10 samples taken between 2003 and 2005.

Table 3.3.4.5-16 summarizes the raw water coliform data for the Thamesford wells. No *E. coli* was detected in the three wells. Total coliform was detected in all three wells. River Well #1 had 17 occurrences of total coliform from 2003 to 2006 of which there was only one in 2006. Stanley Street Well #3 had eight occurrences of total coliform from 2003 to 2005 with none in 2006. The data sets for these wells are graphed as scatter plots and discussed below. From 2003 to 2005, River Well #2 had only one total coliform detection in August 2004 but sample sizes are small for this well.

Figure 3.3.4.5-20 shows the total coliform in River Well #1. Most occurrences in 2003 to 2005 are spread between the months of June and December with a maximum of 2 counts per 100 mL in September 2003.

Figure 3.3.4.5-21 shows the total coliform in River Well #3. Most occurrences in 2003 to 2006 are spread between the months of June and October with a maximum of 2 counts per 100 mL in July 2004 and September 2005.

Table 3.3.4.5-16: Summary Data for Thamesford Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
River Well #1	2003	33	0	0	7 (21%)	0-9
	2004	52			6 (11.5%)	0-5
	2005	53			3 (5.7%)	0-1
	2006	37			1 (2.7%)	0-1
River Well #2	2003	1	0	0	0	0
	2004	3	0	0	1 (33%)	0-4
	2005	6	0	0	0	0
	2006					
Stanley St. Well #3	2003	32	0	0	2 (6.3%)	0-1
	2004	49			5 (10%)	0-2
	2005	46			1 (2.2%)	0-2
	2006	35			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

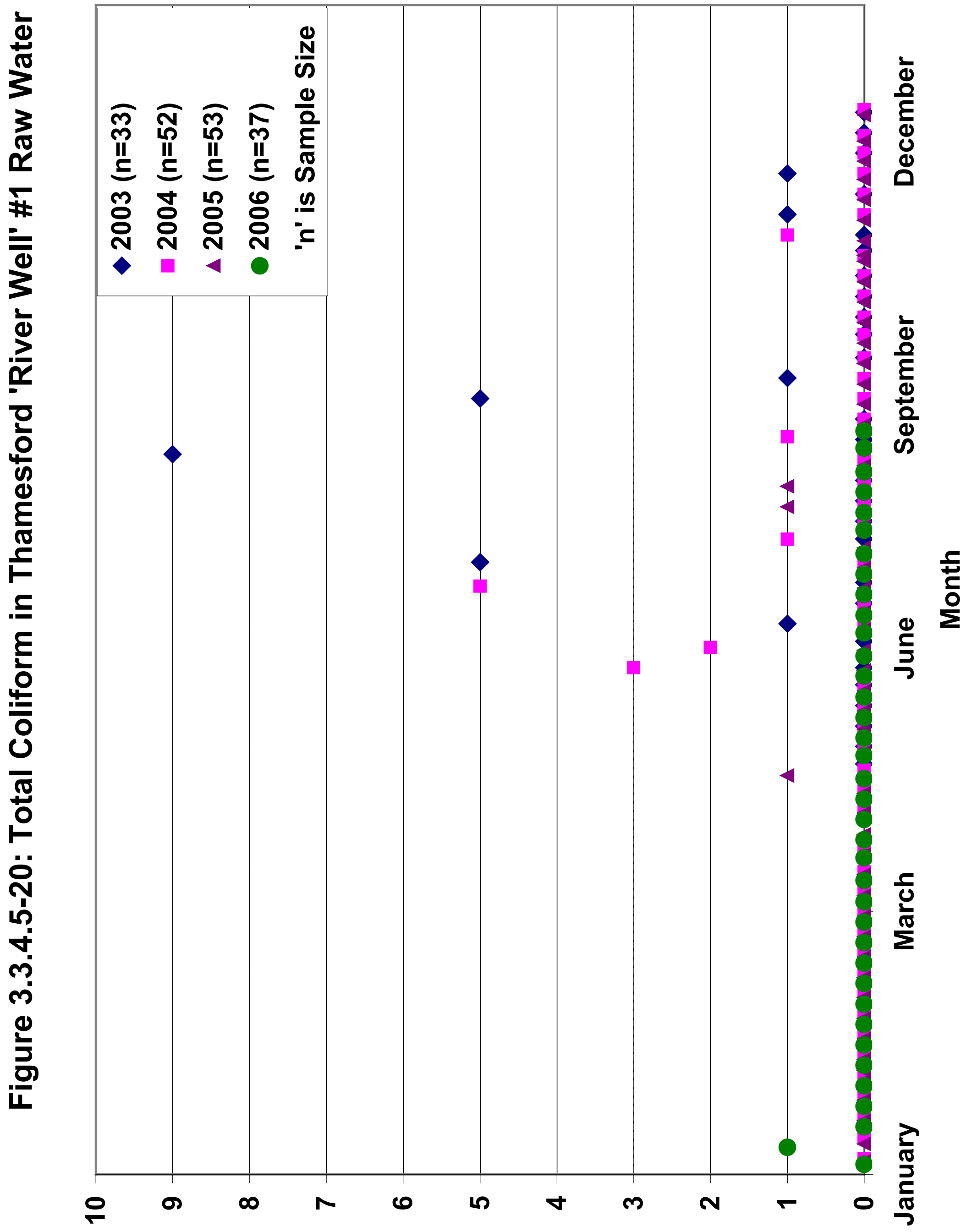

Figure 3.3.4.5-20: **Total Coliform in Thamesford 'River Well' #1 Raw Water**

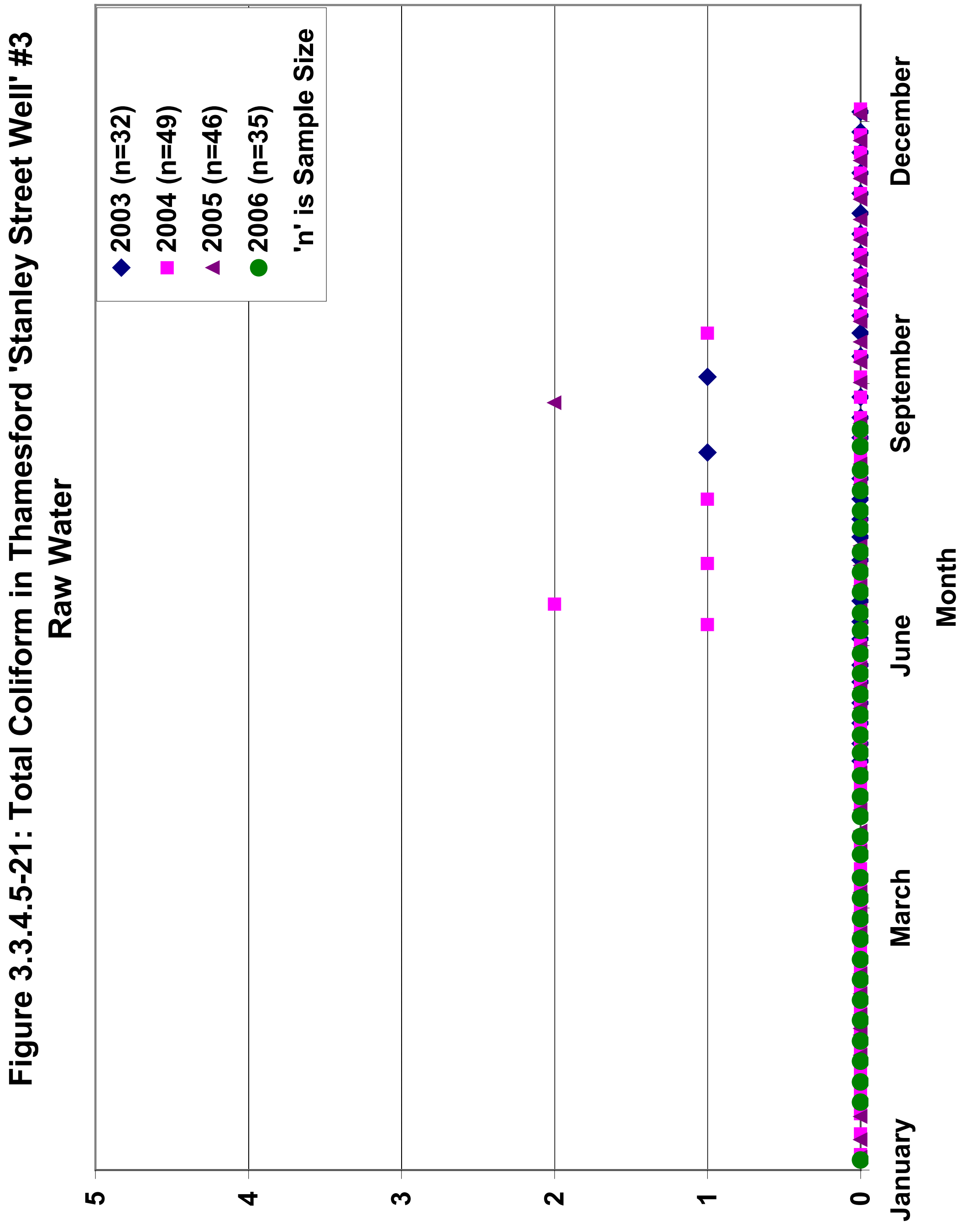

Figure 3.3.4.5-21: Total Coliform in Thamesford 'Stanley Street Well' #3 Raw Water

(10) Woodstock Well Supply

The Woodstock supply system is comprised of 10 wells. Most wells have coliform data from May 2003 to September 2006. Thornton Well Field Well #5 has data from May 2003 to February 2006. Southside Park Well #6 has data from May 2005 to September 2006 but only one sample in 2003 and none in 2004. Hart Springs Well #9 has data from May 2003 to September 2006. No samples were collected while the wells were offline for rehabilitation[102].

Table 3.3.4.5-17 summarizes the raw water coliform data for the 10 Woodstock wells. None of the wells has *E. coli* detected. Nine of the wells have total coliform detected in them. Only one well, Southside Park Well #6, has no coliform detected for the period of data available.

There were one occurrence of total coliform at each of three wells, Tabor Well Field Well #2 in November 2003, Thornton Well Field Well #3 in March 2004, and Thornton Well Field Well #5 in December 2003.

Thornton Well Field Well #1 had eight occurrences of total coliform in 2004 and 2005 and none in 2003 and 2006. In the Tabor Well Field Well #4, total coliform was detected three times in 2003 and none thereafter. Sutherland Well #7 had 15 occurrences of total coliform in 2003 to 2006, while Thornton Well Field #8 had 17 occurrences in 2003 and 2004 but none in 2005 and 2006. In Hart Springs Well #9 total coliform was detected thrice in 2004 and 2005 but did not occur in 2003 and 2006. In Thornton Well Field #11, total coliform occurred nine times in 2003 to 2005 but was not detected in 2006. Wells with three or more occurrences of total coliform are also graphed as scatter plots.

Figure 3.3.4.5-22 shows the total coliform in Thornton Well Field Well #1. Most of the detected coliform is in the months of June to September, with a maximum of 15 counts per 100 mL in August 2004.

Figure 3.3.4.5-23 shows the total coliform in Tabor Well Field Well #4. Three instances of total coliform detection are in August, October and November 2003 with a maximum of 7 counts per 100 mL. There were no positive results in 2004, 2005 and 2006.

Figure 3.3.4.5-24 shows the total coliform in Sutherland Well #7. The total coliform is detected several times in October and November 2003 and July to October 2004. There were single samples with positive results in September 2005 and July 2006. A maximum of 41 counts per 100 mL occurred in September 2004.

Figure 3.3.4.5-25 shows the total coliform in Thornton Well Field #8. There are many instances of total coliform detection in November and December 2003, and from February to September 2004. A maximum of 160 counts per 100 mL occurred in August 2004. There have been no positive coliform results in 2005 and 2006.

Figure 3.3.4.5-26 shows the total coliform in Hart Springs Well #9. There are no positive results in 2003 and 2006. A maximum of 200 counts per 100 mL occurred in September 2004, but in August 2005 the maximum count was only 1 per 100 mL for that year.

Figure 3.3.4.5-27 shows the total coliform in Thornton Well Field #11. In 2003, total coliform was detected in September, November and December. Total coliform was also detected in August 2004, and in February, March and July 2005. The maximum count was 12 per 100 mL in November 2003. There were no positive results in 2006.

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[102] County of Oxford Water Operations Coordinator. May 2007. Personal communication.

Table 3.3.4.5-17: Summary Data for Woodstock Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Thornton Well Field Well #1	2003	33	0	0	0	0
	2004	52			6 (11.5%)	0-15
	2005	39			2 (5%)	0-1
	2006	37			0	0
Tabor Well Field Well #2	2003	33	0	0	1 (3%)	0-1
	2004	51			0	0
	2005	51			0	0
	2006	35			0	0
Thornton Well Field Well #3	2003	33	0	0	0	0
	2004	51			1 (2%)	0-1
	2005	50			0	0
	2006	38			0	0
Tabor Well Field Well #4	2003	33	0	0	3 (9%)	0-7
	2004	50			0	0
	2005	52			0	0
	2006	37			0	0
Thornton Well Field Well #5	2003	33	0	0	1 (3%)	0-2
	2004	51			0	0
	2005	52			0	0
	2006	7			0	0
Southside Park Well #6	2003	1	0	0	0	0
	2004					
	2005	23	0	0	0	0
	2006	37	0	0	0	0
Sutherland Well #7	2003	32	0	0	3 (9%)	0-37
	2004	49			10 (20%)	0-41
	2005	45			1 (2.2%)	0-4
	2006	47			1 (2.1%)	0-4
Thornton Well Field Well #8	2003	33	0	0	4 (12%)	0-3
	2004	51			13 (25%)	0-160
	2005	46			0	0
	2006	37			0	0

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Hart Springs Well #9	2003	19	0	0	0	0
	2004	15			2 (13%)	0-200
	2005	27			1 (3.7%)	0-1
	2006	37			0	0
Thornton Well Field Well #11	2003	34	0	0	4 (11.7%)	0-12
	2004	52			2 (3.8%)	0-6
	2005	52			3 (5.8%)	0-11
	2006	37			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

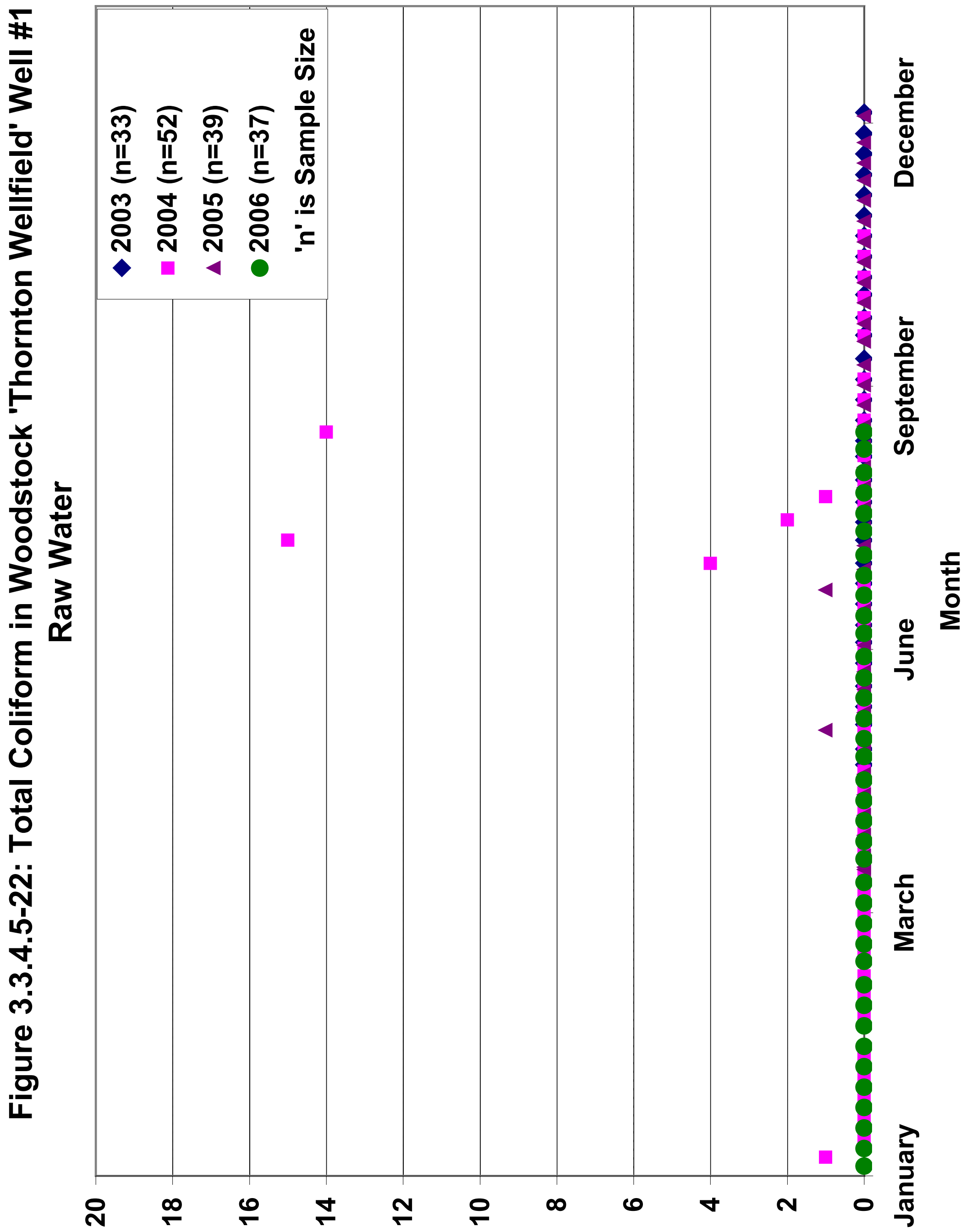


Figure 3.3.4.5-22: **Total Coliform in Woodstock ‘Thornton Wellfield’ Well #1 Raw Water**

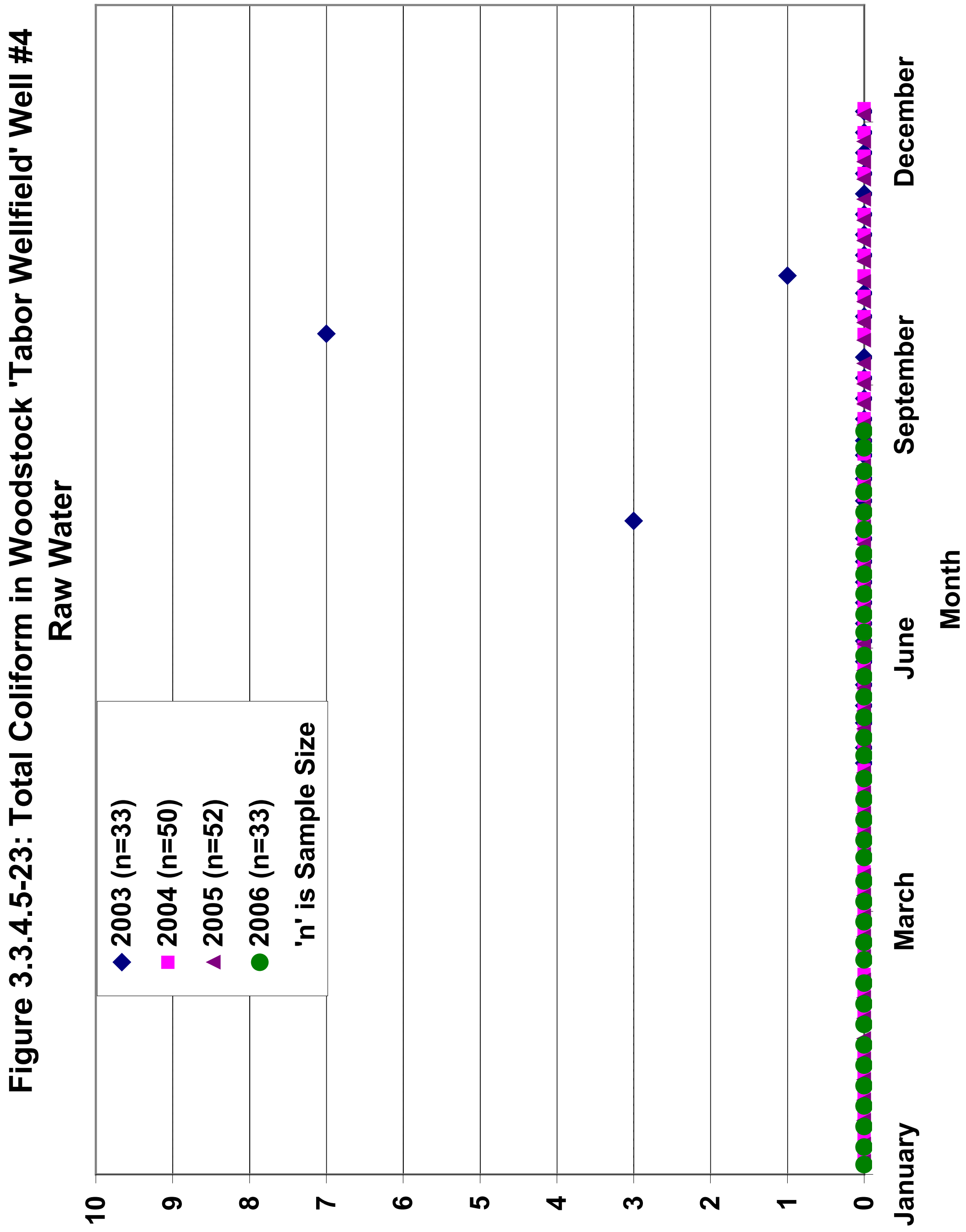


Figure 3.3.4.5-23: Total Coliform in Woodstock 'Tabor Wellfield' Well #4 Raw Water

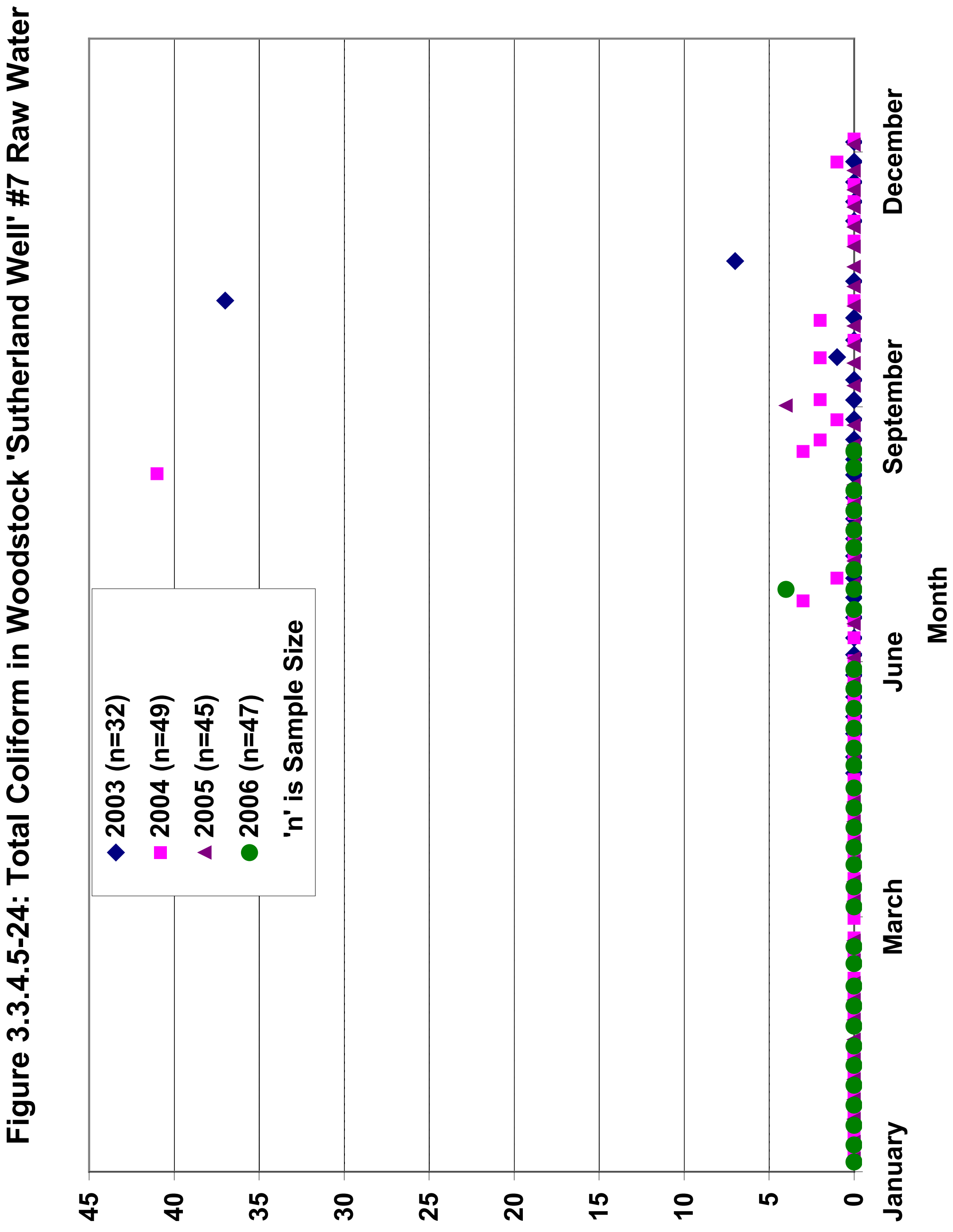


Figure 3.3.4.5-24: **Total Coliform in Woodstock 'Sutherland Well' #7 Raw Water**

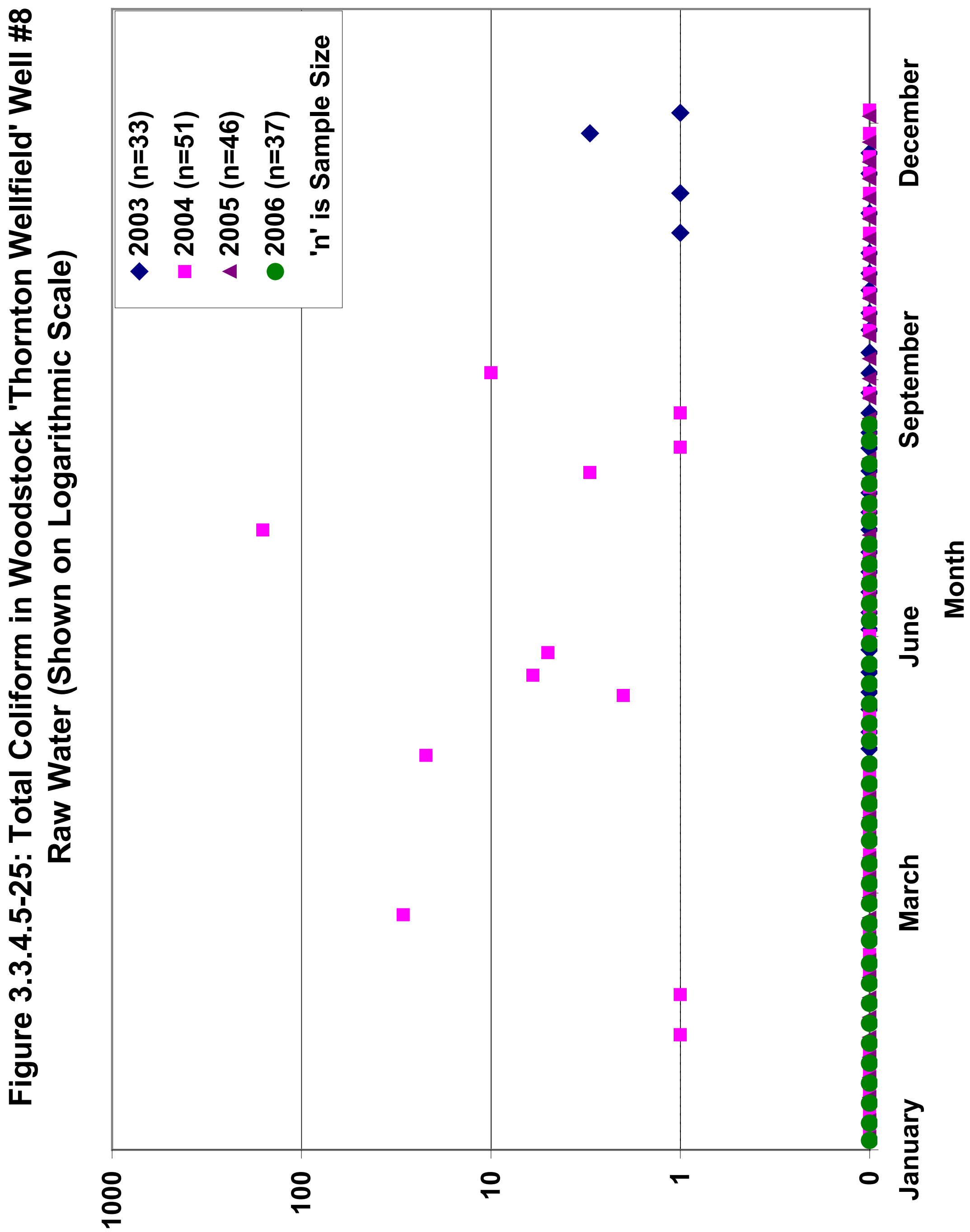


Figure 3.3.4.5-25: Total Coliform in Woodstock 'Thornton Wellfield' Well #8 Raw Water (Shown on Logarithmic Scale)

Figure 3.3.4.5-25: Total Coliform in Woodstock ‘Thornton Wellfield’ Well #8 Raw Water

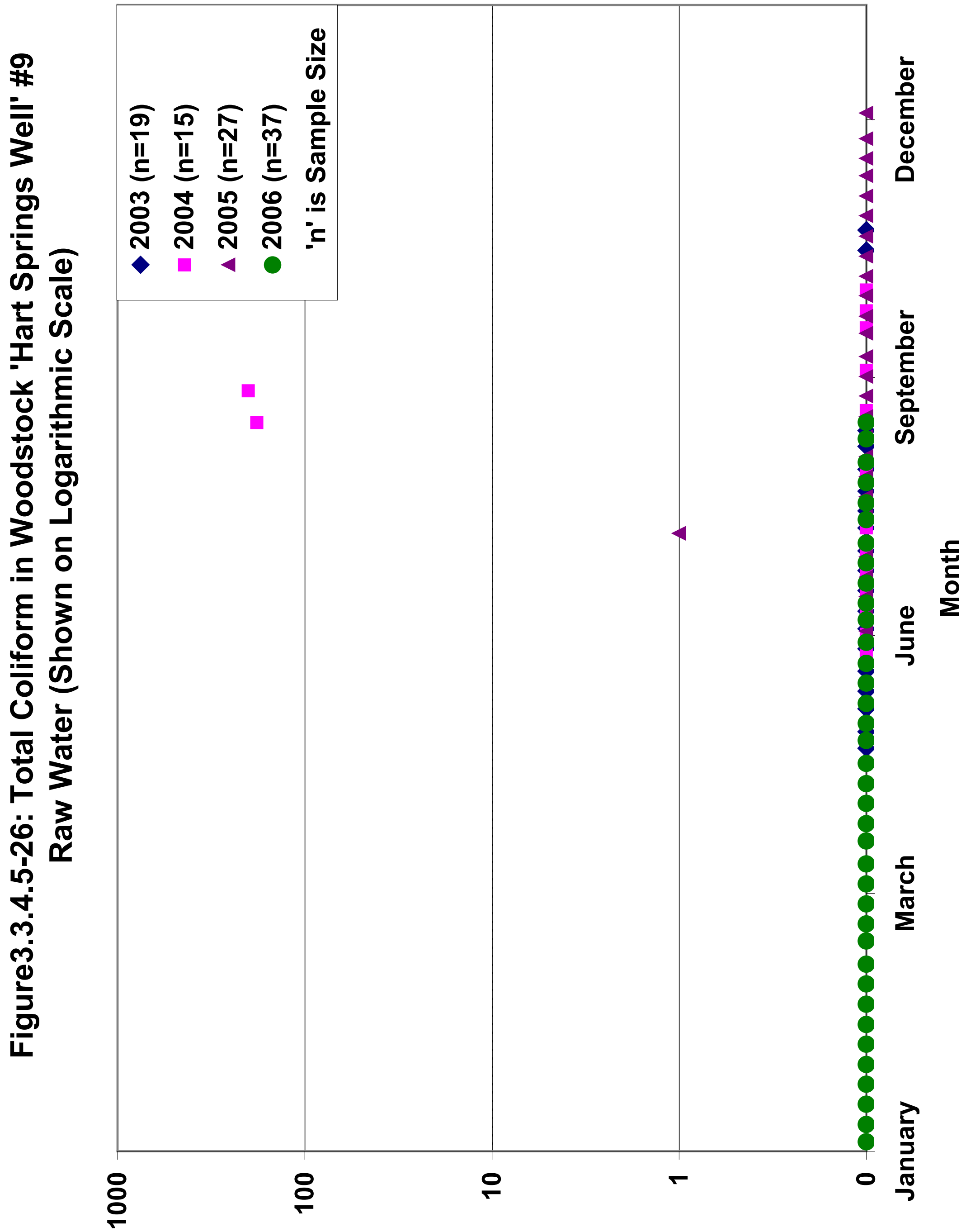


Figure 3.3.4.5-26: Total Coliform in Woodstock ‘Hart Springs Well’ #9 Raw Water

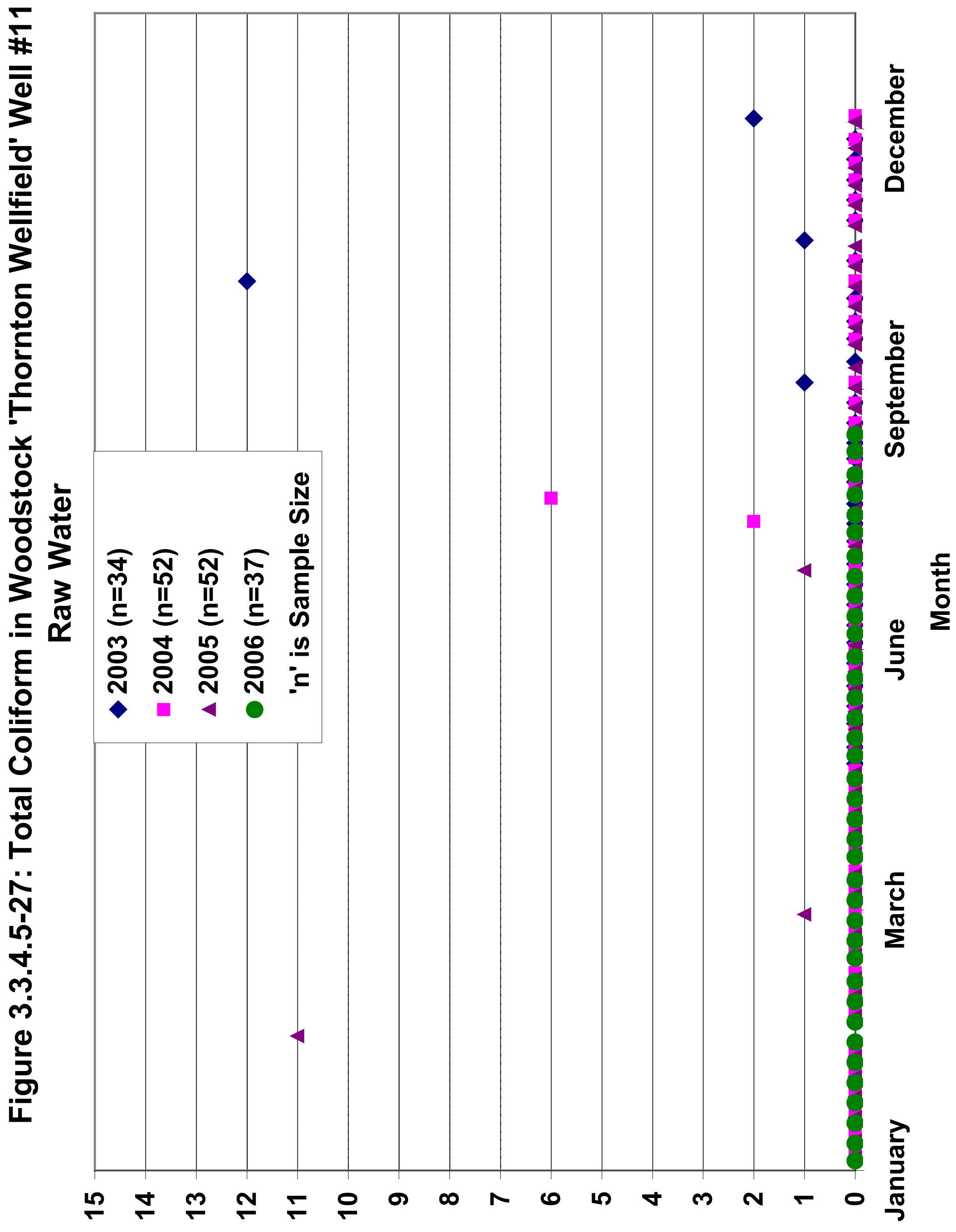


Figure 3.3.4.5-27: **Total Coliform in Woodstock 'Thornton Wellfield' Well #11 Raw Water**

(C) Municipal Groundwater Well Supply Systems - Perth

In the municipality of Perth, the six well supply systems that service populations within the Thames Watershed & Region are Mitchell, Sebringville (Black Creek Estates), Shakespeare (Miller Ave.), St. Marys, St. Pauls and Stratford.

(1) Mitchell Well Supply

There are three wells in the Mitchell supply system. Data from May 2003 to September 2006 is available for all the wells.

Table 3.3.4.5-18 summarizes the raw water coliform data for the Mitchell wells. None of the wells has *E. coli*. However, all of the wells have total coliform in them. In Well #1, total coliform was detected in November 2004 and July 2006 with a maximum of 3 counts per 100 mL. In Well #2, total coliform was detected once in August 2004 with a maximum of 1 count per 100 mL. In Well #3, total coliform was detected three times in 2004 to 2006 (data is graphed as a scatter plot and discussed below).

Figure 3.3.4.5-28 shows the total coliform in Well #3. Low counts of 1 per 100 mL were reported in February 2005 and July 2006. The maximum total coliform count of 18 per 100 mL occurred in November 2004.

Table 3.3.4.5-18: Summary Data for Mitchell Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	33	0	0	0	0
	2004	52			1 (2%)	0-3
	2005	56			0	0
	2006	39			1 (2.5%)	0-1
#2	2003	33	0	0	0	0
	2004	52			1 (2%)	0-1
	2005	50			0	0
	2006	39			0	0
#3	2003	32	0	0	0	0
	2004	52			1 (2%)	0-18
	2005	50			1 (2%)	0-1
	2006	39			1 (2.5%)	0-1

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

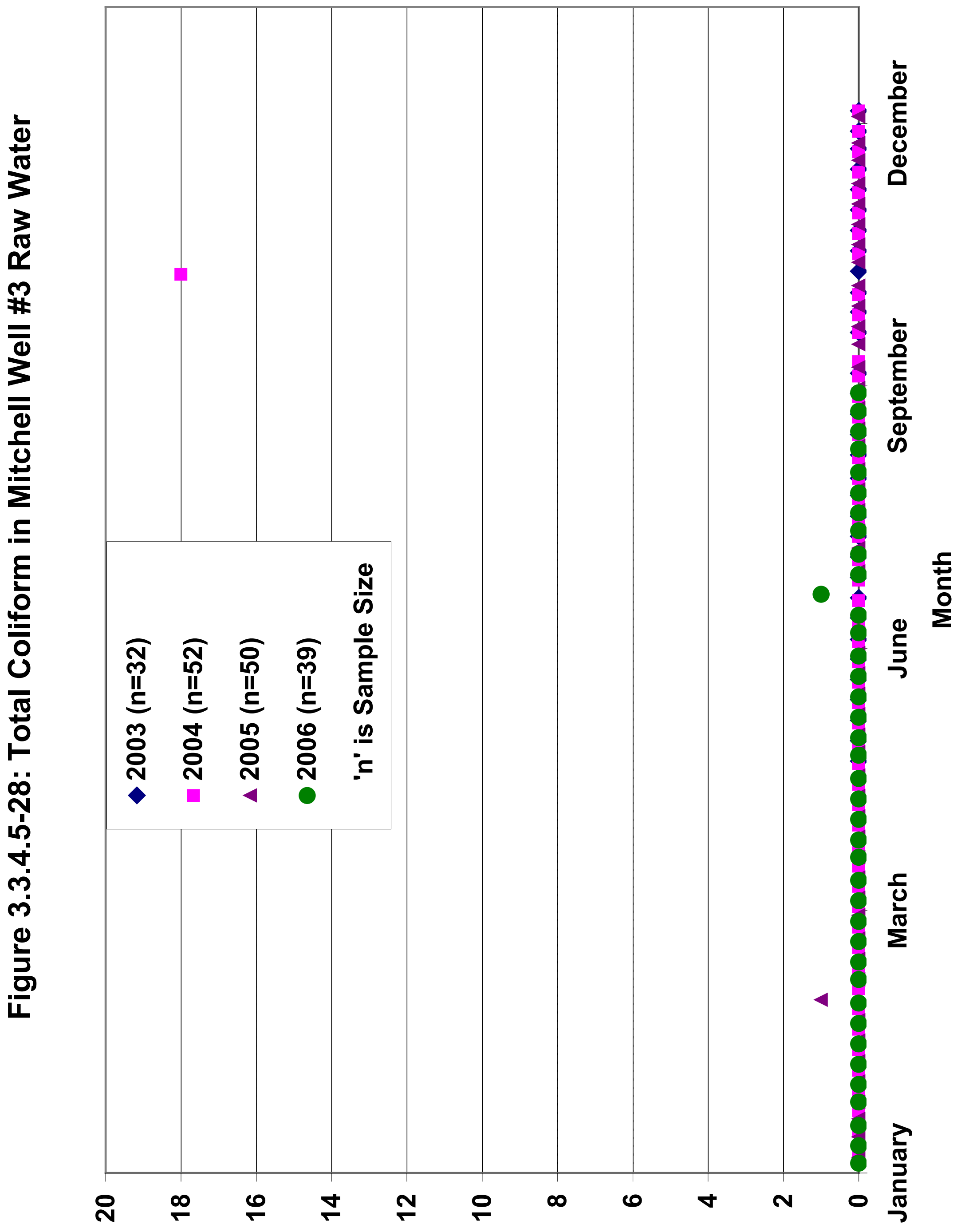


Figure 3.3.4.5-28: Total Coliform in Mitchell Well #3 Raw Water

(2) Sebringville (Black Creek Estates) Well Supply

There is one well in the Sebringville (Black Creek Estates) supply system. Data from May 2003 to September 2006 is available.

Table 3.3.4.5-19 summarizes the coliform data for the Sebringville (Black Creek Estates) well. No total coliform or *E. coli* were detected in this well.

Table 3.3.4.5-19: Summary Data for Sebringville (Black Creek Estates) Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Black Creek Estates Well	2003	32	0	0	0	0
	2004	49				
	2005	51				
	2006	28				

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(3) Shakespeare (Miller Ave.) Well Supply

There is one well in the Shakespeare (Miller Ave.) supply system. Data from May 2003 to September 2006 is available but lacks data in January to June 2004 as well as February and June 2006. Sample sizes are small, ranging from seven to 14 per year.

Table 3.3.4.5-20 summarizes the raw water coliform data for the Shakespeare (Miller Ave.) well. No total coliform or *E. coli* were detected in this well.

Table 3.3.4.5-20: Summary Data for Shakespeare (Miller Ave.) Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Shakespeare Well	2003	14	0	0	0	0
	2004	7				
	2005	12				
	2006	7				

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(4) St. Marys Well Supply

There are two active wells (#1 and #3) in the St. Marys supply system. Data from May 2003 to August 2006 is available for Well #1 (Timms Lane) and Well #3 (209 Thomas Street). Well #3 has a large sample size of 104 in 2004.

Table 3.3.4.5-21 summarizes the raw water coliform data for the three St. Marys wells. Well #1 had four instances of *E. coli* in 2003 to 2005 with none in 2006. The total coliform in this well also occurred 48 times from 2003 to 2006. The data is graphed as a scatter plot and discussed below. In Well #3, 36 instances of total coliform occurred from 2003 to 2006 with most of them in 2004. There was no *E. coli* in Well #3. The data is graphed as a scatter plot and discussed below.

Figure 3.3.4.5-29 shows the total coliform in Well #1. *E. coli* counts of 1 per 100 mL were detected in November 2003, May 2004, and twice in December 2005. The total coliform was detected in the months of January to July for the years 2003 to 2006 and October to December for the years 2003 and 2005. Total coliform maximum counts ranged from 19 per 100 mL (December 2005) to 74 counts per 100 mL (January 2006).

Figure 3.3.4.5-30 shows the total coliform in Well #3. In 2003, total coliform occurred in the months of June to December. In the years 2004 to 2006, it was detected in the months of January to June. The maximum count of 81 per 100 mL was in March 2004.

Table 3.3.4.5-21: Summary Data for St. Marys Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Well #1 – Timms Lane	2003	32	1	0-1	13 (40%)	0-53
	2004	51	1	0-1	17 (33%)	0-33
	2005	55	2	0-1	5 (9%)	0-19
	2006	30	0	0	13 (43%)	0-74
Well #3 - 209 Thomas St.	2003	66	0	0	8 (12%)	0-7
	2004	104			21 (20%)	0-81
	2005	65			3 (4.5%)	0-5
	2006	30			4 (13%)	0-3

*NDSF (No Data, Sample Frozen) on October 13, 2004
Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

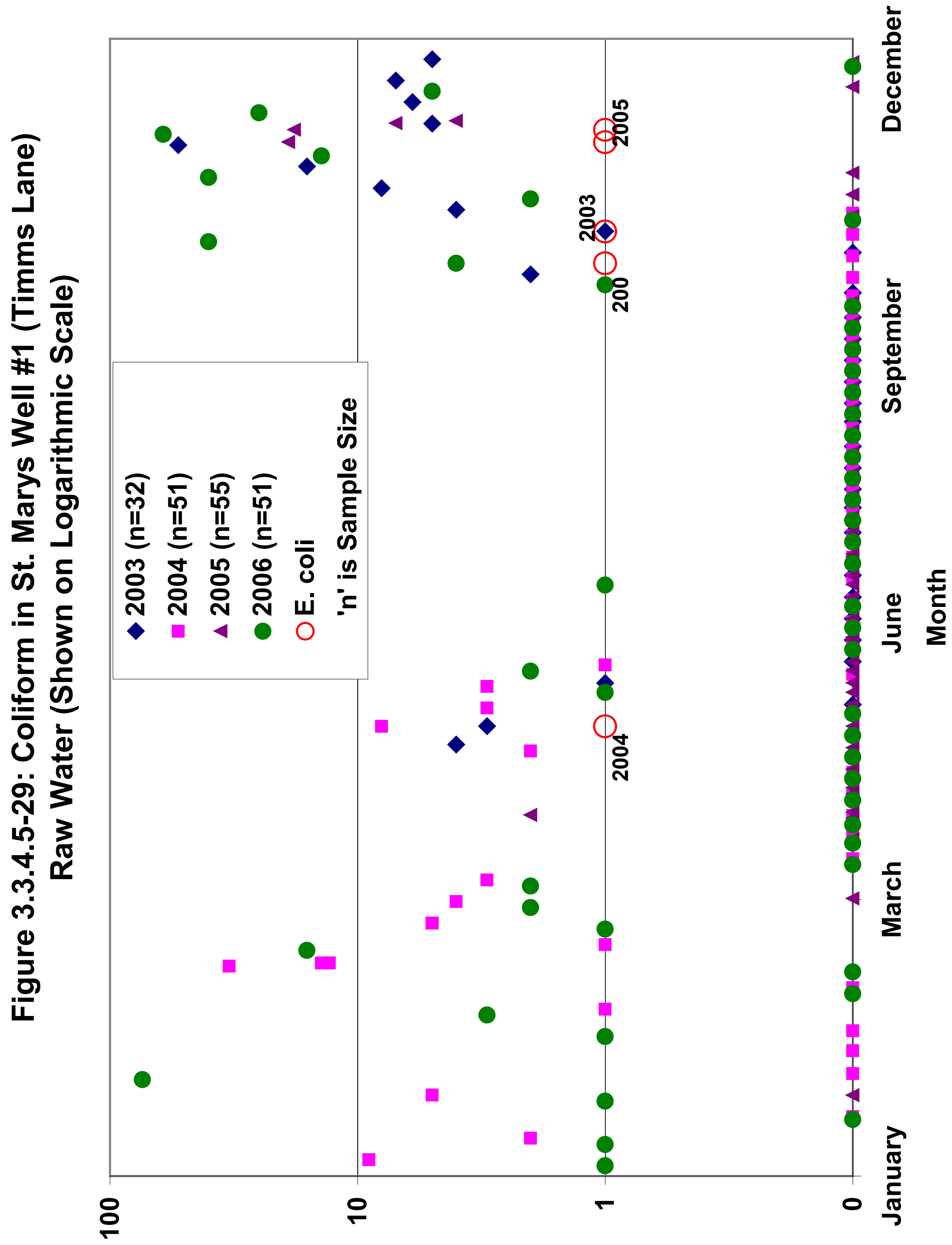


Figure 3.3.4.5-29: **Coliform in St. Marys Well #1 (Timms Lane) Raw Water**

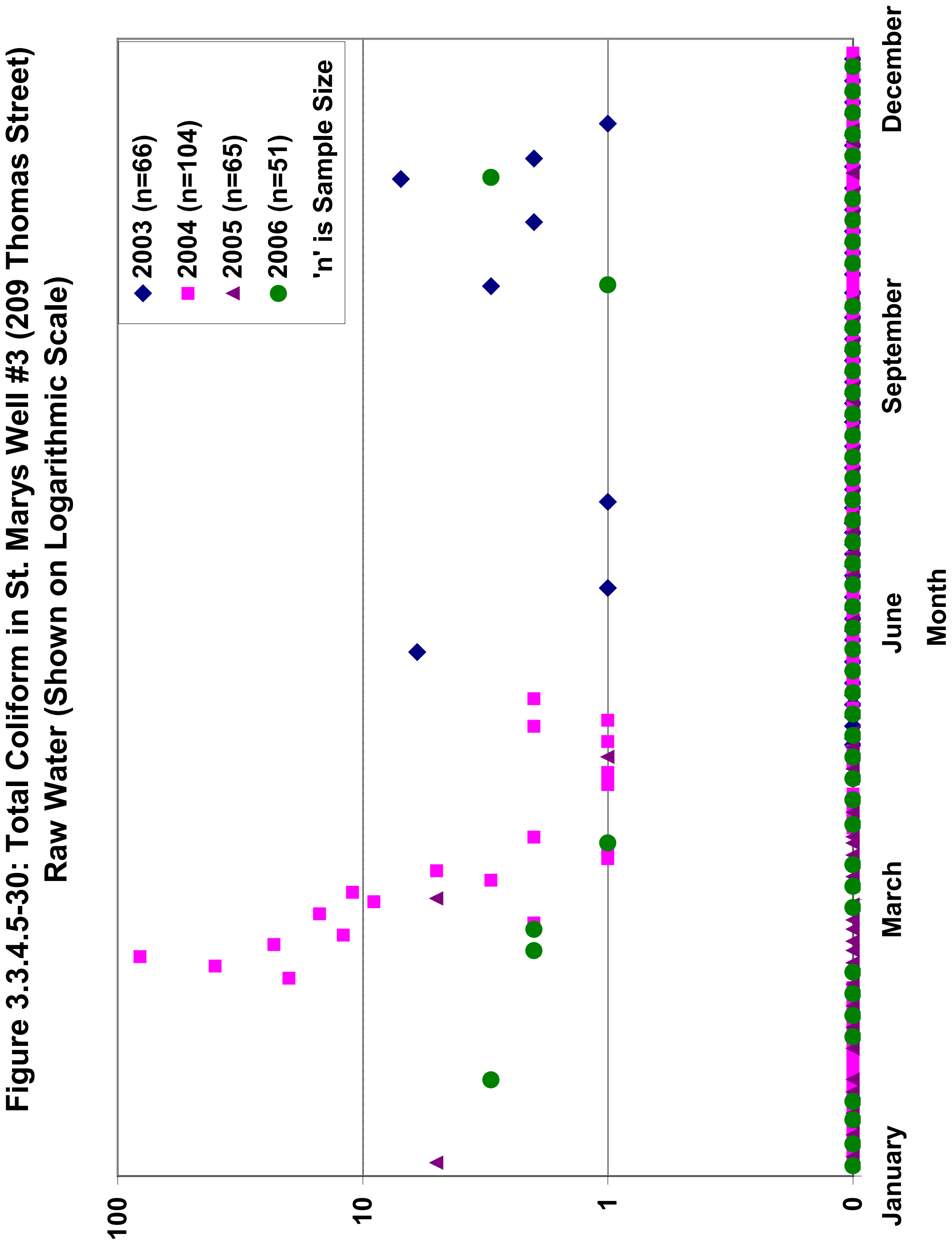


Figure 3.3.4.5-30: Total Coliform in St. Marys Well #3 (209 Thomas Street) Raw Water

(5) St. Pauls Well Supply

There is one well in the St. Pauls supply system. Data from May 2003 to September 2006 is available.

Table 3.3.4.5-22 summarizes the raw water coliform data for the St. Pauls well. No total coliform or *E. coli* were detected in this well.

Table 3.3.4.5-22: Summary Data for St. Pauls Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
St. Pauls Well	2003	32	0	0	0	0
	2004	46				
	2005	51				
	2006	29				

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(6) Stratford Well Supply

The Stratford well supply system is comprised of 11 wells. Data from May 2003 to September 2006 is available. However there is a few months' data gap for the Romeo Wells #1, 2, 3, 4 and 7, and the Chestnut Street, Mornington and O'Loane Avenue Wells. The results from the Romeo Wells are discussed first and then the other wells are discussed as a group.

(a) Romeo Wells #1, 2, 3, 4, 6 and 7

Table 3.3.4.5-23 summarizes raw water coliform data for the Stratford 'Romeo' Wells. Only one out of six Romeo Wells tested positive for *E. coli*. The bacteria were detected in Romeo Well #4, in 2003, with a count of 1 per 100 mL. However, five out of six Romeo Wells contained total coliform. Only Romeo Well #6 contained no coliform.

Romeo Well #2 had only one instance in October 2005 (6 per 100 mL) and Romeo Well #7 had only one instance of total coliform in October 2004 (1 per 100 mL). Romeo Well #3 had two occurrences in March 2004 and October 2005 (maximum count of 2 per 100 mL). Romeo Well #1 had three instances of total coliform in 2004, but none in 2003, 2005 and 2006. Romeo Well #4 had the most occurrences with a total eight in 2003, and 2005 to 2006. There were none in 2004 but there were only seven samples taken. The data for Romeo Wells # 1 and #4 is graphed as scatter plots and discussed in more detail below.

Figure 3.3.4.5-31 shows the total coliform in Romeo Well #1. There were two detections of the bacteria in March 2004, and one in September 2004 that was the highest count in the Romeo Wells at 142 per 100 mL.

Figure 3.3.4.5-32 shows the coliform in Romeo Well #4. The one instance of an *E. coli* count of 1 per 100 mL occurred in July 2003. Total coliform occurred in the months of June to August in 2003, in October 2005 and March 2006. The maximum count of 30 per 100 mL was recorded in July 2003.

Table 3.3.4.5-23: Summary Data for Stratford 'Romeo' Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Romeo – Well #1	2003	32	0	0	0	0
	2004	56			3 (5%)	0-142
	2005	41			0	0
	2006	40			0	0
Romeo – Well #2	2003	33	0	0	0	0
	2004	49			0	0
	2005	43			1 (2.3%)	0-6
	2006	40			0	0
Romeo – Well #3	2003	33	0	0	0	0
	2004	52			1 (2%)	0-2
	2005	44			1 (2.3%)	0-1
	2006	40			0	0
Romeo – Well #4	2003	37	1	0-1	6 (16%)	0-30
	2004	7	0	0	0	0
	2005	30	0	0	1 (3.3%)	0-2
	2006	42	0	0	1 (2.3%)	0-4
Romeo – Well #6	2003	31	0	0	0	0
	2004	47				
	2005	52				
	2006	64				
Romeo – Well #7	2003	33	0	0	0	0
	2004	54			1 (1.8%)	0-1
	2005	52			0	0
	2006	14			0	0

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with E. coli values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

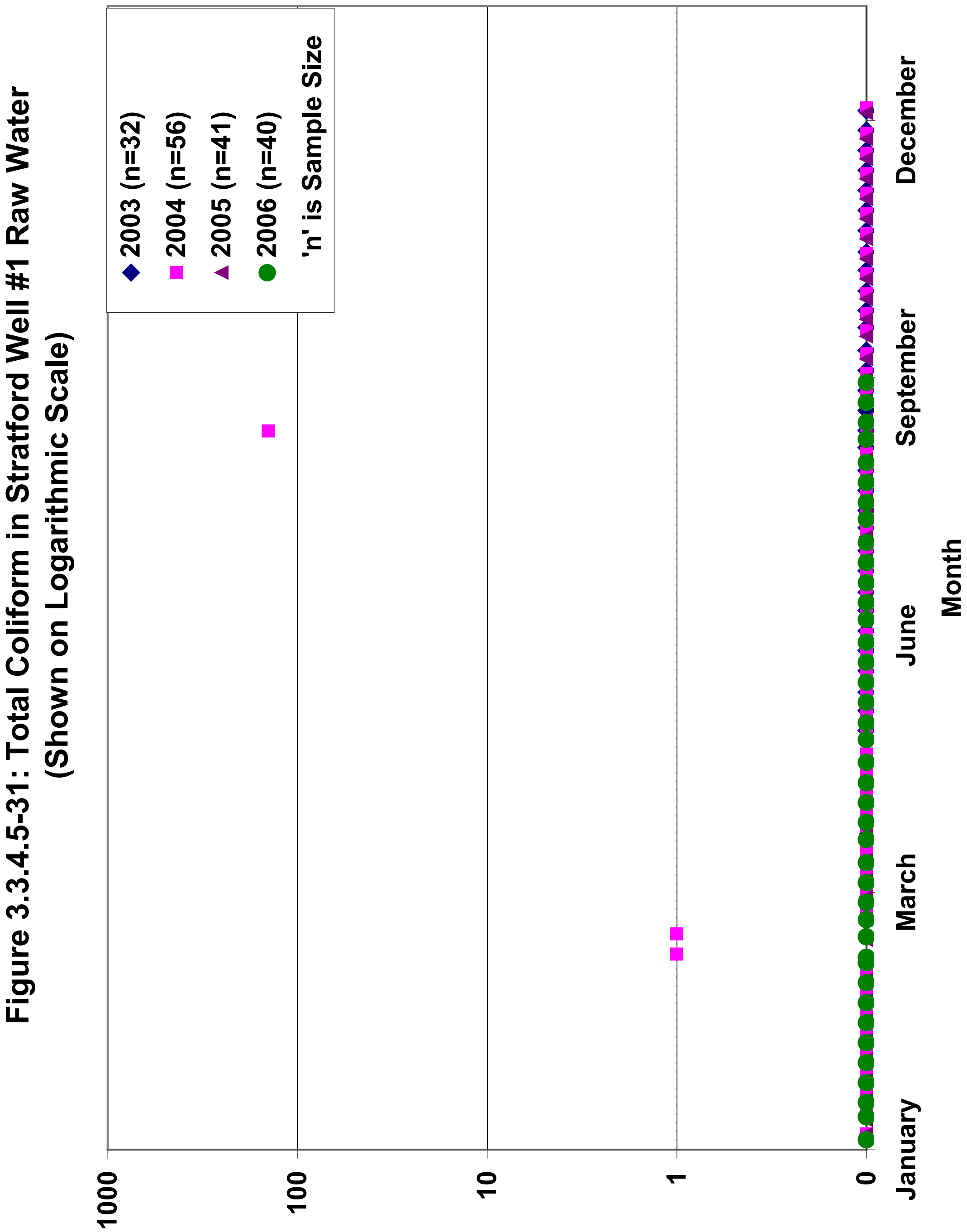


Figure 3.3.4.5-31: **Total Coliform in Stratford Well #1 Raw Water**

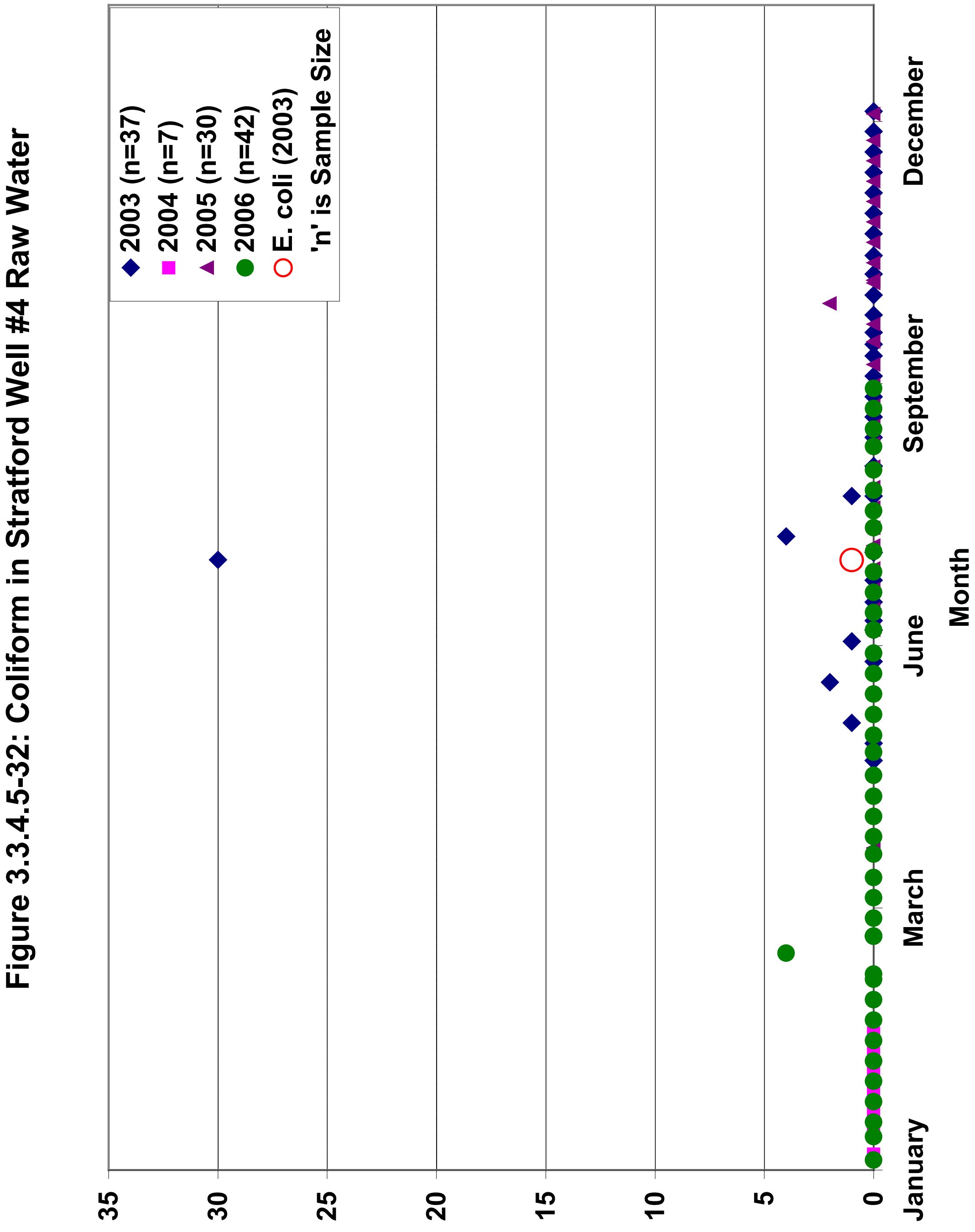


Figure 3.3.4.5-32: **Coliform in Stratford Well #4 Raw Water**

(b) Other (non-Romeo) Stratford Wells

Table 3.3.4.5-24 summarizes raw water coliform data for the other (non-Romeo) Stratford wells.

As discussed under Special Cases in Section 3.3.4.3, the Chestnut Street, Dunn Road, Lorne Avenue, Mornington and O'Loane Avenue have one unreliable result each on June 22, 2005, due to a power outage at the Laboratory when the samples were being tested. It is not possible to conclude that the samples taken on this date contained no coliform and, hence, the results are indeterminable.

Excluding the unreliable result for each well, the Chestnut Street, Dunn Road, Lorne Avenue, Mornington and O'Loane Avenue Wells have no *E. coli* occurrences for the available data. As well, all of the wells, except Mornington, have no total coliform detected. The Mornington Well had a single positive result in November 2004 with a count of 13 per 100 mL.

Table 3.3.4.5-24: Summary Data for Other (non-Romeo) Stratford Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Mornington Well	2003	34	0*	0*	0	0
	2004	38			1 (2.6%)	0-13
	2005	53			0*	0*
	2006	35			0	0
Chestnut Street Well	2003	32	0*	0*	0	0
	2004	55			0	0
	2005	32*			0*	0*
	2006	36			0	0
Dunn Road Well	2003	33	0*	0*	0	0
	2004	51			0	0
	2005	52*			0*	0*
	2006	37			0	0
Lorne Avenue Well	2003	33	0*	0*	0	0
	2004	51			0	0
	2005	54*			0*	0*
	2006	39			0	0
O Loane Avenue Well	2003	33	0*	0*	0	0
	2004	53			0	0
	2005	53*			0*	0*
	2006	27			0	0

*URAPO (Unreliable Results Affected by Power Outage) on June 22, 2005
Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(D) Municipal Groundwater Well Supply Systems - Chatham-Kent

In the municipality of Chatham-Kent, there are two well supply systems that service populations in the communities of Highgate and Ridgetown in the Thames Watershed & Region.

(1) Highgate Well Supply

The Highgate supply system has two wells, #1 and #2. Data from October 2003 to September 2006 is available for Well #1 and data from September 2003 to September 2006 is available for Well #2.

Table 3.3.4.5-25 summarizes raw water coliform data for the Highgate wells. Neither well had *E. coli* present during the times data is available. However, both wells tested positive for total coliform.

Well #2 had only two instances of total coliform. Both occurrences were in September 2004 with a maximum of 2 counts per 100 mL. Well #1 had 13 instances of total coliform in 2004. There was only one occurrence in 2005. There were no total coliform detected in Well #1 during 2003 and 2006. However, the sample size in 2003 is small (n=11). The data for Well #1 is graphed as a scatter plot and described below.

Figure 3.3.4.5-33 shows the total coliform in Well #1. One instance occurred in April 2004 with a count of 4 per 100 mL. The 13 other total coliform results occurred in September 2004 to January 2005. The maximum coliform count was 35 per 100 mL in September 2004.

Table 3.3.4.5-25: Summary Data for Highgate Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	11	0	0	0	0
	2004	40			13 (32%)	0-35
	2005	37			1 (2.7%)	0-1
	2006	37			0	0
#2	2003	16	0	0	0	0
	2004	51			2 (4%)	0-5
	2005	44			0	0
	2006	37			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

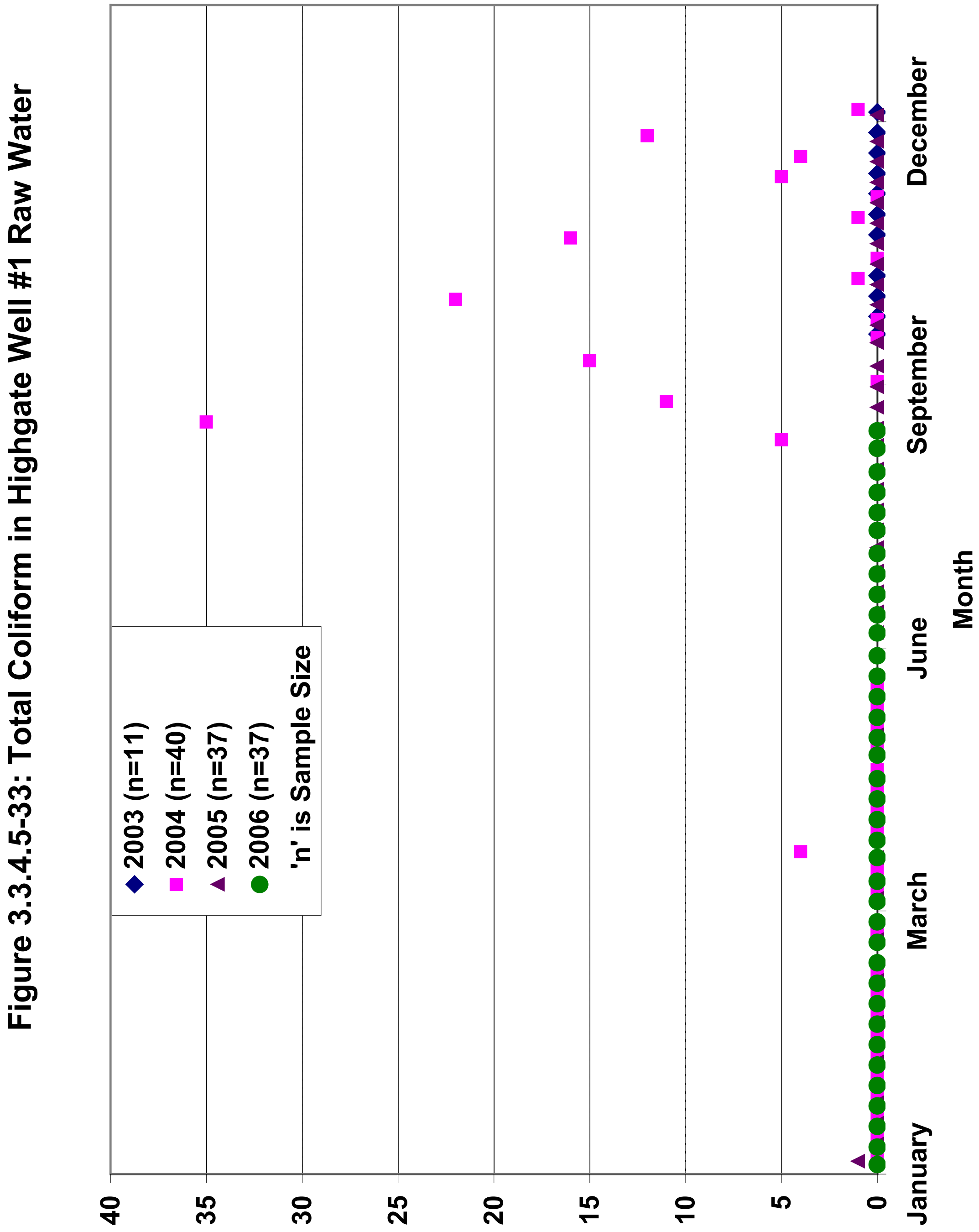


Figure 3.3.4.5-33: Total Coliform in Highgate Well #1 Raw Water

(2) Ridgetown Well Supply

The Ridgetown well supply system has six wells. Data from May 2003 to September 2006 is available for five wells and data from December 2003 to September 2006 is available for one well (Well #4).

Table 3.3.4.5-26 summarizes raw water coliform data for the Ridgetown wells. None of the wells had *E. coli* present during the times for which data is available. Four of the wells had one to two occurrences of total coliform. Two wells (#4 and #6) had more than three positive results.

Well #1A had positive results in August 2004 and May 2005 with a maximum of 1 count per 100 mL. There was one instance of total coliform each in Well #2 (April 2006), Well #3 (September 2003) and Well #5 (September 2005). The total coliform counts in these wells ranged from 1 to 3 counts per 100 mL.

Well #4 had six occurrences of total coliform in 2005 and 2006. Well #6 had nine occurrences of total coliform in 2004 and 2005. The data for Wells #4 and #6 are graphed as scatter plots and discussed below.

Figure 3.3.4.5-34 displays the total coliform occurrences of Well #4. These were in August to December 2005 and in August 2006. A maximum of 5 counts per 100 mL occurred in September 2005.

Figure 3.3.4.5-35 displays the total coliform occurrences of Well #6. These were in October 2004 to January 2005 with a maximum of 29 counts per 100 mL in December 2004.

Table 3.3.4.5-26: Summary Data for Ridgetown Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	**Range**	**n2>0**	**Range**
#1A	2003	33	0	0	0	0
	2004	58			1 (1.7%)	0-1
	2005	51			1 (1.9%)	0-1
	2006	37			0	0
#2	2003	33	0	0	0	0
	2004	46			0	0
	2005	51			0	0
	2006	37			1 (2.7%)	0-1
#3	2003	33	0	0	1 (3%)	0-3
	2004	39			0	0
	2005	50			0	0
	2006	37			0	0
#4	2003	2	0	0	0	0
	2004	43			0	0
	2005	51			5 (9.8%)	0-5
	2006	37			1 (2.7%)	0-1
#5	2003	33	0	0	0	0
	2004	43			0	0
	2005	51			1 (2%)	0-2
	2006	37			0	0
#6	2003	32	0	0	0	0
	2004	43			7 (1.6%)	0-29
	2005	51			2 (3.9%)	0-2
	2006	37			0	0

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

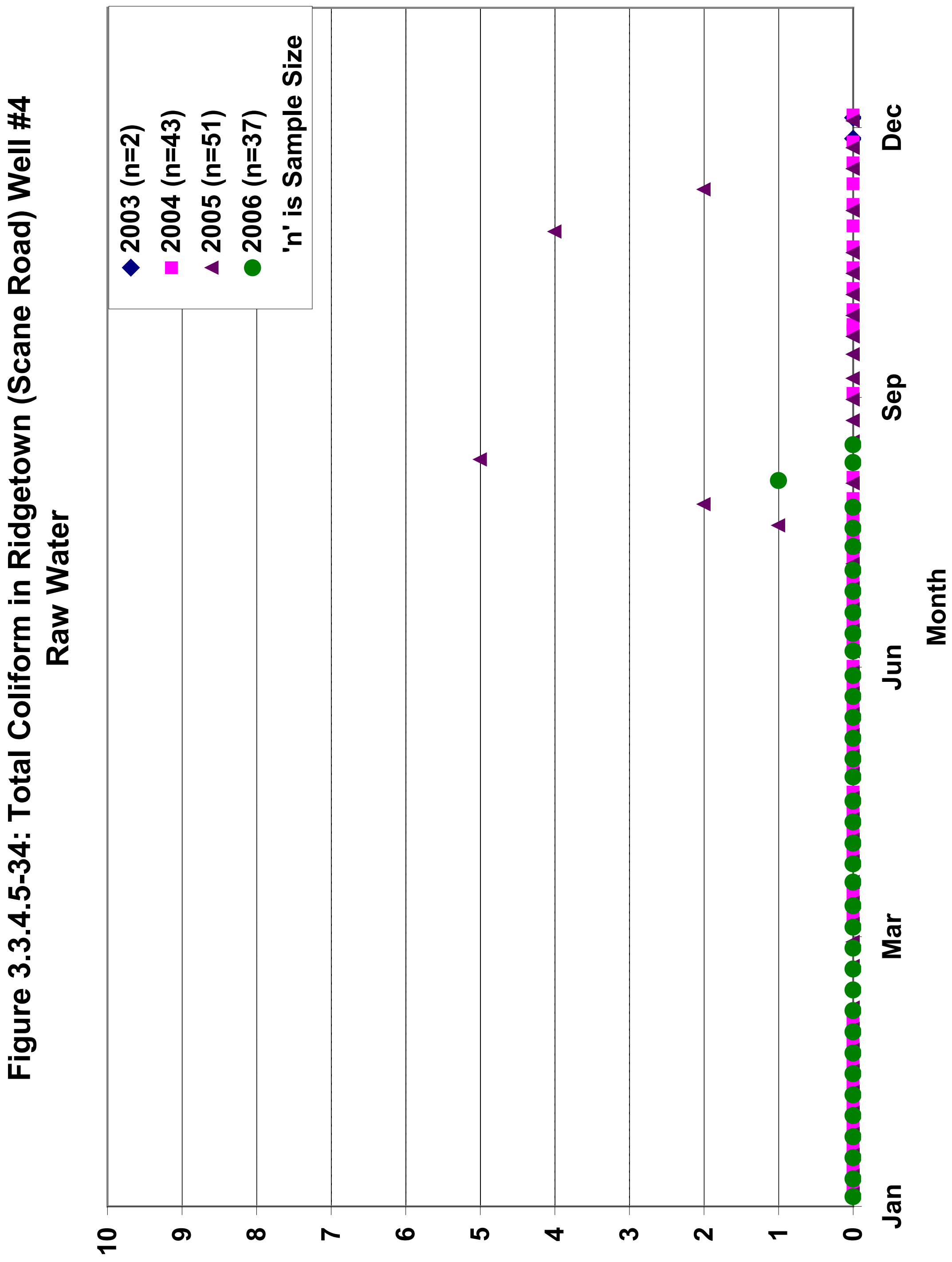


Figure 3.3.4.5-34: **Total Coliform in Ridgetown (Scane Road) Well #4 Raw Water**

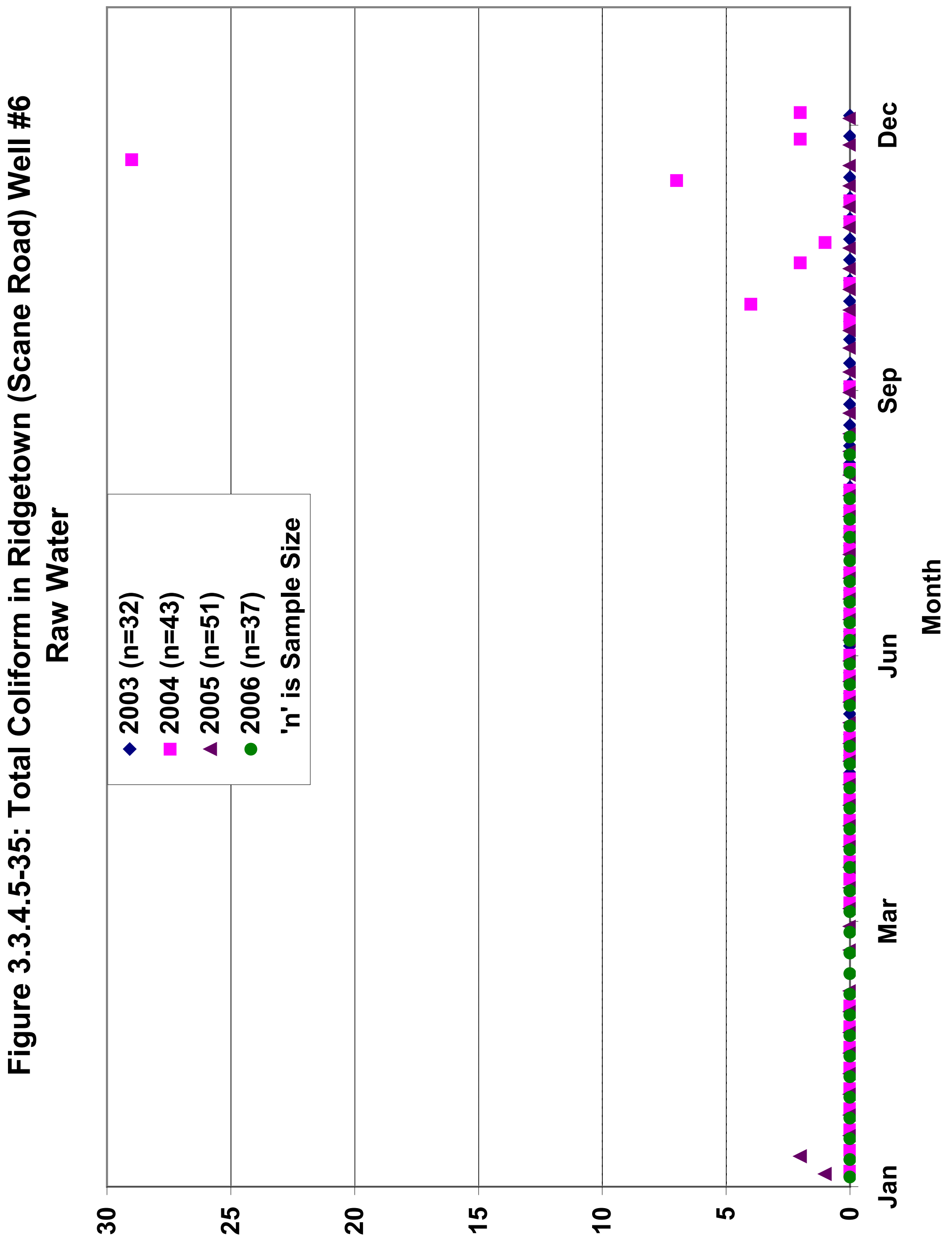


Figure 3.3.4.5-35: Total Coliform in Ridgetown (Scane Road) Well #6 Raw Water

(E) Extra Wells Reviewed

The **Table 3.3.4.4.-1: Extra Wells Analyzed** lists extra wells that are no longer in use but for which coliform information was available for review. The review is below.

(1) City of London Back Up Wells

Table 3.3.4.5-27 provides minimal information on the four decommissioned City of London back up wells: Byron, and the Komoka Wells # 1, 2 and 3. None of the decommissioned wells tested positive for coliform but the data is minimal. There were two samples from each of the Komoka wells in 2003 only. In 2006, there was one sample from the Byron well.

Table 3.3.4.5-27: Summary Data for Decommissioned City of London Wells

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
Byron	2003					
	2004					
	2005					
	2006	1	0	0	0	0
Komoka Well #1	2003	2	0	0	0	0
	2004					
	2005					
	2006					
Komoka Well #2	2003	2	0	0	0	0
	2004					
	2005					
	2006					
Komoka Well #3	2003	2	0	0	0	0
	2004					
	2005					
	2006					

Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(2) Embro Well Supply

Table 3.3.4.5-28 summarizes the raw water coliform data for the Embro Well #2. Embro Well #2 has been a monitoring well since 1998. In the DWIS data provided, for this monitoring well, data is available for 2003 and 2004 and sample sizes are small (three to four per year). There was no *E. coli* detected. However, total coliform was detected in July (maximum of 252 counts per 100 mL) and August 2003.

Table 3.3.4.5-28: Summary Data for Embro Monitoring Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#2 (monitoring well)	2003	3	0	0	2 (67%)	0-252
	2004	4	0	0	0	0
	2005					
	2006					

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

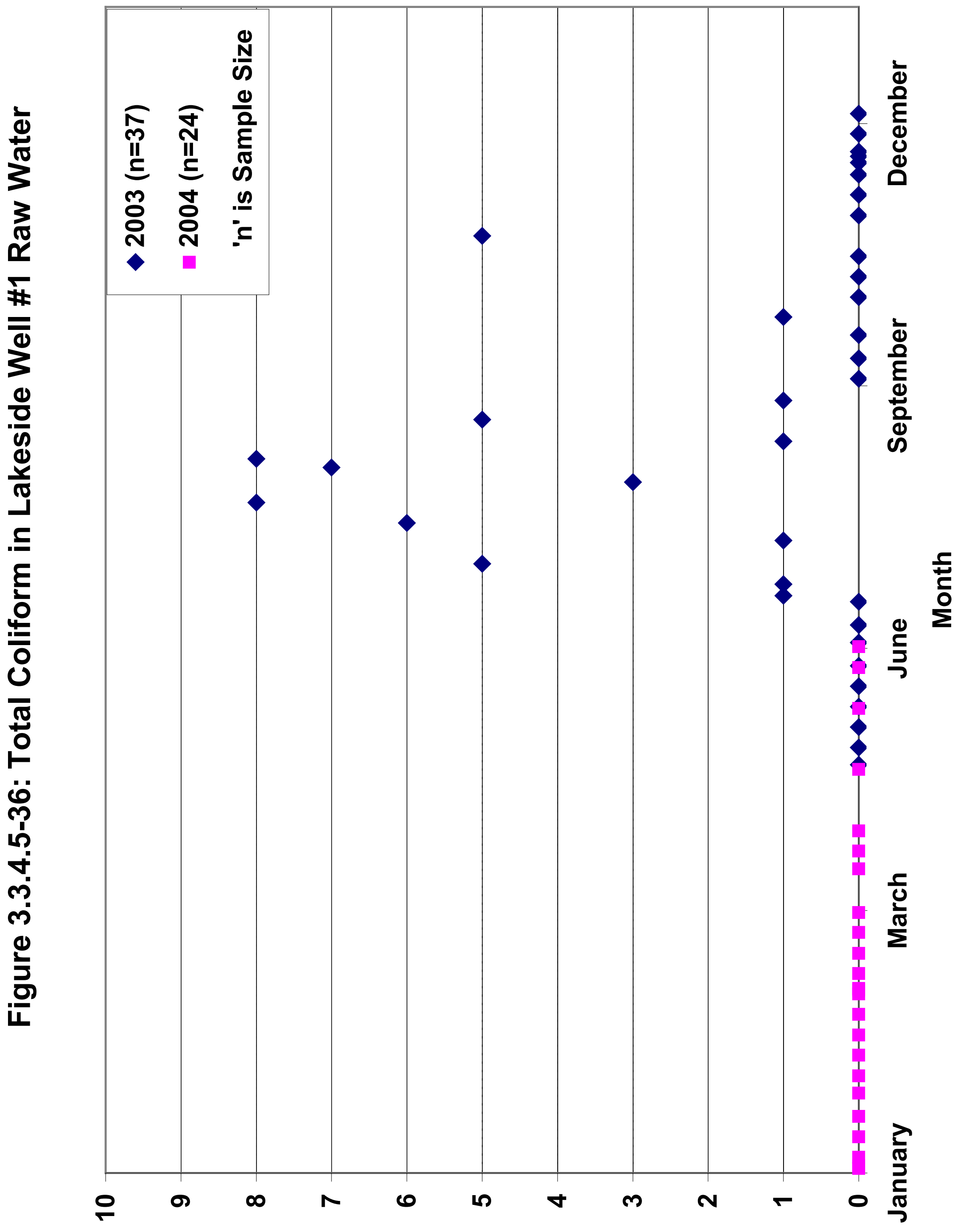
(3) Lakeside Well Supply

Table 3.3.4.5-29 summarizes the raw water coliform data for the Lakeside well #1. DWIS data from May 2003 to June 2004 was available for review of the Lakeside Well #1, which was decommissioned and sealed in December 2005. There was no *E. coli* detected; however, total coliform was detected. Well #1 had 14 occurrences of total coliform in 2003. It had no detections in 2004. Total coliform occurrence in Well #1 is graphed as a scatter plot and shown in **Figure 3.3.4.5-36**. The total coliform was detected between July and November 2003 (maximum of 8 counts per 100 mL in August and September).

Table 3.3.4.5-29: Summary Data for Decommissioned Lakeside Well

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1 (Decommissioned)	2003	37	0	0	14 (38%)	0-8
	2004	24	0	0	0	0
	2005					
	2006					

*NDMT (No Data, Missing in Transit) on April 5, 2005
Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0



Note: Lakeside Well #1 was decommissioned and sealed in 2005

Figure 3.3.4.5-36: **Total Coliform in Lakeside Well #1 Raw Water**

(4) St. Marys Well Supply

The OMOE DWIS database also has coliform data for Well #2 (22 Wellington Street) which was decommissioned in 2006. Data from May 2003 to December 2005, with large sample sizes of 125 to 247 per year with only a few months data gaps from 2005. In 2006, when the well was decommissioned, there were only three samples.

Table 3.3.4.5-30 summarizes the raw water coliform data for the St. Marys Well #2. *E. coli* was not detected. Total coliform occurred once in November 2003 and once May 2004 with counts of 1 per 100 mL.

Table 3.3.4.5-30: Summary Data for Decommissioned St. Marys Well

Well	**Year**	**Sample Size 'n'**	***Escherichia coli***		**Total coliform**	
			n1>0	**Range**	**n2>0**	**Range**
Well #2 - 22 Wellington St. N	2003	152	0	0	1 (0.7%)	0-1
	2004	247*			1 (0.4%)	0-1
	2005	125			0	0
	2006	3			0	0

*NDSF (No Data, Sample Frozen) on October 13, 2004
Note:
'Range' is minimum to maximum values; unit is coliform count/100 mL
'n1>0' is number of samples with *E. coli* values >0
'n2>0' is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0

(5) Sweaburg-Oxford Heights Subdivision Well Supply

There are two wells, Wells #1 and #2, in the Sweaburg-Oxford Heights Subdivision supply system. For both wells, coliform data from May 2003 to July 2006 is available.

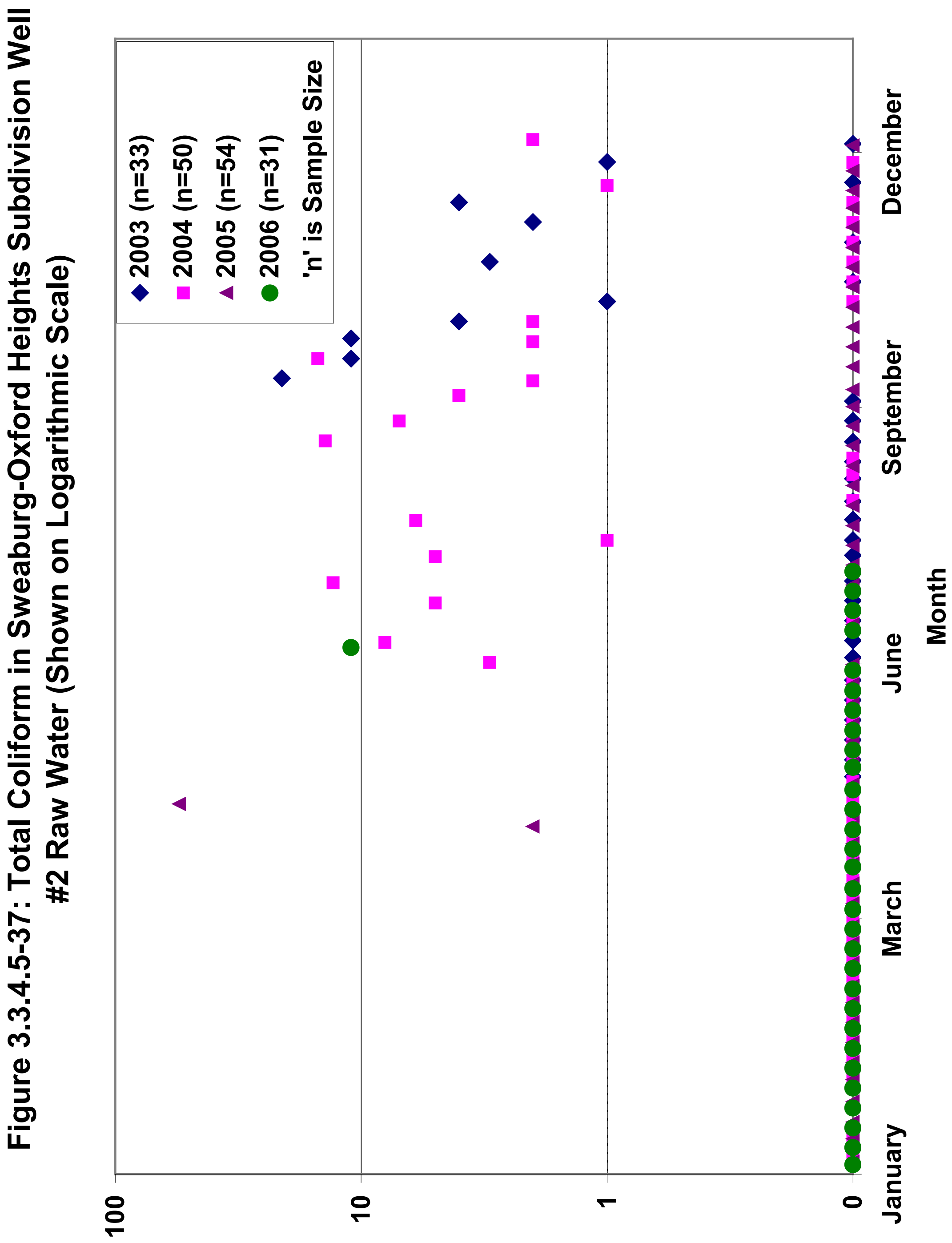
Table 3.3.4.5-31 summarizes the raw water coliform data for the Sweaburg-Oxford Heights Subdivision wells. There was no *E. coli* detected in either well. Total coliform was detected in both wells. There was only one occurrence of total coliform in Well #1 in July 2006. There were 25 occurrences of total coliform in Well #2 in 2003 and 2004. There were only three occurrences in 2005 to 2006. Maximum counts in Well #2 ranged from 11 to 55 per 100 mL. The data is graphed as a scatter plot and discussed below.

Figure 3.3.4.5-37 shows the total coliform occurrences in Well #2. Total coliform was detected several times in 2003 and 2004 in the months of June to December (note: data in 2003 starts from May). In May 2005, the highest count of 55 total coliform per 100 mL was recorded. Data in 2006 ends in July but there was one occurrence in June.

Table 3.3.4.5-31: Summary Data for Sweaburg-Oxford Heights Subdivision Wells
(No longer in use)

Well	Year	Sample Size 'n'	*Escherichia coli*		Total coliform	
			n1>0	Range	n2>0	Range
#1	2003	33	0	0	0	0
	2004	56			0	0
	2005	52			0	0
	2006	31			1 (3.2%)	0-1
#2	2003	33	0	0	9 (27%)	0-21
	2004	50			16 (32%)	0-15
	2005	54			2 (3.7%)	0-55
	2006	31			1 (3.2%)	0-11

Note:
‘Range’ is minimum to maximum values; unit is coliform count/100 mL
‘n1>0’ is number of samples with *E. coli* values >0
‘n2>0’ is number of samples with total coliform values >0
Numbers in brackets are percent of samples with values >0
As of August 3, 2006 the Sweaburg Well Supply was abandoned and customers are now served from the Woodstock Well Supply (Source of info: Annual OMOE Drinking Water System Report for the Sweaburg Well Supply (Oxford Heights Subdivision) 2006).



Note: Sweaburg-Oxford Heights subdivision well supply system is no longer in use (since August 2006)

Figure 3.3.4.5-37: **Total Coliform in Sweaburg-Oxford Heights Subdivision Well #2 Raw Water**

3.3.4.6 Provincial Groundwater Monitoring System (PGMN) – Microbiological Characterization

Map 15: Provincial Groundwater Monitoring Network shows the location of the monitoring wells in the Thames Watershed & Region. There are a total of 35 PGMN in the watershed.

There are 12 PGMN wells in the Lower Thames Valley Conservation Authority watershed. None of the PGMN wells in the LTVCA watershed are analyzed for *E. coli* or total coliform.

Of the 23 PGMN wells in the UTRCA watershed, only four wells were sampled in 2005. They were only sampled once each for *E. coli*. In 2006, 13 wells were sampled once each for *E. coli* and one well was sampled twice. The testing did not include total coliform.

Based on the low number of samples, the data in the Provincial Groundwater Monitoring Information System (PGMIS) provides limited *Escherichia coli* data to characterize microbiological water quality in the PGMN wells.

Table 3.3.4.6-1 shows the *Escherichia coli* data available for PGMN wells in the Thames Watershed & Region. All results are reported to be below a count of 10 per 100 mL, which is the laboratory detection limit used for non-drinking water groundwater samples.

Table 3.3.4.6-1: *Escherichia coli* in PGMN Wells - Thames Watershed & Region

No.	Well Name	Well ID	County	*E. coli*, count per 100 mL		
				2005	2006	Date of Sampling
1	Komoka	W0000056	Middlesex		<10	11/21/2006
2	Workshop Well	W0000437	Middlesex		<10	10/24/2006
3	Thamesford	W0000053	Oxford		<10	10/31/2006
4	Mt. Elgin	W0000055	Oxford		<10	12/19/2006
5	Innerkip	W0000180	Oxford		<10	11/8/2006
6	Golspie	W0000201	Oxford		<10	11/13/2006
7	Embro Deep	W0000369-3	Oxford		<10	11/6/2006
8	Motherwell	W0000054	Perth	<10	<10	11/22/2005, 11/3/2006
9	Wildwood	W0000076	Perth		<10	11/9/2006
10	Shakespeare Deep	W0000218-5	Perth		<10	10/30/2006
11	North Mitchell Farm	W0000219	Perth		<10	11/29/2006
12	Ellice	W0000368	Perth	<10	<10, <10	11/22/2005, 12/14/2006 (sampled twice)
13	Fish Creek Shallow	W0000371-2	Perth	<10	<10	11/23/2005, 11/23/2006
14	Fish Creek Deep	W0000371-3	Perth	<10	<10	11/23/2005, 11/23/2006

Note: All wells are in the UTRCA watershed only. PGMN wells in the LTVCA watershed are not currently analyzed for *E. coli*.

3.3.4.7 Data Gaps – Microbiological Groundwater Quality

a) Municipal Supply

Table 3.3.4.3-1 to **Table 3.3.4.3-30** show sample sizes and also indicate the limitations or gaps in coliform data for the municipal groundwater wells of the Thames Watershed & Region. The most common period of data that was available is May 2003 to September 2006. Several wells have data gaps (months or years). Wells no longer in service as drinking water supply wells generally have small sample sizes.

Our review of the water quality data obtained, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water. Differences in the period of the data sets reviewed are identified as 'data gaps.' The specific reasons for these gaps in data are not ascertained and are not relevant to the characterizing of the water source. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these 'data gaps.' The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

b) PGMN Wells

- None of the LTVCA PGMN wells were analysed for *E. coli* or total coliform.
- Not all PGMN wells in the UTRCA watershed were analyzed for *E. coli*. Of the 23 UTRCA watershed PGMN wells, only four wells were sampled in 2005 while 15 were sampled in 2006.
- The laboratory detection limit (10 per 100 mL) used for non-drinking water groundwater samples is higher than drinking water source testing.
- None of the PGMN wells in the Thames Watershed & Region were analyzed for total coliform.

3.4 Raw Water Characterization for Drinking Water Intakes

This section of the Watershed Characterization Report provides a summary of the surface water intakes for the water treatment plants that supply drinking water to communities in the Thames Watershed & Region and an evaluation of the intake raw water quality in terms of physical, chemical and microbial parameters. It also provides an overview of monitoring programs for the surface water sources for the intakes.

3.4.1 Surface Water Intakes

Lake Erie and Lake Huron are the two major surface water sources of drinking water for residents living in the Thames Watershed & Region. Some residents also receive treated Lake St. Clair water.

Pumping stations pump raw water from the lakes to water treatment plants (WTP) where the water is treated, often stored in reservoirs and passed on through pipelines to residents. **Table 3.4.1-1: Intakes Servicing the Thames Watershed & Region** identifies the eight water treatment facilities that supply parts of the region and their intake sources.

Map 38: Drinking Water Systems/Intakes shows the location of these Great Lakes drinking water intakes. The Chatham and the South Chatham-Kent Water Treatment Plants share a common intake making the total number of intakes seven. Four of the intakes and treatment plants are located outside the watershed but supply water to systems that service communities in the Thames Watershed & Region.

Table 3.4.1-1: Intakes Servicing the Thames Watershed & Region

System	Intake Source
Chatham Water Treatment Plant* South Chatham-Kent Water Treatment Plant* West Elgin Water Treatment Plant Wheatley Water Treatment Plant Union Water Supply System** Elgin Primary Area Water Supply**	Lake Erie
Lake Huron Primary Area Water Supply**	Lake Huron
Stoney Point Water Treatment Plant**	Lake St. Clair

* Shared intake
**Located outside of the SWP area

Lake Erie is the smallest of the Great Lakes (483 km^3) by volume. During the 1960s, it was known as the 'dead lake' due to eutrophication caused by excessive phosphorus loading from municipal sewage and agricultural runoff. In the late 1990s, agricultural and urban land uses within the Lake Erie watershed were the highest in the Great Lakes basin[103]. Pathogens such as *E. coli*, a type of fecal coliform bacteria, are also a problem in the waters of Lake Erie[104].

Lake Huron is the second largest Great Lake by surface area and the third largest by volume (3540 km^3). Contaminants to Lake Huron originate from a number of sources, including industrial and municipal discharges, spills, landfills, storm sewers, and agricultural runoff[105]. Lake Huron has a low degree of industrialization compared to the other Great Lakes. The southeast shore of Lake Huron (Sauble Beach to Sarnia) and the St. Clair River have numerous beach closures and warnings due to algae and *E. coli*[105].

Lake St. Clair, together with the St. Clair River and the Detroit River, provides the connection channel between Lake Huron and Lake Erie. Lake St. Clair is considered to be part of the Lake Erie basin, and is small by volume[106] (4.17 km^3). Roughly 98% of the water entering Lake St. Clair originates from Lake Huron via the St. Clair River[107]. The southeastern (Canadian) part of Lake St. Clair is relatively stable water enriched by nutrients inflowing from tributaries with inputs from agricultural drainage and urban development[108]. Toxic chemicals identified in Lake St. Clair impair water use for drinking, fish consumption and recreational purposes. The Sarnia, Ontario, industrialized area has contributed metals, PCBs (polychlorinated biphenyls) and other toxic chemicals to the lake through the St. Clair River[109]. Spills into the St. Clair River are a concern on both sides of the border, as they can compromise water quality[110].

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[104] Lake Erie LaMP Management Committee. April 2006. The Lake Erie Lakewide Management Plan 2006 Report.

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[106] Great Lakes Information Network website, Lake St. Clair Facts and Figures. www.great-lakes.net/lakes/ref/stclfact.html

[107] Lake St. Clair Canadian Watershed Coordination Council. 2005. The Lake St. Clair Canadian Watershed Draft Technical Report: An examination of current conditions.

[108] Leach, J.H. 1980. Limnological sampling intensity in Lake St. Clair in relation to distribution of water masses. In Journal of Great Lakes Research.

[109] Lake St. Clair: Its Current State and Future Prospects. 1999. Conference Summary Report. Conference held at Thomas Edison Inn, Port Huron, MI, Nov. 30-Dec. 1, 1999.

[110] United States Army Corps of Engineers and the Great Lakes Commission. June 2004. St. Clair River and Lake St. Clair Comprehensive Management Plan.

3.4.1.1 Surface Water Intakes within the Thames Watershed & Region

Three of the seven surface water intakes servicing municipalities in the region are located within the Thames Watershed & Region. All of these surface water intakes are along the Lake Erie shoreline in the LTVCA watershed. The intakes are at Erie Beach, at West Lorne, and south of Wheatley as shown on **Map 38: Drinking Water Systems/Intakes.**

The intake at Erie Beach feeds the Chatham Water Treatment Plant (WTP), which supplies treated water to Chatham and Thamesville as well as central and northern parts of Chatham-Kent. The maximum flow rate capacity of the Chatham WTP is 68,190 m^3/day and the population served is 60,000[111]. The same intake also provides raw water to the South Chatham-Kent WTP, which supplies water to the lower portion of the Municipality of Chatham-Kent. This plant has a capacity of 22,800 m^3/day and it services a population of 10,500.

The intake at West Lorne provides raw water to the West Elgin WTP which supplies treated water to the Municipalities of Dutton-Dunwich and South-west Middlesex, the community of Bothwell in Chatham-Kent, and the Village of Newbury in Middlesex County. The West Elgin WTP serves a population of 9,985 and has a maximum capacity of 6,829 m^3/day[112].

The Lake Erie intake south of Wheatley feeds the Wheatley WTP, which supplies drinking water to the Village of Wheatley, a portion of Mersea Township, a portion of Romney and Wheatley Provincial Park, Town of Tilbury, and parts of the former Townships of Tilbury North and Tilbury East[113]. Its treatment capacity is 10,200 m^3/day and it serves a total population of 3,800[114].

3.4.1.2 Surface Water Intakes outside the Thames Watershed & Region

Four surface water intakes and treatment plants are located outside of the Thames Watershed & Region and supply water to systems that service municipalities within the watershed. They take water from Lake Huron at Grand Bend, Lake St. Clair at Stoney Point, and Lake Erie at Union and near Port Stanley.

Lake Huron Intake

The Lake Huron Primary Water Supply System (LHPWSS) services the City of London and parts of the Municipalities of Middlesex Centre, Lucan-Biddulph and Strathroy-Caradoc. The WTP is located in South Huron north of the community of Grand Bend. The plant has a current treatment capacity of 340,000 m^3/d (340 million litres per day or 75 million Imperial gallons per day) and it serves a population of approximately 325,000 people.[115]

Lake Erie Intakes

The Elgin Area Primary Water Supply System (EAPWSS) services the municipalities of London and Southwold in the Thames Watershed & Region. The WTP is located east of the community of Port Stanley in Central Elgin. The plant has a current treatment capacity of 90,000 m^3/d (90 million litres per day or 20 million Imperial gallons per day) and it supplies water to a population of approximately 94,400 people[115].

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[111] Municipality of Chatham-Kent. 2006. Yearly Compliance Report for the Chatham Water Treatment Plant.

[112] OMOE. Drinking Water System Inspection Report for the West Elgin Water Treatment Plant, Inspection Number 1-57S5L, 2006.

[113] OMOE. Drinking Water System Number 220003332, Ontario Ministry of the Environment Annual Report, 2004.

[114] OMOE. Drinking Water System Number 220003332, Ontario Ministry of the Environment Annual Report, 2003.

[115] City of London. October 19, 2005. Lake Huron & Elgin Area Water Supply Systems. http://watersupply.london.ca.

The Union Water Supply System has a raw water intake located west of the Town of Leamington on Lake Erie. It services rural areas that are part of the LTVCA watershed[116] in the former Township of Mercia, which is now part of the Municipality of Leamington. It services an estimated population of 56,000 including the rest of the Municipality of Leamington, the Town of Kingsville, a portion of the Town of Essex, and a portion of the Town of Lakeshore[117]. The current rated capacity of the Union Water Supply System is 124,589 m^3/day[118].

Lake St. Clair Intake

The Stoney Point Water Treatment Plant intake is located west of Lighthouse Cove on Lake St. Clair. It services the northeast portion of the Town of Lakeshore[119] including Lighthouse Cove and Comber in the Thames watershed[116]. The maximum treatment capacity is 4600 m^3/day[120] and it serves a total population of 5800[121].

3.4.2 Water Quality Parameter Selection and Standards

As discussed in **Section 3.1.2: Selecting Parameters for Drinking Water Intake Quality**, a 'multi-tier' parameter review was done to determine the parameters that would be used to assess intake water quality. The drinking water quality standards and the aquatic life protection standards for these parameters were identified as part of **Section 3.1.4: Water Quality Standards, Objectives and Guidelines.**

Drinking water standards are established for treated drinking water supplied to communities. In this report, the data for raw (untreated) water is compared to the treated water standards since there are no standards specifically for raw water. The comparison with the treated water standards is only intended to provide a means of quality assessment using a reference number (the standard) and is not intended to judge conformance of raw water to the standards.

The Ontario Drinking Water Standards (ODWS) are used to assess the quality of intake source water for most of the parameters. However, not all of the parameters, for example phosphorus, have an ODWS. Where the ODWS is not available, an alternative assessment standard was established by using:

- The United States Environmental Protection Agency (USEPA) Maximum Concentration Level (MCL) from the USEPA National Primary Drinking Water Regulations,[122] or
- Ontario Provincial Water Quality Objectives (for healthy aquatic life) when the USEPA MCLs are not available.

Table 3.4.2-1: Water Quality Standards, Objectives and Guidelines provides a summary of the current (most recent) standards that were used to evaluate the intake water quality.

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[116] Lower Thames Valley Conservation Authority. February 2007. Personal communication.

[117] OMOE. Drinking Water System Number 210000853, Ontario Ministry of the Environment Annual Report, 2005.

[118] OMOE. April 7, 2004. Part 4 of the Certificate of Approval Drinking Water Systems Number 8328-5WNJBZ for the Union Water Supply System.

[119] OMOE. Drinking Water System Number 220003396, Ontario Ministry of the Environment Annual Report, 2005.

[120] OMOE. December 18, 2000. Permit to Take Water #00-P-1366.

[121] OMOE. Drinking Water System Number 220003396, Ontario Ministry of the Environment Annual Report, 2006.

[122] USEPA. Drinking Water Contaminants – Organic Chemicals. www.epa.gov/safewater/contaminants/index.html#organic

Table 3.4.2-1: Water Quality Standards, Objectives and Guidelines

Parameter	Standard/Guideline
Basic Parameters	
Phosphorus	0.02 mg/L (IPWQO - lakes)[b]
Nitrate	10 mg/L (ODWS MAC)[a]
Turbidity	5 NTU (ODWS AO)[a]
Chloride	250 mg/L (ODWS AO)[a]
pH	6.5 to 8.5 (ODWS OG)[a]
Temperature	15^{0}C (ODWS AO)[a]
Total coliform	Not detectable (ODWS MAC)[a]
Escherichia coli	Not detectable (ODWS MAC)[a]
Ontario Regulation 170/03 Schedule 23 Inorganic Parameters	
Antimony	0.006 mg/L (ODWS IMAC)[a]
Arsenic	0.025 mg/L (ODWS IMAC)[a]
Barium	1 mg/L (ODWS MAC)[a]
Boron	5 mg/L (ODWS IMAC)[a]
Cadmium	0.005 mg/L (ODWS MAC)[a]
Chromium	0.05 mg/L (ODWS MAC)[a]
Mercury	0.001 mg/L (ODWS MAC)[a]
Selenium	0.01 mg/L (ODWS MAC)[a]
Uranium	0.02 mg/L (ODWS MAC)[a]
Ontario Regulation 170/03 Schedule 24 Organic Parameters	
Alachlor	0.005 mg/L (ODWS IMAC)[a]
Aldicarb	0.009 mg/L (ODWS MAC)[a]
Aldrin + Dieldrin	0.0007 mg/L (ODWS MAC)[a]
Atrazine + N-dealkylated metabolites	0.005 mg/L (ODWS IMAC)[a]
Azinphos-methyl	0.02 mg/L (ODWS MAC)[a]
Bendiocarb	0.04 mg/L (ODWS MAC)[a]
Benzene	0.005 mg/L (ODWS MAC)[a]
Benzo(a)pyrene	0.00001 mg/L (ODWS MAC)[a]
Bromoxynil	0.005 mg/L (ODWS IMAC)[a]
Carbaryl	0.09 mg/L (ODWS MAC)[a]
Carbofuran	0.09 mg/L (ODWS MAC)[a]
Carbon Tetrachloride	0.005 mg/L (ODWS MAC)[a]
Chlordane (Total)	0.007 mg/L (ODWS MAC)[a]
Chlorpyrifos	0.09 mg/L (ODWS MAC)[a]
Cyanazine	0.01 mg/L (ODWS IMAC)[a]
Diazinon	0.02 mg/L (ODWS MAC)[a]

Parameter	Standard/Guideline
Dicamba	0.12 mg/L (ODWS MAC)[a]
1,2-Dichlorobenzene	0.2 mg/L (ODWS MAC)[a]
1,4-Dichlorobenzene	0.005 mg/L (ODWS MAC)[a]
Dichlorodiphenyltrichloro-ethane (DDT) + metabolites	0.03 mg/L (ODWS MAC)[a]
1,2-dichloroethane	0.005 mg/L (ODWS IMAC)[a]
1,1-Dichloroethylene	0.014 mg/L (ODWS MAC)[a]
Dichloromethane	0.05 mg/L (ODWS MAC)[a]
2,4-Dichlorophenol	0.9 mg/L (ODWS MAC)[a]
2,4-Dichlorophenoxy acetic acid (2,4-D)	0.1 mg/L (ODWS IMAC)[a]
Diclofop-methyl	0.009 mg/L (ODWS MAC)[a]
Dimethoate	0.02 mg/L (ODWS IMAC)[a]
Dinoseb	0.01 mg/L (ODWS MAC)[a]
Diquat	0.07 mg/L (ODWS MAC)[a]
Ontario Regulation 170/03 Schedule 24 Organic Parameters	
Diuron	0.15 mg/L (ODWS MAC)[a]
Glyphosate	0.28 mg/L (ODWS IMAC)[a]
Heptachlor + Heptachlor Epoxide	0.003 mg/L (ODWS MAC)[a]
Lindane (Total)	0.004 mg/L (ODWS MAC)[a]
Malathion	0.19 mg/L (ODWS MAC)[a]
Methoxychlor	0.9 mg/L (ODWS MAC)[a]
Metolachlor	0.05 mg/L (ODWS IMAC)[a]
Metribuzin	0.08 mg/L (ODWS MAC)[a]
Monochlorobenzene	0.08 mg/L (ODWS MAC)[a]
Paraquat	0.01 mg/L (ODWS IMAC)[a]
Parathion	0.05 mg/L (ODWS MAC)[a]
Pentachlorophenol	0.06 mg/L (ODWS MAC)[a]
Phorate	0.002 mg/L (ODWS IMAC)[a]
Picloram	0.19 mg/L (ODWS IMAC)[a]
Polychlorinated Biphenyls (PCB)	0.003 mg/L (ODWS IMAC)[a]
Prometryne	0.001 mg/L (ODWS IMAC)[a]
Simazine	0.01 mg/L (ODWS IMAC)[a]
Temephos	0.28 mg/L (ODWS IMAC)[a]
Terbufos	0.001 mg/L (ODWS IMAC)[a]
Tetrachloroethylene (perchloroethylene)	0.03 mg/L (ODWS MAC)[a]
2,3,4,6-Tetrachlorophenol	0.1 mg/L (ODWS MAC)[a]
Triallate	0.23 mg/L (ODWS MAC)[a]
Trichloroethylene	0.005 mg/L (ODWS MAC)[a]

Parameter	Standard/Guideline
2,4,6-Trichlorophenol	0.005 mg/L (ODWS MAC)[a]
2,4,5-Trichlorophenoxy acetic acid (2,4,5-T)	0.28 mg/L (ODWS MAC)[a]
Trifluralin	0.045 mg/L (ODWS IMAC)[a]
Vinyl Chloride	0.002 mg/L (ODWS MAC)[a]
SOLEC 2007 Parameters	
Nitrite	1.0 mg/L (ODWS MAC)[a]
Dissolved Organic Carbon	5 mg/L (ODWS AO)[a]
IJC 1993, Lake Erie LaMP 2006 Parameters	
Toxaphene	0.003 mg/L (USEPA MCL)[c]
2,3,7,8 TCDD (dioxin)	0.000000015 mg/L (ODWS IMAC)[a]
2,3,7,8 TCDF	0.000000015 mg/L (ODWS IMAC)[a]
Mirex (dechlorane)	0.001 ug/L (PWQO)[b]
Hexachlorobenzene	0.001 mg/L (USEPA MCL)[c]
Lake Huron IAP 2002	
Nickel	25 ug/L (PWQO)[b]
Lake Erie LaMP 2006, Lake Huron IAP 2002	
Lead	10 µg/L (ODWS MAC)[a]
Copper	1000 µg/L (ODWS AO)[a]
Zinc	5 mg/L (ODWS AO)[a]
Lake Erie LaMP 2006	
Alpha-hexachlorocyclohexane	None
Beta-hexachlorocyclohexane	None
Pentachlorobenzene	0.03 µg/L (PWQO)[d]
Anthracene	0.0008 µg/L (Emergency IPWQO)[e]
benzo(a)anthracene	0.0004 µg/L (Emergency IPWQO)[e]
benzo(b)fluoranthene	None
Benzo(k) fluoranthene	0.0002 µg/L (Emergency IPWQO)[e]
Benzo(g,h,i)perylene	0.00002 µg/L (Emergency IPWQO)[e]
Chrysene	0.0001 µg/L (Emergency IPWQO)[e]
fluoranthene	0.0008 µg/L (Emergency IPWQO)[e]
phenanthrene	0.03 µg/L (Emergency IPWQO)[e]
Indeno(123-cd)pyrene	None
Parameters from DWS Reports - Chatham WTP, Wheatley WTP and Elgin PAWS	
Hardness	80-100 mg/L (ODWS OG)[a]
Aluminum	0.1 mg/L (ODWS OG)[a]

ODWS: Ontario Drinking Water Standard
    MAC: Maximum Acceptable Concentration
    IMAC: Interim Maximum Acceptable Concentration
    AO: Aesthetic Objective

OG: Operational Guidelines
PWQO: Provincial Water Quality Objective
IPQWO: Interim Provincial Water Quality Objective
Emergency IPWQO: Emergency Interim Provincial Water Quality Objective
USEPA: United States Environmental Protection Agency
MCL: Maximum Concentration Level

Source of Water Standard, Guideline or Objective in Table 3.4.2-1:
[a]Ministry of the Environment. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. http://www.ene.gov.on.ca/envision/gp/4449e.pdf.
[b]OMOE. 1979. Rationale for the establishment of Ontario's Water Quality Objectives. 236 pp.
[c]OMOEE. 1996. Scientific Criteria Document for the Development of Provincial Water Quality Objectives and Guidelines - Antimony. PIBS 3348e02, 32 pp.
[d]OMOE. 1984. Scientific Criteria Document for Standard Development - Chlorinated Benzenes in the Aquatic Environment. 197 pp.
[e]Ministry of the Environment. 1994. Water Management: Policies, Guidelines, Provincial Water Quality Objectives. http://www.ene.gov.on.ca/envision/gp/3303e.pdf.

3.4.3 Existing Monitoring Programs

There are a number of monitoring programs that can provide data to assess intake and source water quality.

(1) Drinking Water Surveillance Program (DWSP)

The Drinking Water Surveillance Program (DWSP) is a voluntary program operated by the Ministry of the Environment (OMOE) in cooperation with municipalities to gather scientific data on drinking water quality in Ontario. This OMOE program was started in 1990 and raw water quality from both groundwater and surface water sources is monitored for a comprehensive suite of inorganic, organic, and radiological parameters. Monitoring frequency ranges from two to six samples per year depending on the variability of water source quality.

For surface water sources supplying communities in the Thames Watershed & Region, the intakes to the Chatham WTP, Stoney Point WTP, Lake Huron PWSS, Elgin Area PWSS and Union WSS are currently DWSP monitoring stations[123].

(2) Drinking Water Information System (DWIS)

The Drinking Water Systems Regulation (Ontario Regulation 170/03) of the Safe Drinking Water Act (2002) requires that municipal drinking water systems sample raw water supplies (and treated water). Data collected are archived in the Drinking Water Information System (DWIS)[124] of the Drinking Water Management Division of the OMOE. All municipal sources and systems that are provincially regulated surface water treatment plants are part of this system. **Map 38: Drinking Supplies/Intakes** shows the locations of water treatment plants intakes and associated water supply systems in the Thames and SCRCA watersheds. This map also shows the communities that utilize groundwater.

At the time this report was prepared, DWIS data sets were not available for all of the plants supplying communities in the Thames Watershed and Region. The DWIS data sets for the Chatham, South Chatham-Kent and West Elgin water treatment plants were available for review.

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[123] OMOE. Drinking Water Surveillance Program Summary Report for 2000, 2001 and 2002. www.ene.gov.on.ca/envision/water/dwsp/0002/index.htm

[124] OMOE. 2006. Ontario Safe Drinking Water Act: Drinking Water Systems under O. Reg. 170/03. www.ontario.ca/ONT/portal51/drinkingwater/Combo?docId=STEL01_049278&breadcrumbLevel=1&lang=en

(3) Drinking Water System (DWS) Reports & Plant Operation Records

Drinking Water System Reports for provincially regulated plants must be submitted annually to the OMOE. Also, additional Plant Operation Records of routine monitoring are kept at the plants. Both of these can provide supplementary information on water quality before and after treatment. In some cases, the information on treated water quality can be useful in evaluating source (raw) water quality if the plant treatment processes do not have a significant impact on the parameters being assessed.

(4) Great Lakes Monitoring

The following are Great Lakes monitoring programs that assess lake water quality. Data sets from these programs were not used as part of this review of water treatment plant intake (raw) water quality. However, information from these programs may be useful in assessing water source quality for Great Lakes intakes.

(a) Great Lakes Index Station Network

Fifty-seven index stations[125] have been established throughout the Great Lakes basin in areas that are representative of background (ambient) conditions and provide information on how conditions are changing. The Environmental Monitoring and Reporting Branch of the OMOE performs the sampling. Priority toxic contaminants in sediment and suspended particulate material are monitored. Spring, summer, and fall water sampling is done for various physical and chemical measurements. The information can be used to describe background water quality conditions for drinking water intakes in the Great Lakes.

In the Thames Watershed & Region watershed area, there is one location in a nearshore area of Lake Erie at Pointe Aux Pins/Rondeau (near the Erie Beach intake) and another on Lake St. Clair at Lighthouse Cove (near the Stoney Point intake). Other stations outside the watershed but near intakes that service populations within the watershed are on Lake Huron at Cape Ipperwash (near the Grand Bend intake) and on Lake Erie at Port Stanley (close to the Elgin Area PWSS intake)[126].

(b) Great Lakes Nearshore Reconnaissance Monitoring

Reconnaissance monitoring[125] is designed to identify the status of environmental indicators in the immediate nearshore zone most directly affected by land-based activities. Sampling is undertaken for nutrient, bacteriological, physical, and aesthetic features of water quality along specific ranges of shoreline. In addition, Harbour Sediment Quality Screening involving sampling for trace contaminants and sediment quality is also conducted. Data from these programs can be used to assess potential impacts of land-based activities on drinking water intakes in the Great Lakes nearshore. Under this program, the Great Lakes are sampled in a multi-year cycle, as shown below in **Table 3.4.3-1: Nearshore Reconnaissance Monitoring**.

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[125] OMOE. November 1999. Surface Water Monitoring and Assessment, 1997 Lake Ontario Report. www.ene.gov.on.ca/envision/techdocs/3933-1.htm

[126] OMOE staff. Personal communication.

Table 3.4.3-1: Nearshore Reconnaissance Monitoring

Year	Lake Basin/Connecting Channel Unit
1997	Lake Ontario, St. Lawrence River, Niagara River
1998	Lake Erie, Detroit River, Lake St. Clair, St. Clair River
1999	Lake Superior, St. Marys River, North Channel
2000	Lake Ontario, St. Lawrence River, Niagara River
2001	Lake Erie, Detroit River, Lake St. Clair, St. Clair River
2002	Lake Huron, Georgian Bay

(c) Great Lakes Water Intake Biomonitoring

Water intake biomonitoring[125] is undertaken to identify long-term trends in nutrient status using year-round (weekly-monthly) nutrient concentrations and phytoplankton biomass as indicators. Monitoring has been ongoing for more than 20 years from raw intake water at 18 water treatment plants that draw water from the Great Lakes. Results are used to assess the effectiveness of nutrient management programs in the Great Lakes. A secondary benefit of this monitoring data is that it may provide an indication of effects from a variety of stressors not actively monitored in the aquatic environment (e.g. climate change). Information from this program was used by the Ausable Bayfield Conservation Authority (ABCA) review of the Lake Huron Primary Water Supply System intake.

3.4.4 Water Quality Monitoring, Results and Analysis

In this section of the Watershed Characterization Report, water quality is examined for the eight surface water intakes that draw raw water from Lake Huron, Lake St. Clair and Lake Erie to supply communities in the Thames Watershed & Region.

The Lake Huron Primary Water Supply System (LHPWSS) takes water from Lake Huron, and the Stoney Point Water Treatment Plant draws water from Lake St. Clair. Six plants (Union, Wheatley, Chatham, South Chatham-Kent, West Elgin and Elgin Area Primary) obtain water from Lake Erie. The South Chatham-Kent WTP intake raw water is the same as for the Chatham WTP. In this Report, the only the data from the Chatham WTP is used to characterize the water quality for this intake.

3.4.4.1 Sources of Data

The main sources of data used to examine intake raw water quality in this Report were the Drinking Water Surveillance Program (DWSP) and Drinking Water Information System (DWIS) database. In addition, information from Drinking Water System (DWS) Reports and local Plant Operation Records was used to help in the review.

Drinking Water Surveillance Program (DWSP)

The DWSP data from 1990 to 2005 was used to analyze the physical and chemical characteristics of raw water for the

- Chatham WTP,
- West Elgin WTP,
- Elgin Area PWSS, and
- Lake Huron PWSS.

The DWSP data is comprised of annual average, minimum and maximum values. There is some data missing for different parameters and years. DWSP data for early 1990s fecal coliform counts were available for some raw water intakes.

No DWSP data was available for the Wheatley WTP and the West Elgin WTP. For these plants, information was used from the water treatment plant continuous analyzer data for pH, turbidity and temperature, as well as independent laboratory results of inorganic and organic parameters. The monthly minimum, maximum and average levels from continuous analyzer data were used to obtain annual minimum, maximum and average data used in this Report.

Drinking Water Information System (DWIS), Drinking Water System (DWS) & Plant Operational Records

The Drinking Water Information System (DWIS) database provides total coliform and *E. coli* data on a weekly basis from 2003 to 2006 for most raw water intakes. As well, annual Drinking Water System (DWS) Reports prepared by WTPs and WSSs include raw water bacterial analysis results (annual minimum and maximum values) that were used to analyze total coliform and *E. coli* data.

At the time this report was prepared, DWIS databases for the Chatham, South Chatham-Kent and West Elgin water treatment plants were available. The data is on a weekly basis from 2003 to 2006 (some months' data missing for some intakes). In addition, the WTP laboratory monitoring reports for Chatham WTP and West Elgin WTP provide 2001 and 2002 *E. coli* and total coliform counts (annual minimum and maximum values) for those plants. Limited data on fecal coliform counts in the 1990s is available in the DWSP database, as annual minimum, maximum and average values for Chatham, Lake Huron and Elgin Area water treatment plants.[127]

DWIS databases were not available for the Wheatley WTP, Elgin Area WSS and Lake Huron PWSS. The coliform data for Wheatley WTP is obtained from the annual DWS reports (annual minimum and maximum values for 2000 to 2003) available from the Chatham-Kent municipal website and the Chatham-Kent Municipality Compliance Reports (2004 to 2006). For both Elgin Area PWSS and Lake Huron PWSS, the annual DWS reports provided 2003 and 2004 data (annual minimum and maximum values). In addition, laboratory monitoring reports provide 2005 and 2006 data (sampling frequency of two to three times per week).

Information on number of samples per parameter, year and surface water intake are shown in:

- **Table 3.4.4.1-1: Sample Size for Surface Water Intakes - Basic Parameters**
- **Table 3.4.4.1-2a: Sample Size for Surface Water Intakes - Other Parameters**
- **Table 3.4.4.1-2b: Sample Size for Surface Water Intakes - Hardness & Aluminum**

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[127] OMOE. Drinking Water Surveillance Program Summary Report for 2000, 2001 and 2002. www.ene.gov.on.ca/envision/water/dwsp/0002/index.htm

Table 3.4.4.1-1: Sample Size for Surface Water Intakes - Basic Parameters

Parameter	Chatham WTP	n	Elgin PWSS	n	Lake Huron PWSS	n	West Elgin WTP	n	Wheatley WTP	n
Phosphorus	1990	12	1990	6	1990	6				
	1991	6	1991	6	1991	6				
	1992	4	1992	4	1992	4				
	1993	5	1993	4	1993	4				
	1994	4	1994	4	1994	4				
	1995	4	1995	4	1995	4				
	1996	2	1996	2	1996	2	Data Gap			
	1997	2	1997	3	1997	2				
	1998	2	1998	2	1998	2				
	1999	2	1999	2	1999	2				
	2000	2	2000	2	2000	1			2000	1
	2001	3	2001	1	2001	1			2001	4
	2002	2	2002	2	2002	1			2002	3
	2003	2	2003		2003					
	2004	2	2004	2	2004	2				
	2005	2	2005		2005					
Nitrate	1990	12	1990	6	1990	6				
	1991	6	1991	6	1991	6				
	1992	4	1992	4	1992	4				
	1993	5	1993	4	1993	4				
	1994	4	1994	4	1994	4				
	1995	4	1995	4	1995	4				
	1996	2	1996	2	1996	2				
	1997	2	1997	3	1997	2				
	1998	2	1998	2	1998	2				
	1999	2	1999	2	1999	2				
	2000	2	2000	2	2000	1			2000	1
	2001	3	2001	1	2001	1	2001	4	2001	4
	2002	2	2002	2	2002	1	2002	4	2002	3
	2003	2	2003		2003		2003	2		
	2004	2	2004	2	2004	2				
	2005	2	2005		2005					

Parameter	Chatham WTP	n	Elgin PWSS	n	Lake Huron PWSS	n	West Elgin WTP	n	Wheatley WTP	n
Turbidity	1990	12	1990	6	1990	6				
	1991	6	1991	6	1991	6				
	1992	4	1992	4	1992	4				
	1993	5	1993	4	1993	4				
	1994	4	1994	4	1994	4				
	1995	4	1995	4	1995	4				
	1996	2	1996	2	1996	2				
	1997	2	1997	3	1997	3				
	1998	2	1998	10	1998	5				
	1999	2	1999	5	1999	3				
	2000	2	2000	1	2000	1			2000	1
	2001	3	2001		2001	1	2001	365	2001	4
	2002	2	2002	2	2002	1	2002	365	2002	3
	2003	2	2003		2003		2003	365	2003	
	2004	3	2004	2	2004	2	2004	366	2004	
	2005	3	2005		2005		2005	365	2005	
	2006		2006		2006		2006	365	2006	
Chloride	1990	12	1990	6	1990	6				
	1991	6	1991	6	1991	6				
	1992	4	1992	4	1992	4				
	1993	5	1993	4	1993	4				
	1994	4	1994	4	1994	3				
	1995	4	1995	4	1995	4				
	1996	2	1996	2	1996	2				
	1997	2	1997	3	1997	2				
	1998	2	1998	2	1998	1				
	1999	2	1999	2	1999	2				
	2000	2	2000	2	2000	1			2000	1
	2001	3	2001	1	2001	1	2001	4	2001	4
	2002	2	2002	2	2002	1	2002	2	2002	3
	2003	2	2003		2003					
	2004	2	2004	2	2004	2				
	2005	2	2005		2005					

Parameter	Chatham WTP	n	Elgin PWSS	n	Lake Huron PWSS	n	West Elgin WTP	n	Wheatley WTP	n
pH	1990	12	1990	6	1990	6				
	1991	6	1991	6	1991	6				
	1992	4	1992	4	1992	4				
	1993	5	1993	4	1993	4				
	1994	4	1994	4	1994	4				
	1995	3	1995	3	1995	4				
	1996	2	1996	2	1996	2				
	1997	2	1997	3	1997	3				
	1998	1	1998	10	1998	5				
	1999	2	1999	5	1999	3				
	2000	2	2000	1	2000	1			2000	1
	2001	3	2001		2001	1	2001	365	2001	4
	2002	2	2002	2	2002	1	2002	365	2002	3
	2003	2	2003		2003		2003	365	2003	
	2004	3	2004	2	2004	2	2004	366	2004	
	2005	3	2005		2005		2005	365	2005	
	2006		2006		2006		2006	365	2006	
Temperature	1990	12	1990	6	1990	6				
	1991	6	1991	6	1991	6				
	1992	4	1992	4	1992	4				
	1993	5	1993	4	1993	4				
	1994	4	1994	4	1994	4				
	1995	4	1995	4	1995	4				
	1996	2	1996	2	1996	2				
	1997	2	1997	3	1997	3				
	1998	2	1998	10	1998	5				
	1999	2	1999	5	1999	3				
	2000	2	2000	1	2000	1				
	2001	3	2001		2001	1	2001	365		
	2002	2	2002	2	2002	1	2002	365		
	2003	2	2003		2003		2003	365		
	2004	3	2004	2	2004	2	2004	366	2004	366
	2005	3	2005		2005		2005	365	2005	365
	2006		2006		2006		2006	365	2006	365

Parameter	Chatham WTP	n	Elgin PWSS	n	Lake Huron PWSS	n	West Elgin WTP	n	Wheatley WTP	n
Total coliform									2000	26
	2001	52					2001	52	2001	60
	2002	52					2002	52	2002	61
	2003	33	2003	228	2003	199	2003	33	2003	53
	2004	48	2004	254	2004	197	2004	48	2004	52
	2005	51	2005	123	2005	103	2005	51	2005	52
	2006	38	2006	105	2006	101	2006	38	2006	51
E. coli	1990	6	1990	4	1990	6				
	1991	5	1991	5	1991	4				
	1992	2	1992	4	1992	3				
	1993	3	1993	4	1993	2				
			1994	2	1994	1				
									2000	25
	2001	52					2001	52	2001	110
	2002	52					2002	52	2002	68
	2003	33	2003	228	2003	199	2003	33	2003	53
	2004	48	2004	254	2004	197	2004	48	2004	52
	2005	51	2005	123	2005	103	2005	51	2005	52
	2006	38	2006	105	2006	101	2006	38	2006	51

Blank fields indicate missing data

Table 3.4.4.1-2a: Sample Size for Surface Water Intakes - Other Parameters

Parameter	Chatham WTP	n	Elgin PWSS	n	Lake Huron PWSS	n	West Elgin WTP	n	Wheatley WTP	n
Schedule 23 and 24 and others*	1990 and 1991	1 to 12	1990 and 1991	1 to 6	1990 and 1991	1 to 6	2001 to 2003	3 to 6	2000 to 2002	3
	1992 and 1993	1 to 5	1992 and 1993	1 to 4	1992 and 1993	1 to 4				
	1994 and 1995	1 to 4	1994 and 1995	3 to 4	1994 and 1995	1 to 4				
	1996 and 1997	1 to 2	1996 and 1997	1 to 3	1996 and 1997	1 to 2				
	1998 and 1999	1 to 2	1998 and 1999	1 to 2	1998 and 1999	1 to 2				
	2000 and 2001	1 to 3	2000 and 2001	1 to 2	2000 and 2001	1				
	2002 and 2003	1 to 3	2002	1 to 2	2002	1				
	2004 and 2005	1 to 3	2004	1 to 2	2004	1 to 2				
Mercury	1990 to 1996	1 to 12	1990 to 1996	1 to 6	1990 to 1996	1 to 6				

n = Sample size per year

*SOLEC, IJC, Lake Erie LAMP and Lake Huron IAP parameters for Chatham WTP, Elgin PWSS and Lake Huron PWSS only

Table 3.4.4.1-2b: Sample Size for Surface Water Intakes - Other Parameters - Hardness & Aluminum

Parameter	Chatham WTP	n	Elgin PWSS	n	Wheatley WTP	n
Hardness	1990	12	1990	6		
	1991	6	1991	6		
	1992	4	1992	4		
	1993	5	1993	4		
	1994	4	1994	4		
	1995	4	1995	4		
	1996	2	1996	2		
	1997	2	1997	3		
	1998	2	1998	2		
	1999	2	1999	2		
	2000	2	2000	2	2000	1
	2001	3	2001	1	2001	4
	2002	2	2002	2	2002	3
	2003	2	2003			
	2004	2	2004	2		
	2005	2	2005			
Aluminum	1990	12	1990	6		
	1991	6	1991	6		
	1992	4	1992	4		
	1993	5	1993	4		
	1994	4	1994	4		
	1995	4	1995	3		
	1996	2	1996	1		
	1997	2	1997	3		
	1998	2	1998	2		
	1999	2	1999	2		
	2000	2	2000	2	2000	1
	2001	3	2001	1	2001	4
	2002	2	2002	2	2002	3
	2003	2	2003			
	2004	2	2004	2		
	2005	2	2005			

Blank fields indicate missing data

Sample sizes range between one and 12 per year for WTP and WSS monitored under DWSP. Sample sizes are higher for recent years' data on some basic parameters from continuous data analyzers. Sample sizes range between 33 and 52 per year for DWIS data, and higher for data from DWS reports (up to 110 per year). The independent laboratory analyses range from one to four times a year. Local laboratory (WTP or WSS) analyses can be up to 365 per year. The data gaps are described in **Section 3.4.6**.

The Stoney Point WTP and Union WSS intakes lie in the Essex Region Conservation Authority (ERCA) watershed and are characterized by them. This report uses the results and discussion from Chapter 2 of the ERCA Watershed Characterization Report[128]. Their source of data for characterization is the Drinking Water Surveillance Program. The years of data analyzed are 1998 to 2002, and number of samples are two to five per year. The results are shown pictorially in the form of box and whisker figures for the Stoney Point and Union intakes besides intakes not relevant to this study. The figures from the report are presented here in their original form and only the required portions of discussion are extracted from the ERCA report for inclusion in this Report.

In addition to the assessment done in this report, the Ausable Bayfield Conservation Authority (ABCA) has also characterized the Lake Huron Primary Supply System intake raw water (at Port Blake WTP near Grand Bend), which is in their watershed. Their analysis of the intake raw water is in Chapter 2 of their watershed characterization report[129]. Their analysis is based on Great Lakes Intake Biomonitoring data from 1976 to 2004 for phosphorus, nitrate and chloride. *Escherichia coli* (fecal coliform bacteria) for January 2005 to September 2006 are also analyzed by ABCA using data from the DWIS database. The results are shown pictorially for the Port Blake intake as well as the Goderich intake. The Goderich intake is north of Grand Bend and does not supply drinking water to any communities in the Thames-Sydenham & Region Source Protection Region. The figures from the report are presented here in their original form, and the required portions of discussion are extracted from the report for inclusion in this Report.

3.4.4.2 Method of Analysis

The physical and chemical parameters in the raw water to Chatham WTP, Elgin PWSS and Lake Huron PWSS were characterized using DWSP data from 1990 to 2005 (some years' data missing in between for different parameters). For the basic parameters (except microbial) in raw water to these plants, graphs of annual minimum, maximum and average values were developed using Microsoft Excel software.

The West Elgin and Wheatley WTPs do not have DWSP data. The data from the continuous analyzers at the plants as well as independent laboratory results are used. Where data permitted, annual minimum, maximum and average values are graphed using Microsoft Excel software. Where data was limited, results are presented in the form of tables.

Schedule 23 and 24 parameters as well as SOLEC, IJC and Lake specific parameters were analyzed using recent years' data, from 2000 to 2005, wherever data permitted. A total of 88 parameters were checked against

- detection limits,
- water quality standards, and
- half water quality standards.

The checks were performed by using the cross-tab query function of Microsoft Access software.

The detection limit check aids in determining which chemicals are detected in the raw water, based on the specific lab's detecting limits. The comparison against the water quality standards provides an insight into the levels of contamination in the raw drinking source water. The half standard check is also conducted

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[128] Essex Region Source Protection Region. August 2006. Interim Draft Report on Existing Water Quality Conditions and Trends in the Essex Region Watershed.

[129] Luinstra, B., R. Steele and M. Veliz. January 2007. Water Quality in the Ausable Bayfield Maitland Valley Planning Region, Including the Nearshore of Lake Huron. Version 1.0. ABCA.

since OMOE requires that if a chemical from Schedule 23 or 24 reaches half of the ODWS MAC level, it should be monitored by frequent testing[130].

The WTP or WSS specific parameters are based on Drinking Water System (DWS) annual reports available from each WTP or WSS (or the related municipality) website. These documents report parameters above drinking water standards or guidelines. The WTP or WSS specific parameters were analyzed using DWSP data and graphed similar to the basic parameters.

For coliform analyses, where data sets were large enough (Chatham WTP, West Elgin WTP, Elgin Area PWSS and Lake Huron PWSS), scatter plot graphs showing the spread of coliform data over time were created using Microsoft Excel software. Monthly variations between different years' data can be seen from the graphs. A logarithmic scale was employed to show the spread of data over several orders of magnitude. For example, within one data set, the total coliform could range from 0 counts/100 mL to 210,000 counts/100 mL. Graphing on a logarithmic scale aids in displaying such an extreme variation in data values.

For coliform analyses, where data was limited (Wheatley WTP raw water), results are presented in the form of tables. Summary tables of the annual maximum, minimum and average *E. coli* and total coliform values in the raw water to each WTP or WSS are included in this Report.

The Stoney Point WTP and Union WSS intakes lie in the Essex Region Conservation Authority (ERCA) watershed and are characterized by ERCA[128]. The parameters ERCA analyzed are phosphorus, nitrates, ammonium, chloride, pH, aluminum, copper, iron and lead for 1998 to 2002. The results are shown pictorially in the form of box and whisker figures for the Stoney Point and Union intakes. The figures are presented here in their original form which includes intakes that are part of this report. Only the portions of discussion on Stoney Point and Union intakes are extracted from the ERCA report for inclusion in this report.

The Lake Huron PWSS intake raw water (at Port Blake near Grand Bend) is characterized in this report and also by the Ausable Bayfield Conservation Authority (ABCA). The ABCA analysis is based on Great Lakes Intake Biomonitoring data from 1976 to 2004 for phosphorus, nitrate and chloride, and January 2005 to September 2006 data for *E. coli*. For the chemical parameters, box and whisker plots were developed that indicate the 25th, 50th and 75th percentile statistics. The data are pooled into five year data blocks. The microbial (*E. coli*) data is depicted as scatter plots. All of the results are shown pictorially for the Port Blake intake as well as the Goderich intake which is to the north and not part of this study. While the figures are presented here in their original form, only the required portions of discussion are extracted from the ABCA report for inclusion in this Report.

Special Cases

South Chatham-Kent WTP raw water intake

In this Report, the South Chatham-Kent WTP is not considered since its raw water intake is the same as for the Chatham WTP, which is characterized.

Stoney Point WTP and Union WSS raw water intakes

The analyses done by ERCA for the Stoney Point WTP and Union WSS raw water intakes are included in this report.

Lake Huron PWSS raw water intake

The analysis done by ABCA for the Port Blake Lake Huron intake is included in this report.

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[130] OMOE. June 2004. Laboratory Update Bulletin, Drinking Water Testing. Issue 1. www.ene.gov.on.ca/cons/4879e.htm

Phosphorus

The Interim Provincial Water Quality Objective (IPWQO) for phosphorus in lakes recommends that the average total phosphorus concentration for the ice-free period should not exceed 0.02 mg/L to avoid nuisance concentrations of algae. This level has been used to evaluate water quality for sources using Lake Erie, Lake St. Clair and Lake Huron. The IPWQO for streams and smaller rivers is 0.03 mg/L and this value was used in **Section 3.2: Raw Water Characterization for Inland Surface Water** when evaluating local streams and rivers.

Turbidity

Field turbidity data from the DWSP database were used instead of DWSP laboratory measurements. The choice is based on information about the difference in both measurements as per OMOE.[131] "Field turbidity measurements were recorded at the time of sampling by plant personnel and were entered into the DWSP database. Turbidity was also measured at the OMOE laboratory within 48 hours of receiving the sample. Because of this time delay the laboratory measurement is not considered as reliable as the field measurement".

The OMOE DWSP turbidity data units are in FTU (Formazin Turbidity Units), whereas the ODWS aesthetic objective is in NTU (Nephelometric Turbidity Units). The two units are equal when formazin is used as a standard; as well, the OMOE laboratory calibrates the nephelometer with formazin standards[132]. Also, "FTU is considered comparable in value to NTU and is the unit of measurement when using absorptometric methods (spectrophotometric equipment)"[133]. The OMOE laboratory confirmed that the DWSP turbidity is measured using spectrophotometric equipment.

Turbidity values from WTP or WSS continuous data analyzer data are in NTU (Nephelometric Turbidity Units).

Schedule 23 and 24, SOLEC, IJC and Lake specific parameters

Where no DWSP data was available for these parameters (West Elgin WTP and Wheatley WTP), the laboratory analyses sheets (raw water analyses) and annual DWS reports (treated water analyses) were used. However SOLEC, IJC, Lake specific parameters that are not in the Schedules were not analyzed due to lack of data.

The treated water analyses of Schedule 23 and 24 parameters are required by Ontario Regulation 170/03 to be reported in the drinking water system reports of each WTP or WSS. These reports can be used to assess the parameters since water treatment processes are unlikely to affect the parameters. However, if activated carbon is used to remove substances causing odour or colour, it cannot be concluded from the treated water analyses that the Schedule 23 and 24 parameters in the water source are also below detection limits or absent.

The analysis results for mirex must be interpreted with caution since the detection limit itself is higher than the aquatic life toxicity standard. When mirex is detected in a sample, it is automatically considered to be above the standard even though it may not be so.

Parameters not found in the DWSP database

Those parameters (excluding microbiological parameters) listed in the Water Quality Parameter Selection section but not found in the DWSP database are: Alkylated lead, tributyl tin, delta-hexachlorocyclohexane, 3,3'-dichlorobenzidine and 4,4'-methylenebis (2 - chloroaniline). The OMOE

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[131] OMOE. Drinking Water Surveillance Program Summary Report for 2000, 2001 and 2002. DWSP Parameter Groups. www.ene.gov.on.ca/envision/water/dwsp/0002/index.htm#pargroups

[132] OMOE. July 2003. Protocol of Accepted Drinking-Water Testing Methods. www.ene.gov.on.ca/envision/gp/4465e.pdf

[133] Wilde, F.D., and Jacob Gibbs. Turbidity. In USGS Geological Survey TWRI Book 9, 4/98, Chapter 6.7.

laboratory staff indicated that these parameters are not monitored in drinking water since the primary source of ingestion is not through drinking water.

Parameters without Ontario Drinking Water Standards

Some parameters selected, for example phosphorus, do not have an ODWS. Where the ODWS is not available, the United States Environmental Protection Agency (USEPA) Maximum Contaminant Levels (MCL) from the USEPA National Primary Drinking Water Regulations are used. Where the USEPA MCLs are also not available, Provincial Water Quality Objectives (for healthy aquatic life) are used.

Parameters without ODWS are: alpha-hexachlorocyclo hexane, beta-hexachlorocyclo hexane, mirex, nickel, anthracene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k) fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, phenanthrene and indeno(123-cd)pyrene.

Parameters without any standards or guidelines

These parameters are compared against their respective detection limits as a means of analysis. They are alpha-hexachlorocyclo hexane, beta-hexachlorocyclo hexane, benzo(b)fluoranthene, and indeno(123-cd)pyrene.

Coliform values not graphed

In the laboratory, the coliform cannot be counted when overgrowth of the bacteria occurs. The note '>2000' refers to the 'detection limit' beyond which dilution and retesting of the sample is necessary. Within the total coliform data sets, certain instances of 'OG' or overgrowth, or values such as '>2000' are present. These data are not shown in graphs but are noted below the summary tables.

Bias

Weather and event bias may be present in DWSP data (physical and chemical parameters) where the number of samples per years is typically low (one to 12 per year) and the time of sampling is unknown.

Similarly, sampling bias in data from independent laboratory data sheets (analysis typically one to four times a year) may be present.

3.4.4.3 Results and Discussion

The Chatham WTP, Elgin PWSS, Lake Huron PWSS, West Elgin WTP, and Wheatley WTP raw water quality results are discussed in the following order:

A. Basic parameters
B. Other parameters (Schedule 23, Schedule 24, SOLEC, IJC, Lake specific and WTP/WSS specific)

The Lake Huron PWSS intake at Port Blake near Grand Bend is also characterized by the ABCA and their results are taken from Chapter 2 of their report[129]. Their analysis for phosphorus, nitrate and chloride is included in this Report under (A) Basic parameters. The results must be interpreted with caution as sample sizes are small. For most raw water intakes, only one to two samples per year were analyzed under the DWSP from 2000 to 2004, and bias is not examined.

The Stoney Point WTP and Union WSS intakes characterization are taken from Chapter 2 of the ERCA Watershed Characterization Report[128]. The results for the parameters phosphorus, nitrates, chloride, and pH are included in this Report under (A) Basic parameters. The remaining parameters of aluminum, cadmium, copper, iron, lead, sodium and ammonium are included in this Report under (B) Other parameters.

(A) BASIC PARAMETERS

(1) Total Phosphorus

Fate and Behaviour: Phosphorus is generally the limiting nutrient in aquatic ecosystems. While phosphorus is an essential nutrient for plant and animal life, excess phosphorus levels can result in significant increases in unwanted plant growth. Phosphorus is not directly toxic to aquatic life but elevated concentrations can lead to excessive plant growth resulting in undesirable changes including taste and odour problems in drinking water, reduced oxygen levels, reduced biodiversity, and toxic algae blooms.

Sources: Phosphorus sources include commercial fertilizers, animal waste, domestic and industrial wastewater, including soaps and cleaning products. Phosphorus binds to soil and is readily transported to streams with eroding soil.

Standards: Ontario has an Interim Provincial Water Quality Objective (IPWQO) for lakes of 20 µg/L or 0.02 mg/L of total phosphorus to prevent the nuisance growth of algae in lakes. There is no Ontario Drinking Water Standard. Phosphorus does not pose a direct threat to human health; it is an essential component of all cells and is present in bones and teeth[134].

(a) Lake Erie Raw Water to the Chatham WTP:

Figure 3.4.4.3-1 shows the total phosphorus levels in the raw water to the Chatham WTP. More than half (nine of 16 years) of the average levels of total phosphorus in the Chatham WTP raw water have been the IPWQO of 0.02 mg/L from 1990 to 2005. In all but three years, the maximum phosphorus levels were above the IPWQO. However, most of the minimum phosphorus levels are below the IPWQO of 0.02 mg/L for lakes.

(b) Lake Erie Raw Water to the Elgin Area PWSS:

Figure 3.4.4.3-2 shows the total phosphorus levels in the raw water to the Elgin Area PWSS. From 1990 to 2004 (year 2003 data missing), most of the average and maximum values are above the IPWQO of 0.02 mg/L. However, many of the minimum values are below the IPWQO throughout the monitoring period. In recent years, there appears to be a decline in the maximum phosphorus levels.

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Figure 3.4.4.3-3 shows the total phosphorus levels in the raw water to the Lake Huron PWSS. With the exception of maximum levels in 1990, 1993, 1995 and 1997, both the maximum and average phosphorus levels at this intake are below the IPWQO of 0.02 mg/L from 1990 to 2004 (2003 data missing). From 1998 to 2004, the average phosphorus levels have been considerably less (by 2.5 to 5 times) than the IPWQO.

Figure 3.4.4.3-4 shows the total phosphorus (TP) concentrations (mg L^{-1}) at the LHPWSS (Port Blake) Water Intake from 1976 to 2004 with a sample size of 1104. "The median TP concentration at the Port Blake Intake Facility between 1976 and 2004 was significantly lower than the objective (median = 0.012 mg L^{-1}; Mann-Whitney U statistic 988358.5; $p < 0.001$). However, the median concentration at the Port Blake Intake Facility is in the range of concentrations that would be considered to contribute to nearshore nutrient enrichment conditions (i.e., the 90th percentile = 0.03 mg L^{-1})" (Figure and text taken from Chapter 2 of the ABCA Report[129]).

(d) Lake Erie Raw Water to the West Elgin WTP:

There is no total phosphorus data available at the time of the writing of this Report for raw water to the West Elgin WTP.

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[134] CCME website: Phosphorus. www.ccme.ca/sourcetotap/phosphorus.html

(e) Lake Erie Raw Water to the Wheatley WTP:

Table 3.4.4.3-1 shows the total phosphorus levels in the raw water to the Wheatley WTP. No phosphorus was detected in the raw water to this WTP from 2000 to 2002 which were the only years with data.

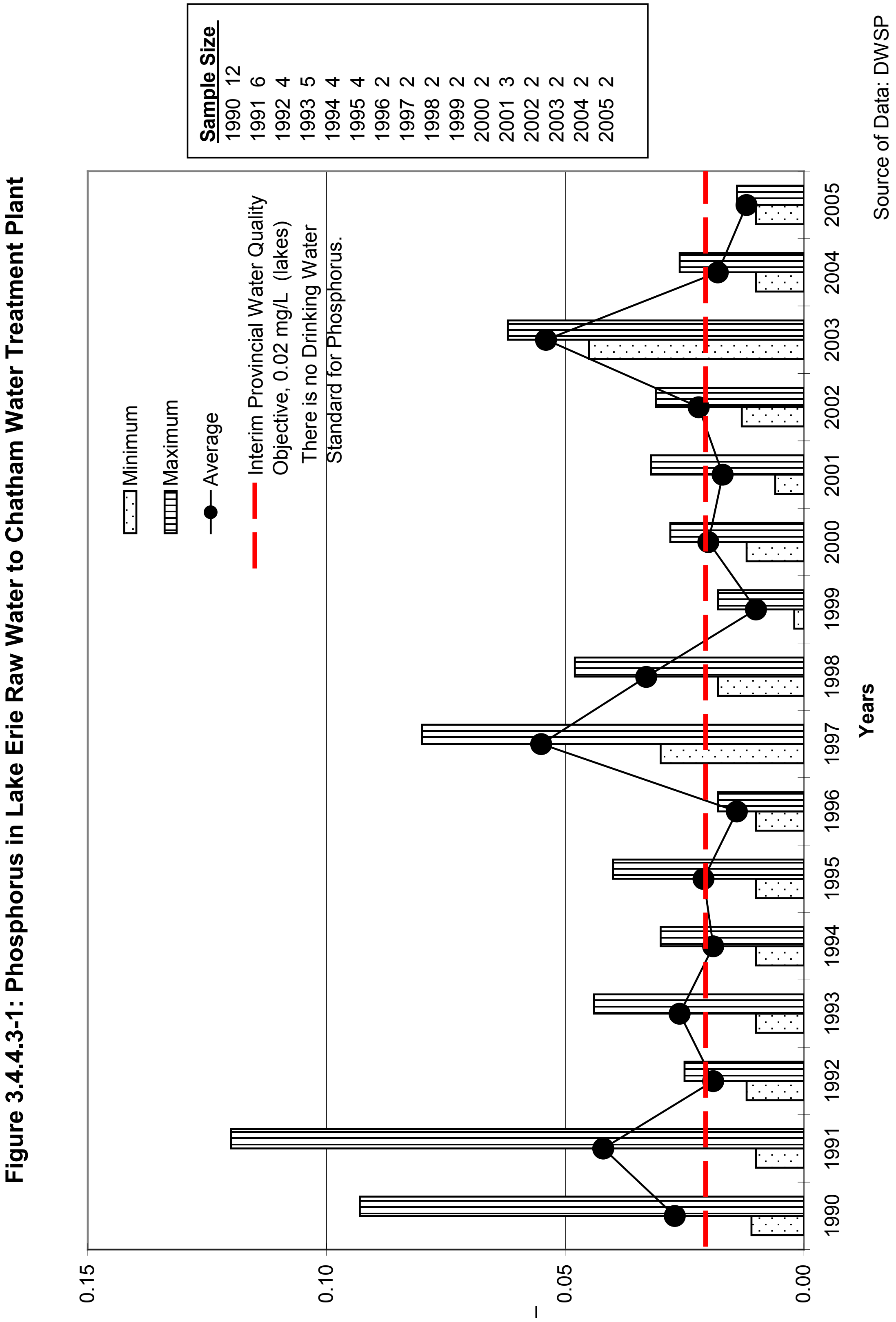
Table 3.4.4.3-1: Phosphorus in Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	Phosphorus, mg/L			n
	Min	Max	Avg	
2000	0	0	0	1
2001	0	0	0	4
2002	0	0	0	3

Source of Data: Municipality of Chatham-Kent Water Quality Laboratory Reports

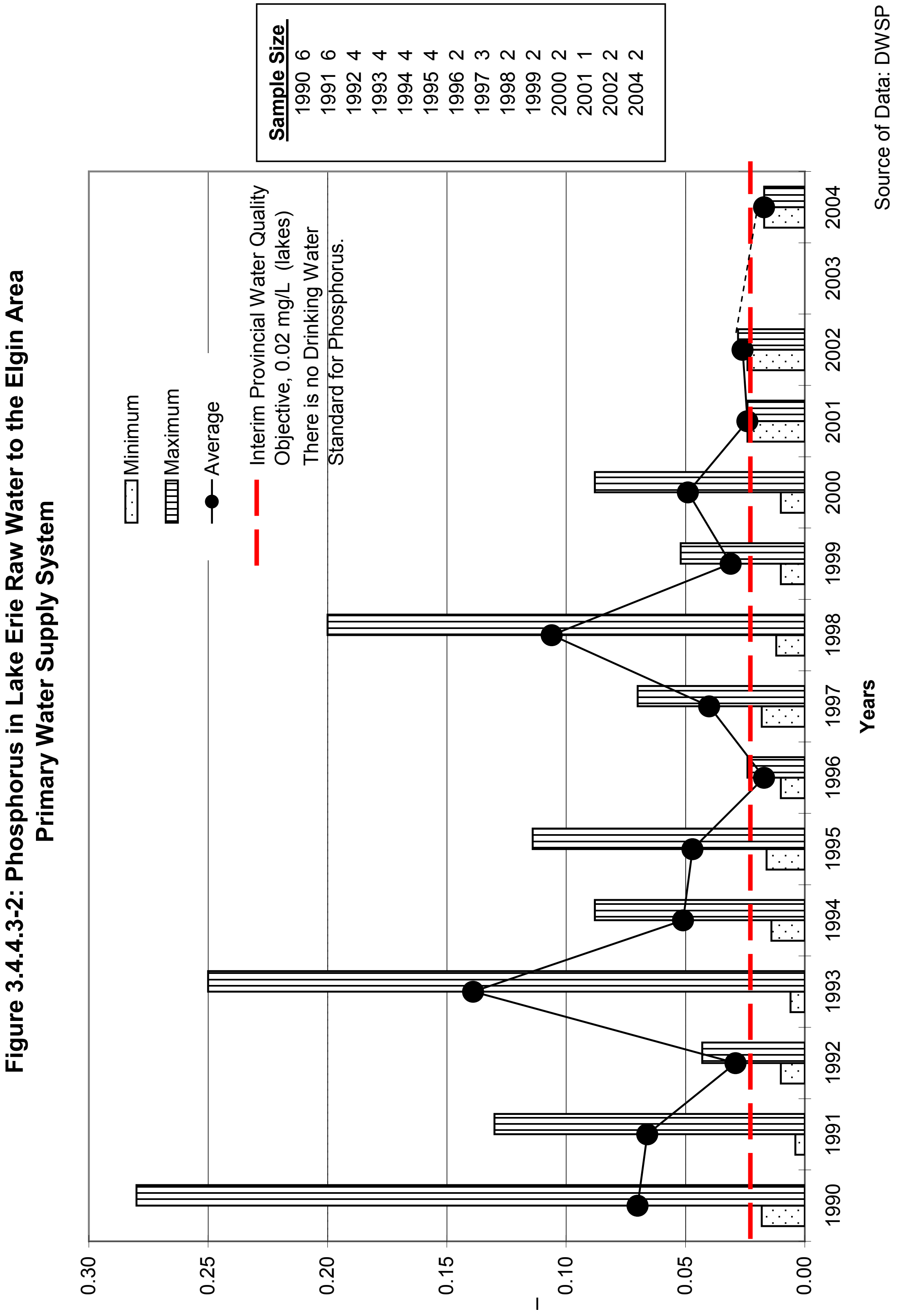
(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

Figure 3.4.4.3-5 shows average total phosphorous concentrations at intake sites in the ERCA watershed. "Average total phosphorous concentrations at the six intake sites were below the PWQO (0.030 mg/L) except for at the Belle River intake site where the mean value for 1998-2000 was 0.05 mg/L (±0.03)" (Figure and text taken from Chapter 2 of the ERCA Watershed Characterization Report[128]). The figure shows that the maximum phosphorus levels at both Stoney Point and Union intakes were above the IPWQO of 0.02 mg/L for lakes.



Source of Data: DWSP

Figure 3.4.4.3-1: **Phosphorus in Lake Erie Raw Water to the Chatham Water Treatment Plant**



Source of Data: DWSP

Figure 3.4.4.3-2: **Phosphorus in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**

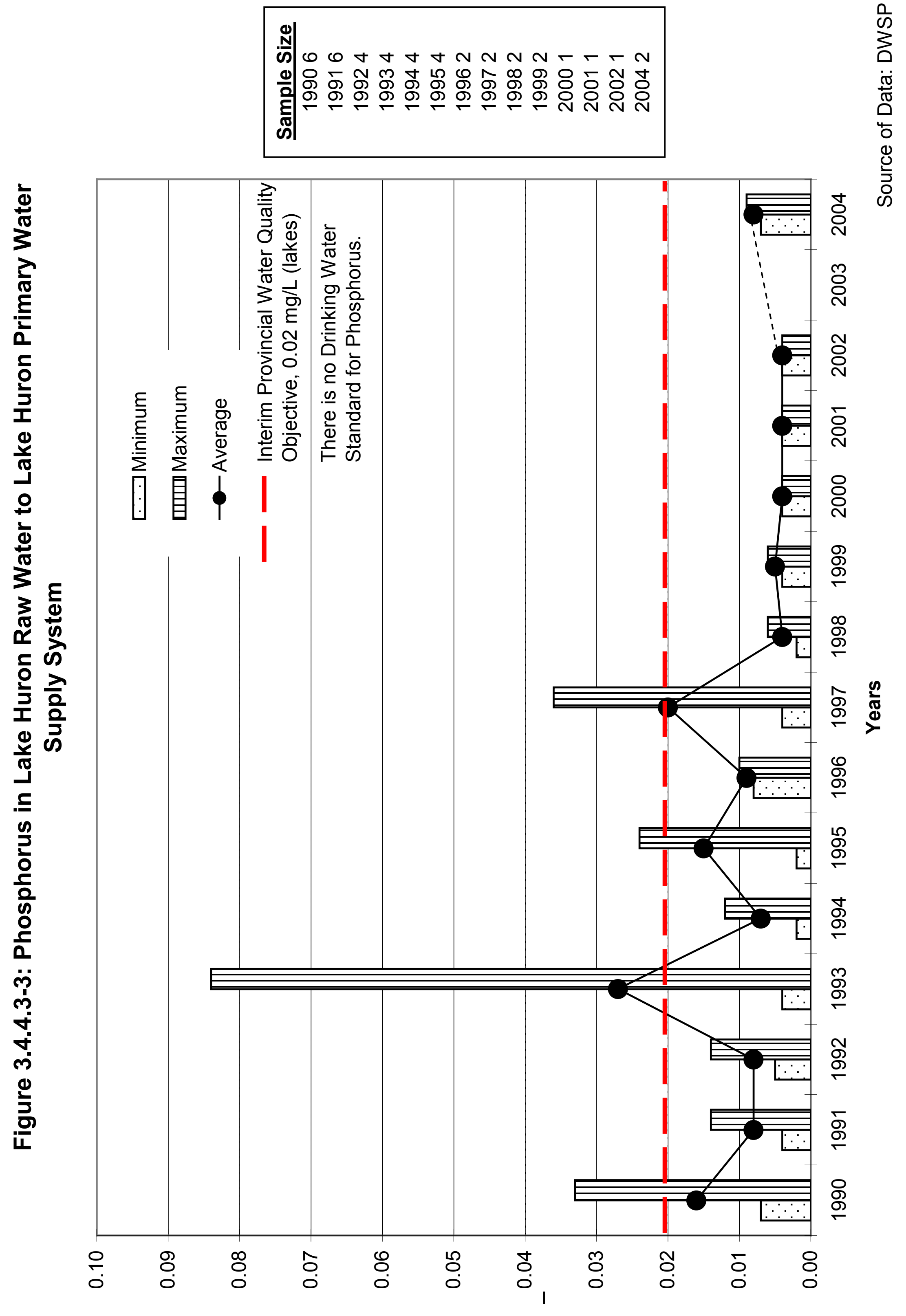


Figure 3.4.4.3-3: **Phosphorus in Lake Huron Raw Water to Lake Huron Primary Water Supply System**

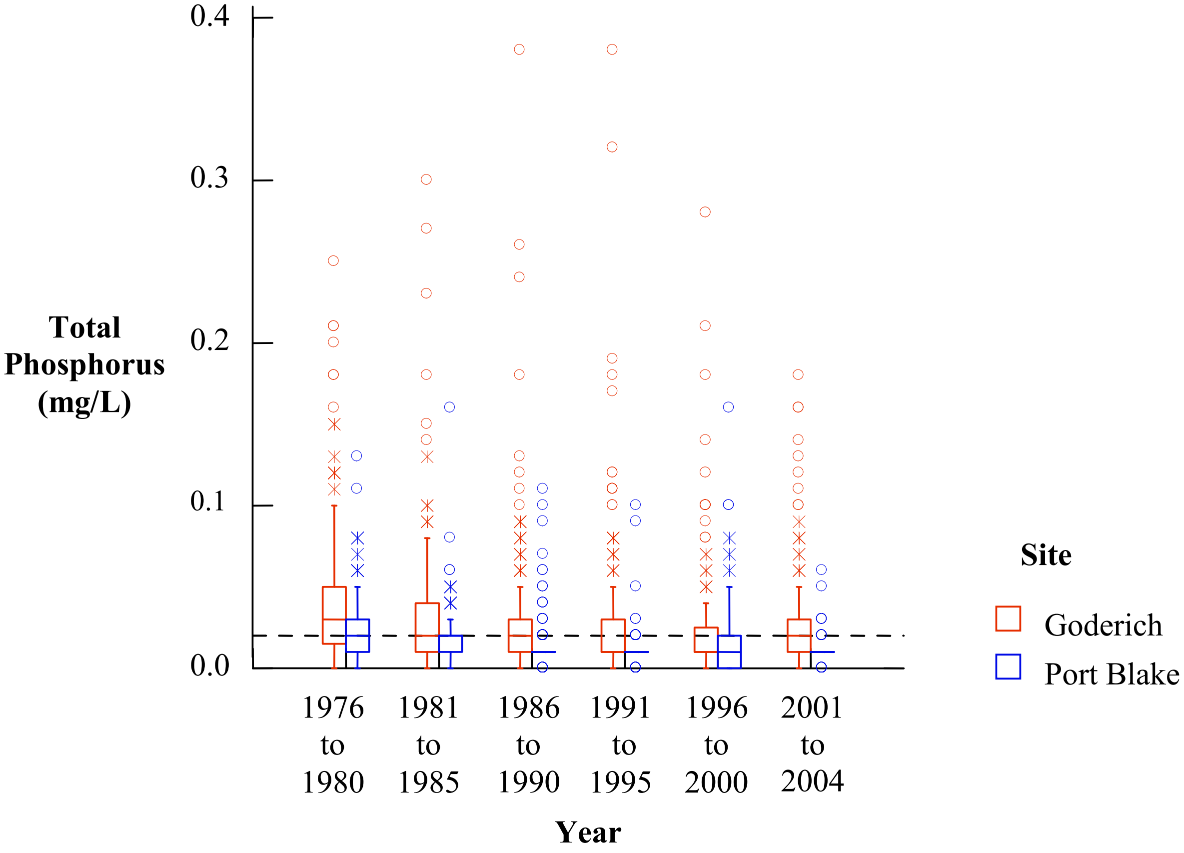


Figure 3.4.4.3-4: **Total Phosphorus Concentrations (mg L^{-1}) at Goderich and Port Blake Water Intake Facilities (ABCA)**

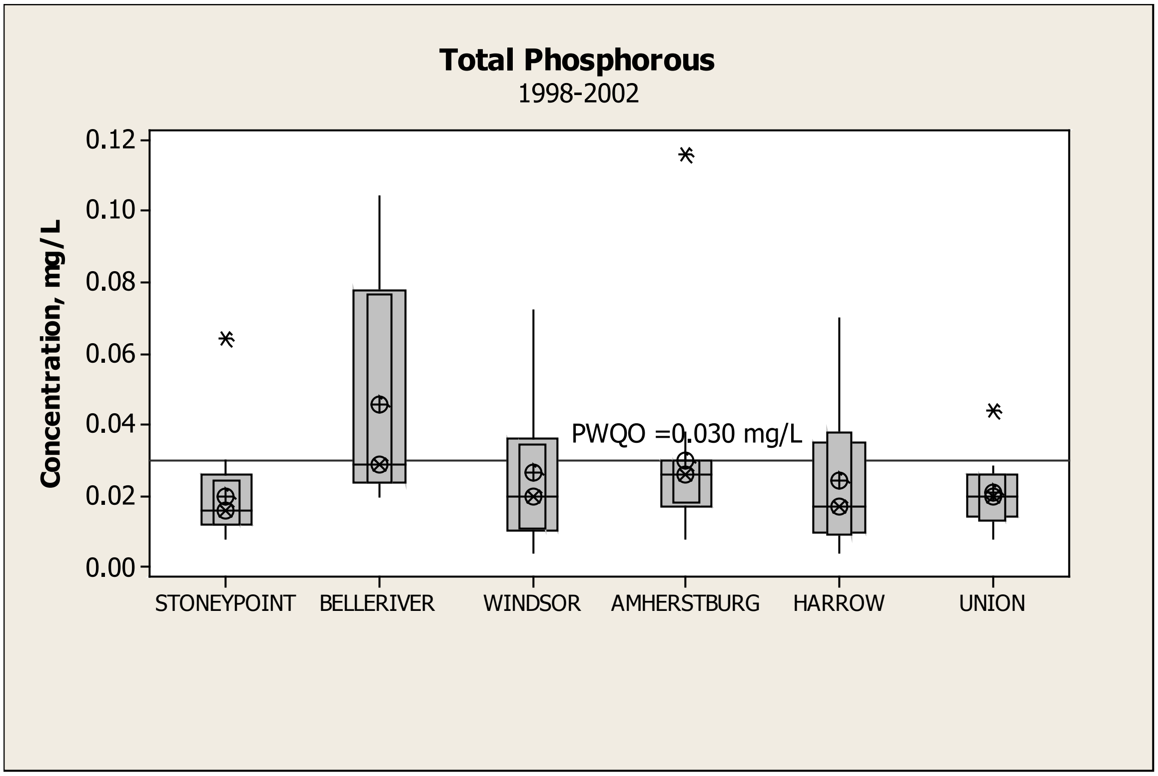


Figure 3.4.4.3-5: **Total Phosphorous Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP).
The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year).

Note: Data for Pelee Township not available at this time.

(2) Nitrate

Fate and Behaviour: The nitrate ion is soluble and does not adsorb to sediment or organic matter. Therefore, nitrate has a high potential for mobility through surface runoff and by leaching into groundwater. Due to its solubility in water, nitrates can readily reach streams by infiltration through soil and percolation via shallow groundwater, or through tile drains. Elevated levels in a watercourse can be toxic to aquatic organisms, especially amphibians. A condition called blue baby syndrome can result from young children drinking water with elevated nitrates.

Sources: Nitrate sources include animal waste, commercial fertilizers, municipal wastewater and septic systems, and atmospheric deposition. Nitrate sources are usually found to be the highest in intensively farmed areas and downstream of municipal wastewater discharges.

Standards: The Ontario Drinking Water Standard (ODWS) for nitrate is a maximum acceptable concentration of 10 mg/L. The Province does not have an objective for aquatic life but there is a Canadian Environmental Quality Guideline to protect aquatic life from direct toxicity. As discussed in the section on Water Quality Standards and Guidelines, a value of 2.93 mg/L will be used to evaluate water quality for aquatic life, and is called the modified CCME guideline. This value is obtained by dividing the CCME guideline of 13 mg/L by 4.43 since the PWQMN nitrate is recorded as mg NO_3^--N·L^{-1} whereas the CCME guideline reports nitrate as mg NO_3^-·L^{-1}.

(a) Lake Erie Raw Water to the Chatham WTP:

Figure 3.4.4.3-6 shows the nitrate levels in the raw water to the Chatham WTP. The maximum nitrate levels have been well below both the ODWS of 10 mg/L and the modified CCME guideline of 2.93 mg/L throughout the period of 1990 to 2005. Most average levels have been between 0.2 and 0.4 mg/L. Both the lowest (0.049 mg/L in 2000) and highest (0.43 mg/L in 2004) average levels occurred within recent years.

(b) Lake Erie Raw Water to the Elgin Area PWSS:

Figure 3.4.4.3-7 shows the nitrate levels in the raw water to the Elgin Area PWSS. The maximum nitrate levels have been well below both the ODWS of 10 mg/L and the modified CCME guideline of 2.93 mg/L throughout the period of 1990 to 2004 (2003 data missing). Similar to the Lake Erie raw water to the Chatham WTP, most average levels have been between 0.2 and 0.4 mg/L. The lowest (0.15 mg/L) and highest (0.38 mg/L) average levels occurred in 2001 and 1997 respectively. Overall, the average nitrate levels have decreased from 1990 to 2001 with a small increase in 2002 and 2004 average nitrate levels. The maximum levels have decreased overall from 1990 to 2004 (2003 data missing).

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Figure 3.4.4.3-8 shows the nitrate levels in the raw water to the Lake Huron PWSS. The maximum nitrate levels have been well below both the ODWS of 10 mg/L and the modified CCME guideline of 2.93 mg/L throughout the period of 1990 to 2004 (2003 data missing). From 1990 to 1998, the average levels have been between 0.3 and 0.65 mg/L, with a highest maximum of 1.2 mg/L in 1995. Thereafter, the average nitrate levels were between 0.3 and 0.4 mg/L with the exception of the year 2000 which had only one sample.

Figure 3.4.4.3-9 shows the nitrate concentrations (mg L^{-1}) at the LHPWSS (Port Blake) Water Intake from 1976 to 2004. "Nitrate concentrations at the Port Blake Facility (median = 0.34) were significantly lower than at the Goderich Facility (Mann-Whitney U Test Statistic 11933230; $p < 0.001$), between 1976 and 2004" (Figure and text taken from Chapter 2 of the ABCA Report[129]).

(d) Lake Erie Raw Water to the West Elgin WTP:

Table 3.4.4.3-2 shows the nitrate levels in the raw water to the West Elgin WTP. There are only three years (2001, 2002 and 2003) of nitrate data available at the time of the writing of this Report. The maximum nitrate levels have been well below both the ODWS of 10 mg/L and the modified CCME guideline of 2.93 mg/L for 2001 to 2003. Average levels range between 0.18 and 0.27 mg/L while maximum levels range between 0.52 and 0.22 mg/L, with the highest nitrate levels occurring in 2002.

Table 3.4.4.3-2: Nitrate in Lake Erie Raw Water to the West Elgin Water Treatment Plant

Year	Nitrate as N, mg/L			
	Min	Max	Avg	n
2001	0.12	0.36	0.24	4
2002	0.12	0.52	0.27	4
2003	0.14	0.22	0.18	2

Source of Data: WTP Laboratory Monitoring Sheets

(e) Lake Erie Raw Water to the Wheatley WTP:

Table 3.4.4.3-3 shows the nitrate levels in the raw water to the Wheatley WTP. There are only three years (2000, 2001 and 2002) of nitrate data available at the time of the writing of this Report. The maximum nitrate levels have been well below both the ODWS of 10 mg/L and the modified CCME guideline of 2.93 mg/L. Average levels range between 0 and 0.31 mg/L while maximum levels range between 0 and 0.38 mg/L, with the highest nitrate levels occurring in 2002.

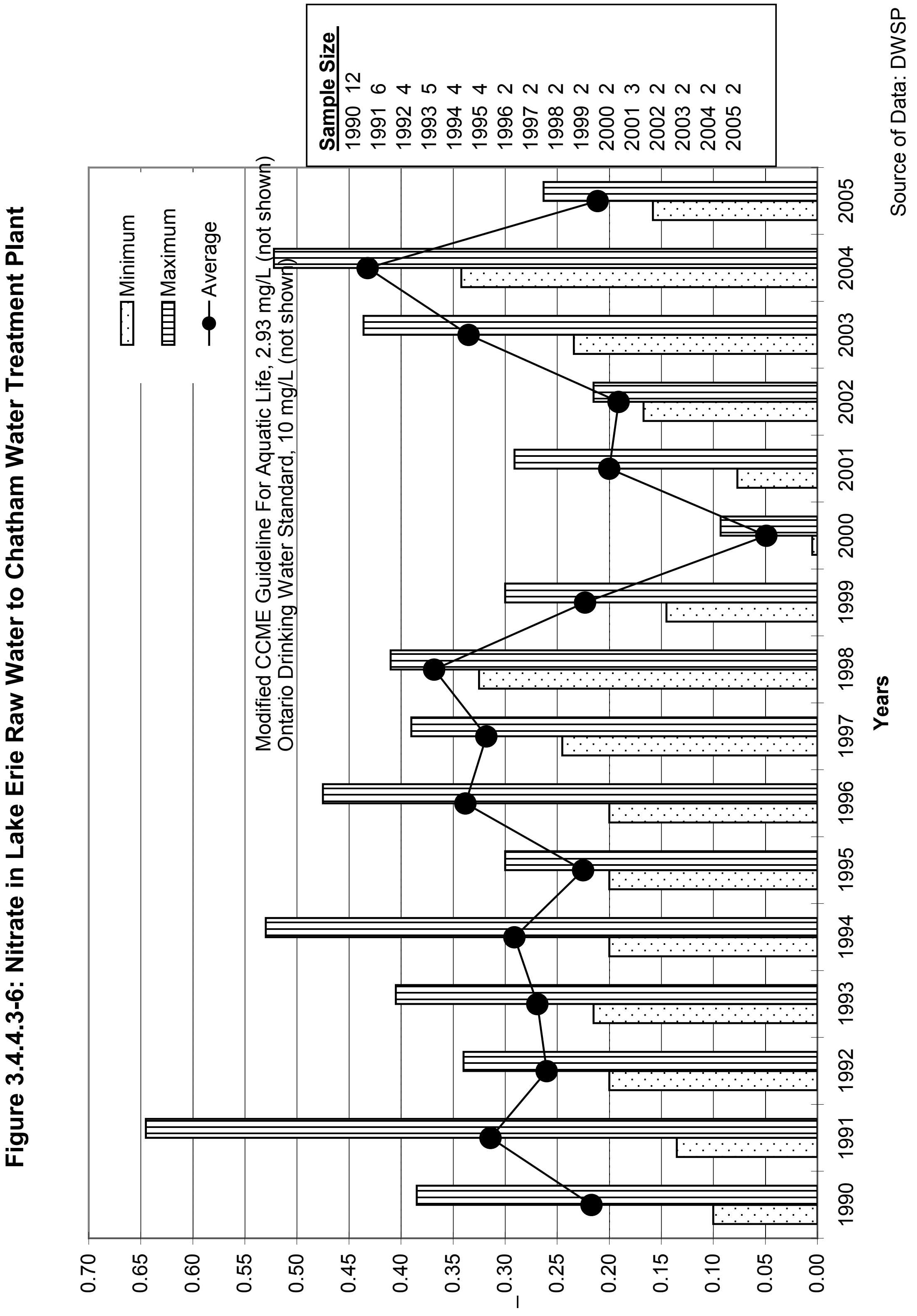
Table 3.4.4.3-3: Nitrate in Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	Nitrate, mg/L			n
	Min	Max	Avg	
2000	0	0	0	1
2001	0	0.28	0.2	4
2002	0.22	0.38	0.31	3

Source of Data: Municipality of Chatham-Kent Water Quality Laboratory Reports

(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

Figure 3.4.4.3-10 shows average nitrate concentrations at intake sites in the ERCA watershed. "At the particular times when this data was collected, average nitrate concentrations were well below the PWQO (2.93 mg/L) at all the six water intakes, except a few spikes of high nitrate levels at the Belle River plant's intake site. The Tukey's test indicated that [the] means of the Stoney Point and the Belle River plant intakes statistically [are the] same, while [the] means of [the] rest [of the] four intakes are statistically [the] same. Nitrate levels exceeded the PWQO (2.93 mg/L) [in] only one of the 15 samples collected at the Stoney Point and the Belle River intakes during 1998-2002" (Figure and text taken from Chapter 2 of the ERCA Watershed Characterization Report[128]).



Source of Data: DWSP

Figure 3.4.4.3-6: **Nitrate in Lake Erie Raw Water to Chatham Water Treatment Plant**

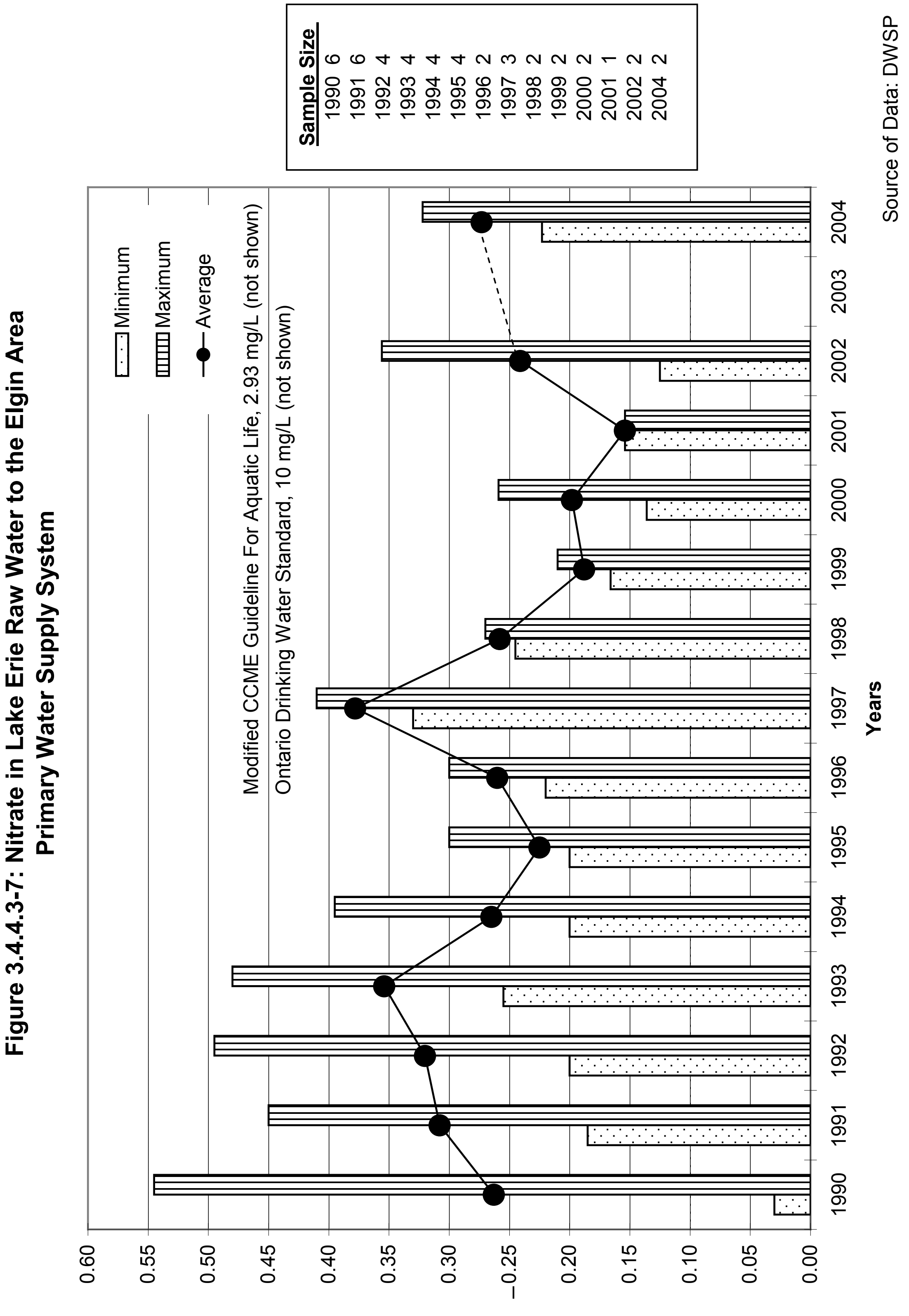
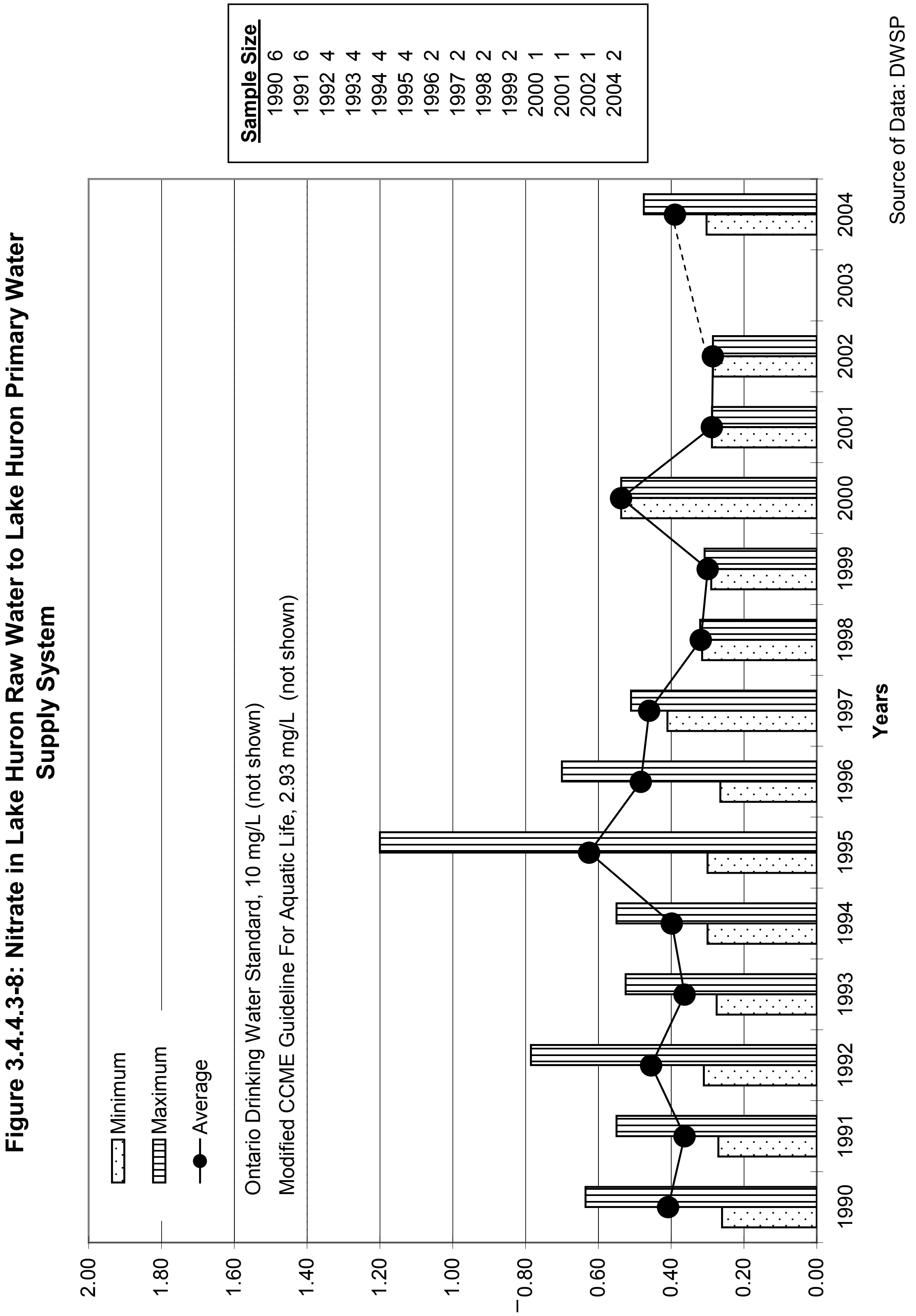


Figure 3.4.4.3-7: **Nitrate in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**



Source of Data: DWSP

Figure 3.4.4.3-8: **Nitrate in Lake Huron Raw Water to Lake Huron Primary Water Supply System**

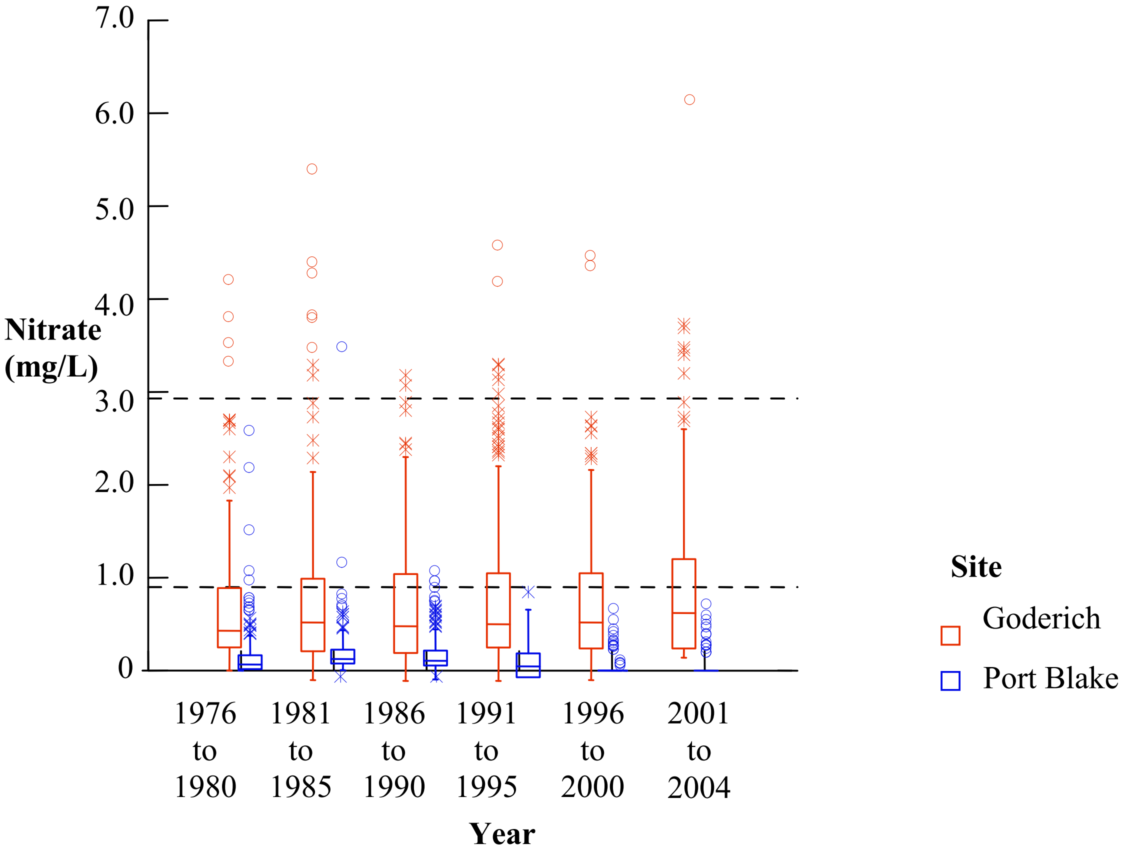


Figure 3.4.4.3-9: **Nitrate Concentrations (mg L^{-1}) at Goderich and Port Blake Water Intake Facilities (ABCA)**

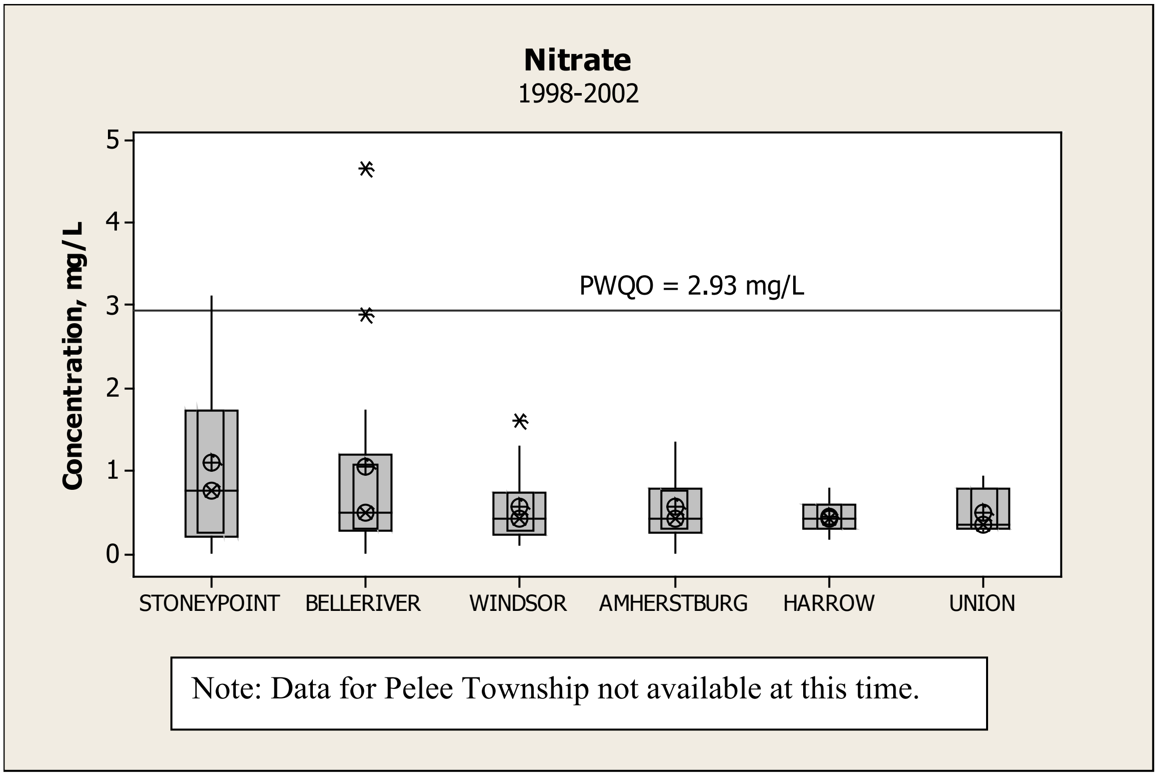


Figure 3.4.4.3-10: **Total Nitrate Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year).

(3) Chloride

Fate and Behaviour: Chloride ions are conservative, moving with water without being lost. Nearly all chloride added to the environment will eventually migrate to surface or groundwater. Chloride can be toxic to aquatic organisms at high concentrations, and affects growth and reproduction at lower concentrations.

Sources: The highest loadings of chloride are typically associated with the application and storage of road salt (calcium chloride). Therefore, urban streams tend to have the highest chloride concentrations.

Standards: The Ontario Drinking Water Standard (ODWS) is 250 mg/L for aesthetic objectives. Ontario does not have a Provincial Water Quality Objective for aquatic life. An Environment Canada/Health Canada assessment report[135] documents toxicity for sensitive aquatic species at 210 mg/L. In this report, it is called the Environment Canada guideline (toxicity to aquatic species). To protect sensitive aquatic species, British Columbia recommends a guideline of 600 mg/L for acute exposure and 150 mg/L (30 day average) for chronic exposure.

(a) Lake Erie Raw Water to the Chatham WTP:

Figure 3.4.4.3-11 shows the chloride levels in the raw water to the Chatham WTP. The maximum chloride levels have been considerably lower than the ODWS aesthetic objective of 250 mg/L as well as the Environment Canada toxicity to aquatic species guideline of 210 mg/L. From 1990 to 2005, the average levels range between 13 and 16.6 mg/L and do not fluctuate much with the exception of 1992. The maximum chloride levels for 1990 to 2005 range between 15 and 17.3 mg/L, with the exception of 1992. In 1992, a maximum chloride level of 29.1 mg/L and average chloride level of 18 mg/L occurred.

(b) Lake Erie Raw Water to the Elgin Area PWSS:

Figure 3.4.4.3-12 shows the chloride levels in the raw water to the Elgin Area PWSS. The maximum chloride levels have been considerably lower than the ODWS aesthetic objective of 250 mg/L as well as the Environment Canada toxicity to aquatic species guideline of 210 mg/L. From 1990 to 2002 (year 2003 data missing), the average levels range between 13.6 and 15.8 mg/L and do not fluctuate much. Similarly, the maximum chloride levels for 1990 to 2002 (year 2003 data missing) range between 14 and 16.5 mg/L. The highest maximum and average chloride levels of 19.6 and 17.2 mg/L occurred recently in 2004.

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Figure 3.4.4.3-13 shows the chloride levels in the raw water to the Lake Huron PWSS. The maximum chloride levels have been considerably lower than the ODWS aesthetic objective of 250 mg/L as well as the Environment Canada toxicity to aquatic species guideline of 210 mg/L. From 1990 to 2002 (year 2003 data missing), the average levels do not fluctuate and range between 6.05 and 7.05 mg/L. Similarly, the maximum chloride levels for 1990 to 2002 (year 2003 data missing) range between 6.2 and 7.6 mg/L. However, slightly higher maximum and average chloride levels of 8.2 and 8 mg/L occurred in 2004.

Figure 3.4.4.3-14 shows the chloride concentrations (mg L^{-1}) at the LHPWSS (Port Blake) Water Intake from 1976 to 2004**.** "The median chloride concentrations at both the Goderich and Port Blake Facilities were substantially below the Canadian guideline. Between 1976 and 2004, the median concentration at the Goderich Facility (8.5 mg L^{-1}) was higher than the median concentration at the Port Blake Facility (median = 6.5 mg L^{-1}; Mann-Whitney U Statistic 12999734.5; p <0.001)" (Figure and text taken from Chapter 2 of the ABCA Report[129]).

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[135] Environment Canada. 2001. Existing Substances Evaluation: Assessment Report - Road Salts. www.ec.gc.ca/substances/ese/eng/psap/final/roadsalts.cfm

(d) Lake Erie Raw Water to the West Elgin WTP:

Table 3.4.4.3-4 shows the chloride levels in the raw water to the West Elgin WTP. There are only two years (2001 and 2002) of chloride data available at the time of the writing of this Report. The maximum chloride levels are considerably lower than the ODWS aesthetic objective of 250 mg/L as well as the Environment Canada toxicity to aquatic species guideline of 210 mg/L. The chloride values range between 11 and 15 mg/L for the two years.

Table 3.4.4.3-4: Chloride in Lake Erie Raw Water to the West Elgin Water Treatment Plant

Year	Chloride, mg/L			
	Min	Max	Avg	n
2001	14	15	14.25	4
2002	11	14	12.5	2

Source of Data: WTP Laboratory Monitoring Sheets

(e) Lake Erie Raw Water to the Wheatley WTP:

Table 3.4.4.3-5 shows the chloride levels in the raw water to the Wheatley WTP. There are only three years (2000, 2001 and 2002) of chloride data available at the time of the writing of this Report. The maximum chloride levels are considerably lower than the ODWS aesthetic objective of 250 mg/L as well as the Environment Canada toxicity to aquatic species guideline of 210 mg/L. The chloride values range between 13 and 15 mg/L for the three years.

Table 3.4.4.3-5: Chloride in Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	Chloride, mg/L			n
	Min	Max	Avg	
2000	15	15	15	1
2001	13	15	14	4
2002	13	15	14.3	3

Source of Data: Municipality of Chatham-Kent Water Quality Laboratory Reports

(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

Figure 3.4.4.3-15 shows chloride concentrations at intake sites in the ERCA watershed. "Mean chloride levels seemed to be well below the PQWO of 250 mg/L at all of the six intakes at the particular times when this data was collected. Chloride concentrations ranged between from as low as 2 mg/L to as high as 35 mg/L. There were no exceedences of the PWQO at all the intakes associated with this set of data" (Figure and text taken from Chapter 2 of the ERCA Watershed Characterization Report[128]).

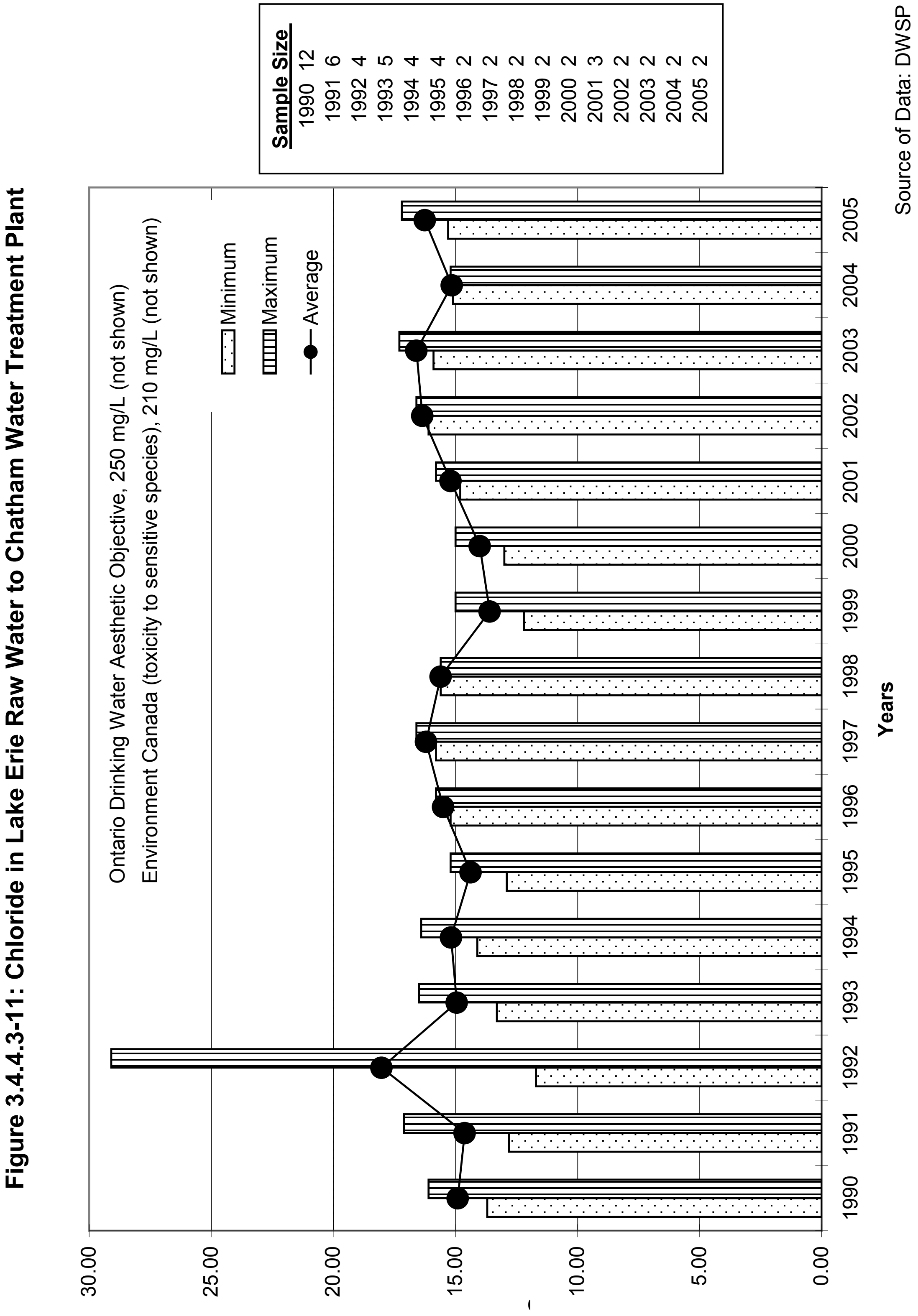


Figure 3.4.4.3-11: **Chloride in Lake Erie Raw Water to Chatham Water Treatment Plant**

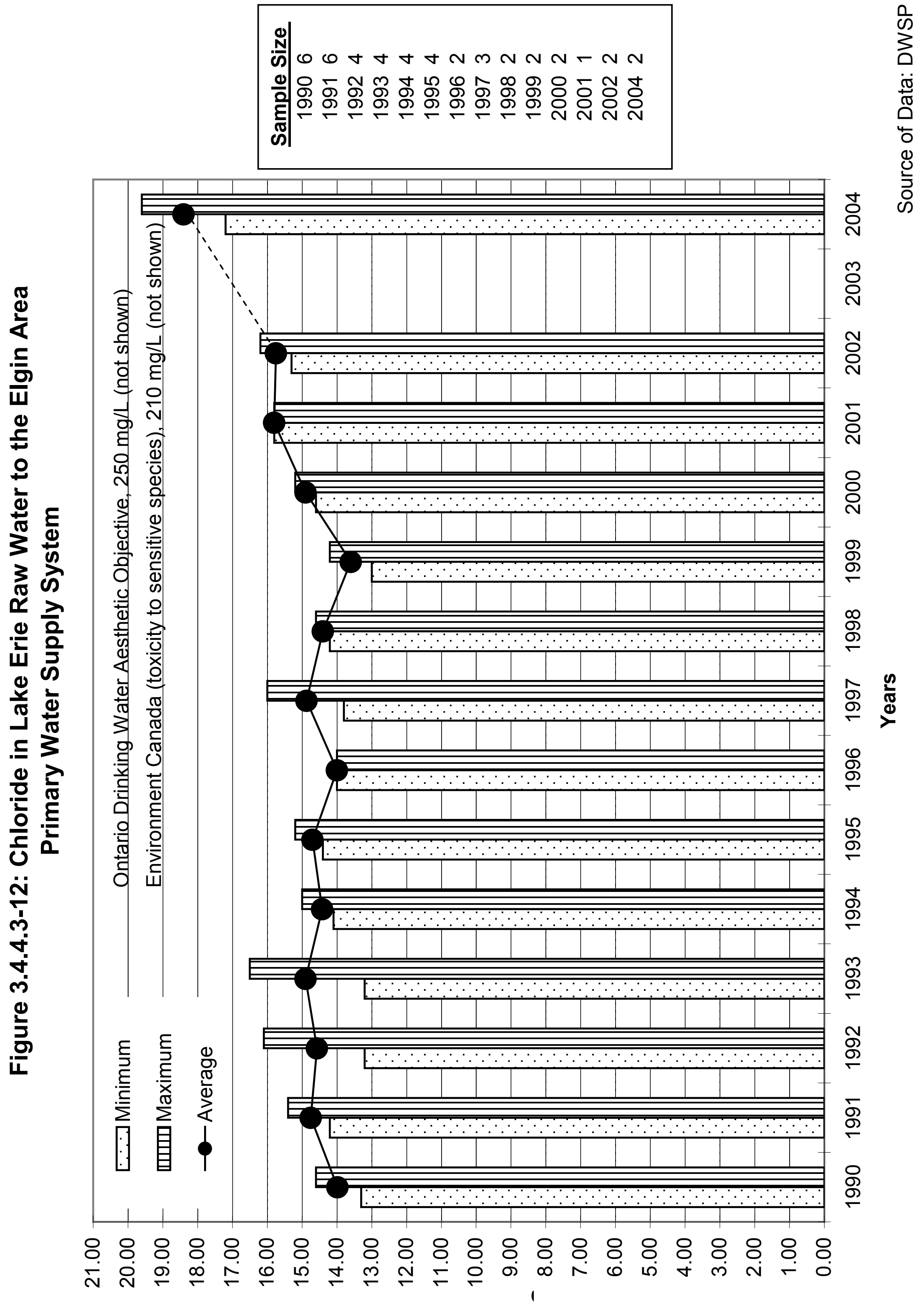


Figure 3.4.4.3-12: **Chloride in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**

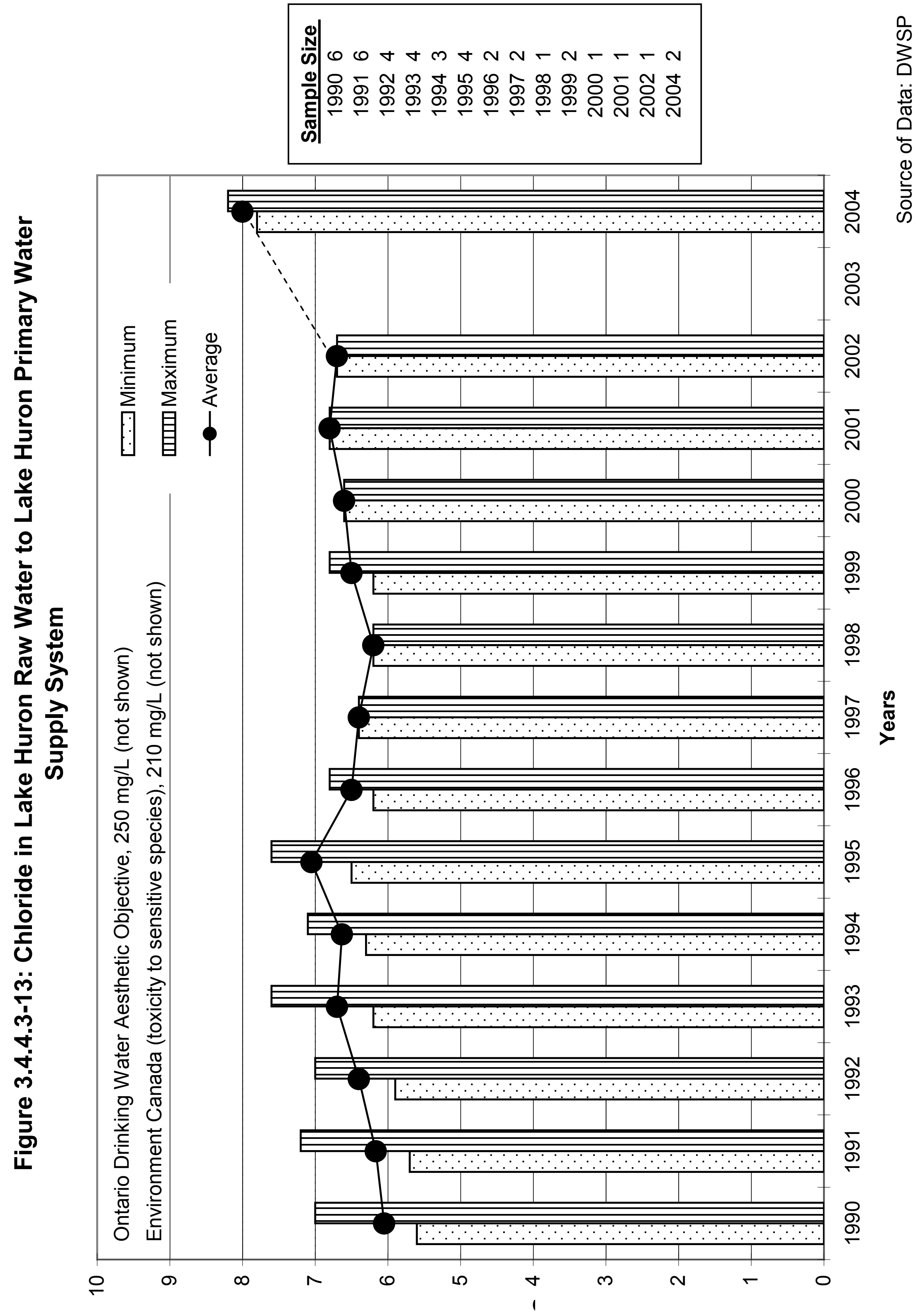


Figure 3.4.4.3-13: **Chloride in Lake Huron Raw Water to Lake Huron Primary Water Supply System**

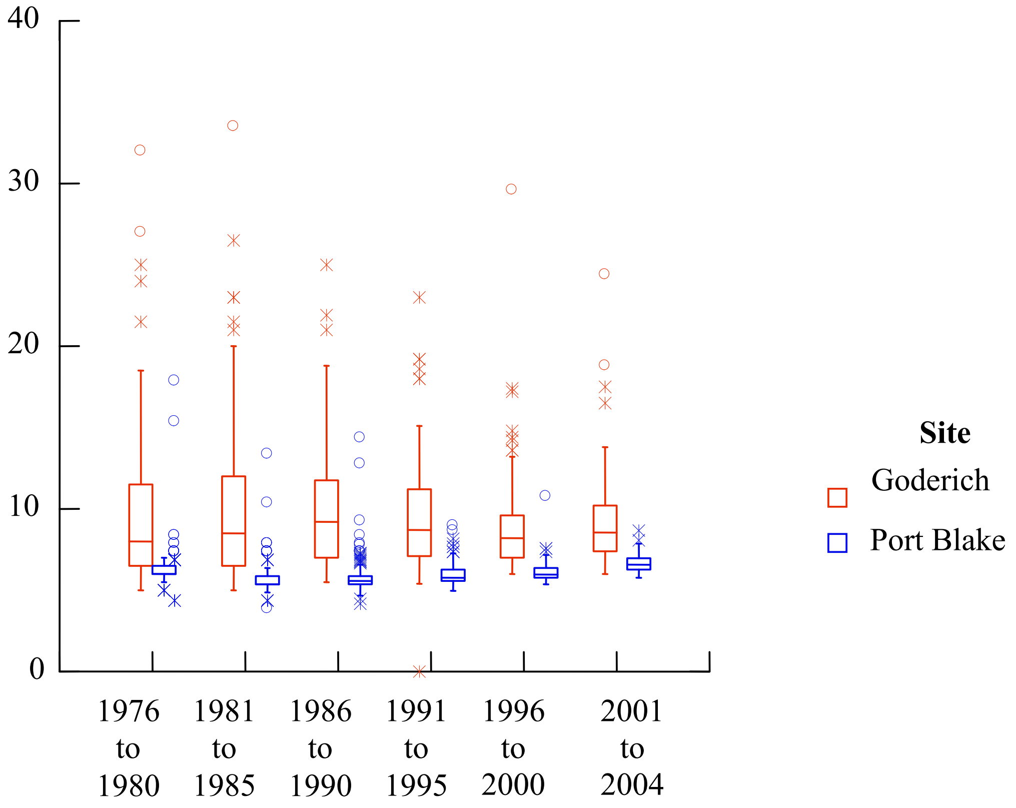
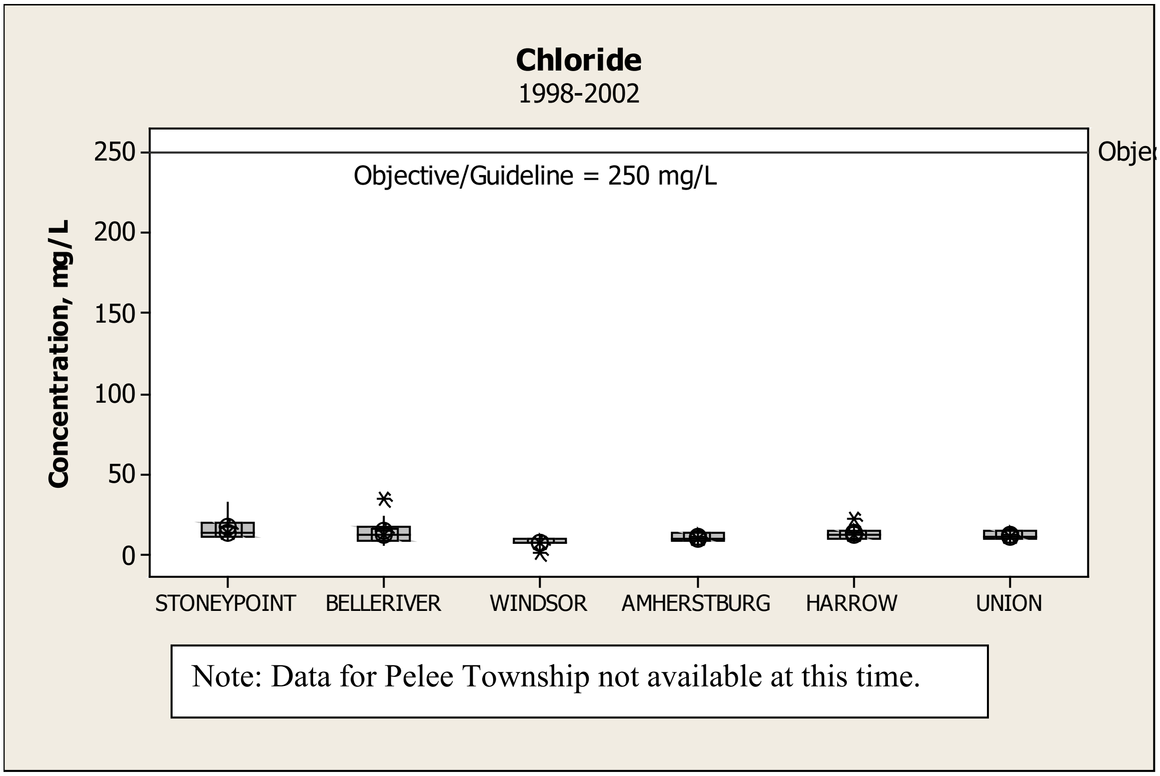


Figure 3.4.4.3-14: **Chloride Concentrations (mg L^{-1}) at Goderich and Port Blake Water Intake Facilities (ABCA)**



Note: Data for Pelee Township not available at this time.

Figure 3.4.4.3-15: **Chloride Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year).

(4) Turbidity

Fate and Behaviour: Turbidity is a measure of water's clarity. The substances and particles that cause turbidity can be responsible for significant interference with disinfection, can be a source of disease-causing organisms, and can shield pathogenic organisms from the disinfection process[136].

Sources: Turbidity is caused by the presence of suspended matter such as clay, silt and microscopic organisms and is commonly present in the water source as a result of soil runoff[136].

Standards: An Ontario Drinking Water Standard (ODWS) aesthetic objective of 5 NTU has been established for turbidity and this objective is applicable to all water at the point of consumption[136]. Turbidity measured to be less than 5.0 NTU is not discernible to the naked eye, but at higher levels the particulate matter in water may cause colour, taste and odour concerns for consumers[137]. For this reason, utilities should try to maintain the level of turbidity in the distribution system to below 5.0 NTU[137].

(a) Lake Erie Raw Water to the Chatham WTP:

Figure 3.4.4.3-16 shows the turbidity levels in the raw water to the Chatham WTP. Most average and maximum turbidity levels have been higher than the ODWS aesthetic objective of 5 NTU from 1990 to

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[136] OMOE. Drinking Water Surveillance Program Summary Report for 2000, 2001 and 2002. DWSP Parameter Groups. www.ene.gov.on.ca/envision/water/dwsp/0002/index.htm#pargroups

[137] Health Canada. 2003. Guidelines for Canadian Drinking Water Quality: Supporting Documentation – Turbidity. www.hc-sc.gc.ca/ewh-semt/pubs/water-eau/turbidity/index_e.

2005. The maximum turbidity levels range between 3.2 and 75.5 FTU with only the years 1996, 2001 and 2005 having maximum turbidity levels lower than the ODWS. The average turbidity levels range between 2.2 and 60.4 FTU. In recent years (2000 to 2005), a considerable peak in turbidity occurred in 2003, with a maximum and average level of 66.2 and 60.4 FTU respectively.

(b) Lake Erie Raw Water to the Elgin PWSS:

Figure 3.4.4.3-17 shows the turbidity levels in the raw water to the Elgin Area PWSS from 1990 to 2004 (2001 and 2003 data missing). All average and maximum turbidity levels are above the ODWS aesthetic objective of 5 NTU. The maximum turbidity levels range between 18 and 450 FTU. Average levels range between 5.8 and 145 FTU. A considerable peak in turbidity occurred in 1999 with a maximum level of 450 FTU but the levels decreased in 2002 and 2004 to less than 25 FTU (2001 and 2003 data missing).

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Figure 3.4.4.3-18 shows the turbidity levels in the raw water to the Lake Huron PWSS. Most maximum and average values between 1990 and 1999 are above the ODWS aesthetic objective of 5 NTU. In this period, maximum levels ranged between 3.8 and 59.7 FTU, and average levels ranged between 2.5 and 20.5 FTU. A significant peak occurred in 1998 with the highest maximum and average turbidity levels. In recent years (2000 to 2004, with 2003 data missing), a decrease in turbidity is observed with all values lower than ODWS of 5 NTU by at least a factor of three. However, the small sample size (one to two samples from 2000 to 2004) may cause bias in values.

(d) Lake Erie Raw Water to the West Elgin WTP:

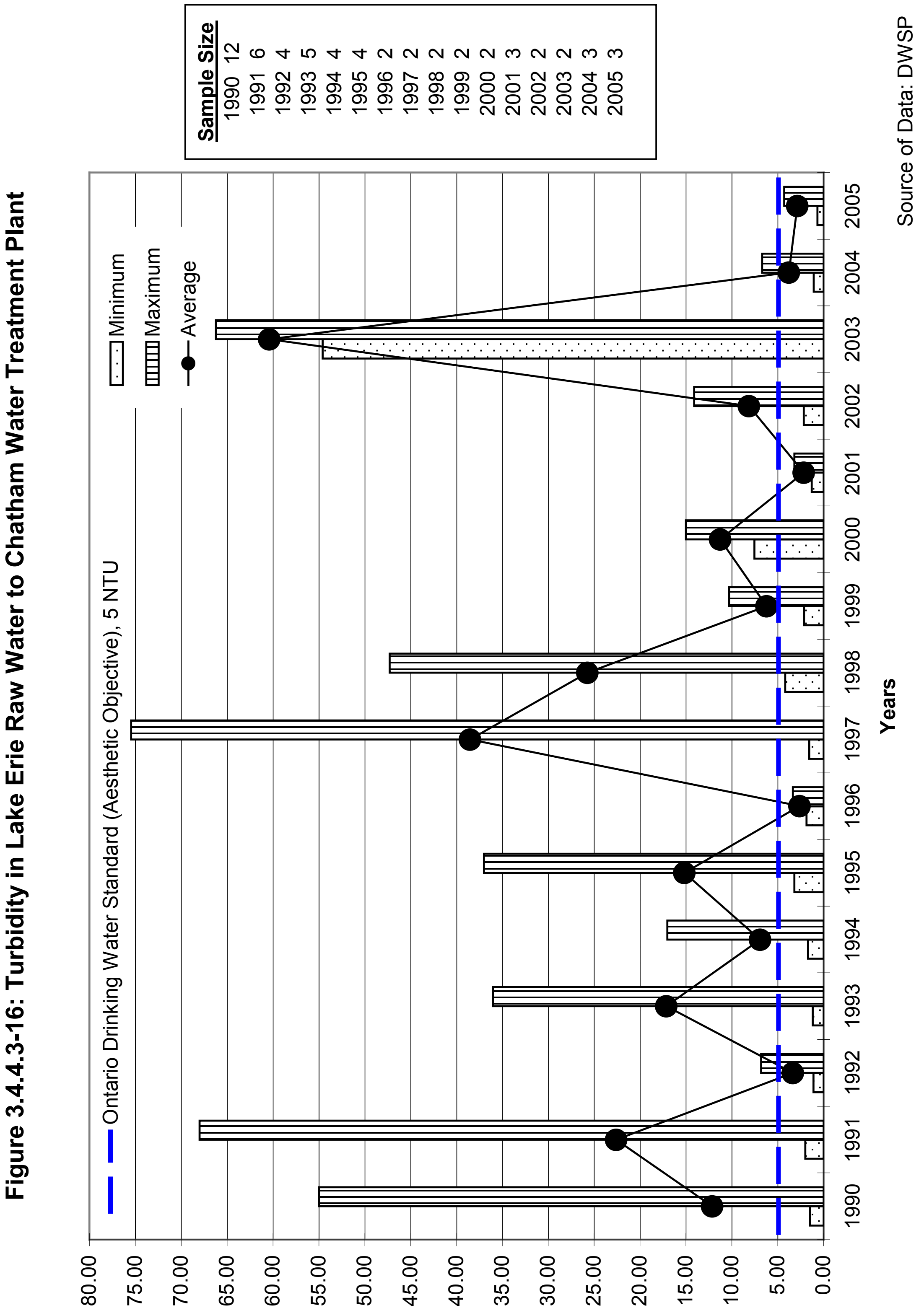
Figure 3.4.4.3-19 shows the turbidity levels in the raw water to the West Elgin WTP from 2001 to 2006. All average and maximum turbidity levels are higher than the ODWS aesthetic objective of 5 NTU and the maximum levels are considerably higher than the average levels. Maximum turbidity levels range between 145.2 and 447 NTU while average levels range between 5.7 and 26.6 NTU.

(e) Lake Erie Raw Water to the Wheatley WTP:

Figure 3.4.4.3-20 shows the turbidity levels in the raw water to the Wheatley WTP from 2000 to 2006 (2003 data missing). Maximum turbidity levels range between 3.5 and 59.3 NTU and average levels range between 2 and 22.9 NTU. In the years 2000 and 2002, all turbidity levels were below the ODWS of 5 NTU. A noticeable peak occurred in 2005, with the highest maximum, minimum and average turbidity levels.

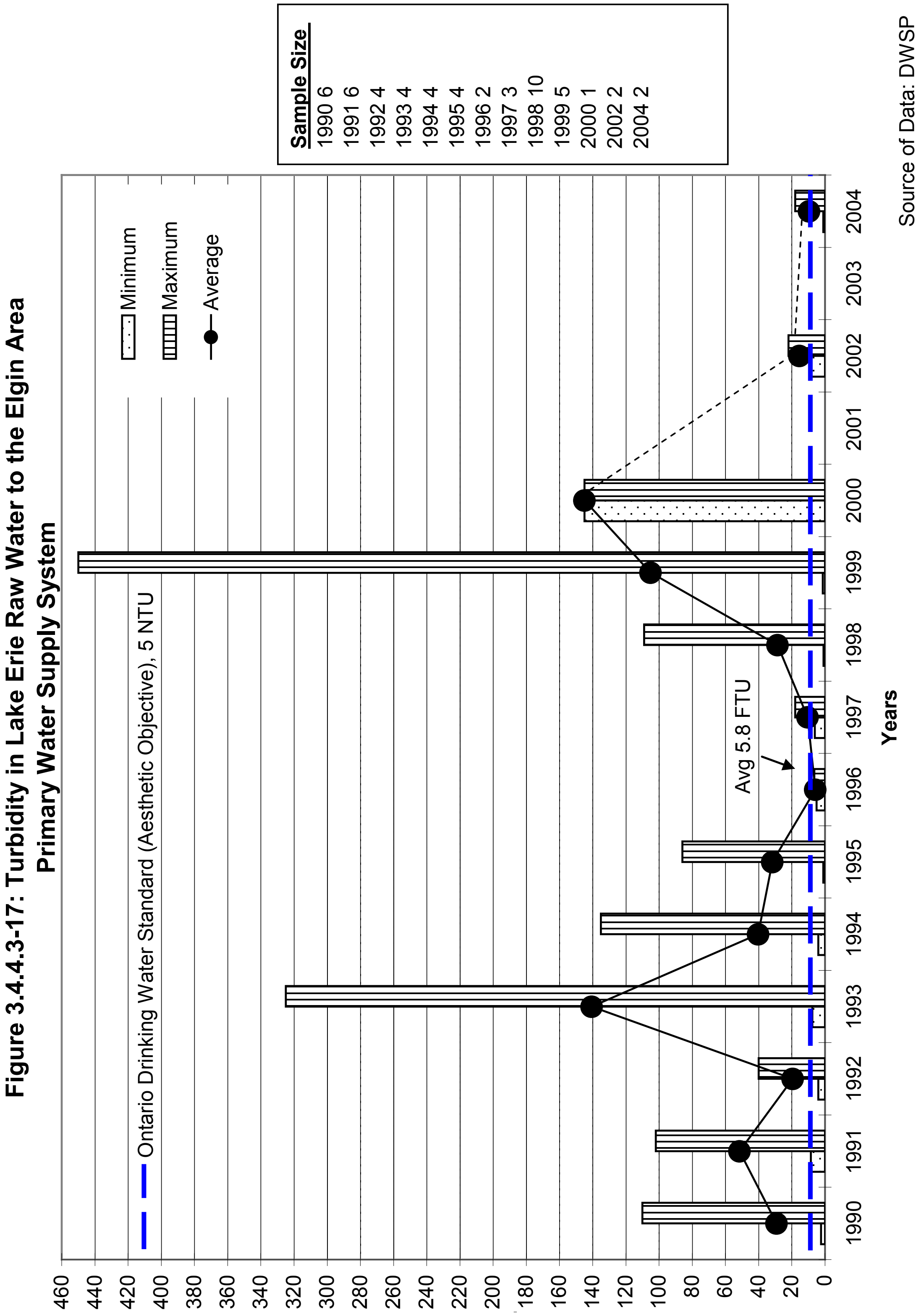
(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

The analysis of turbidity data for these intakes was not done at the time of writing of this report.



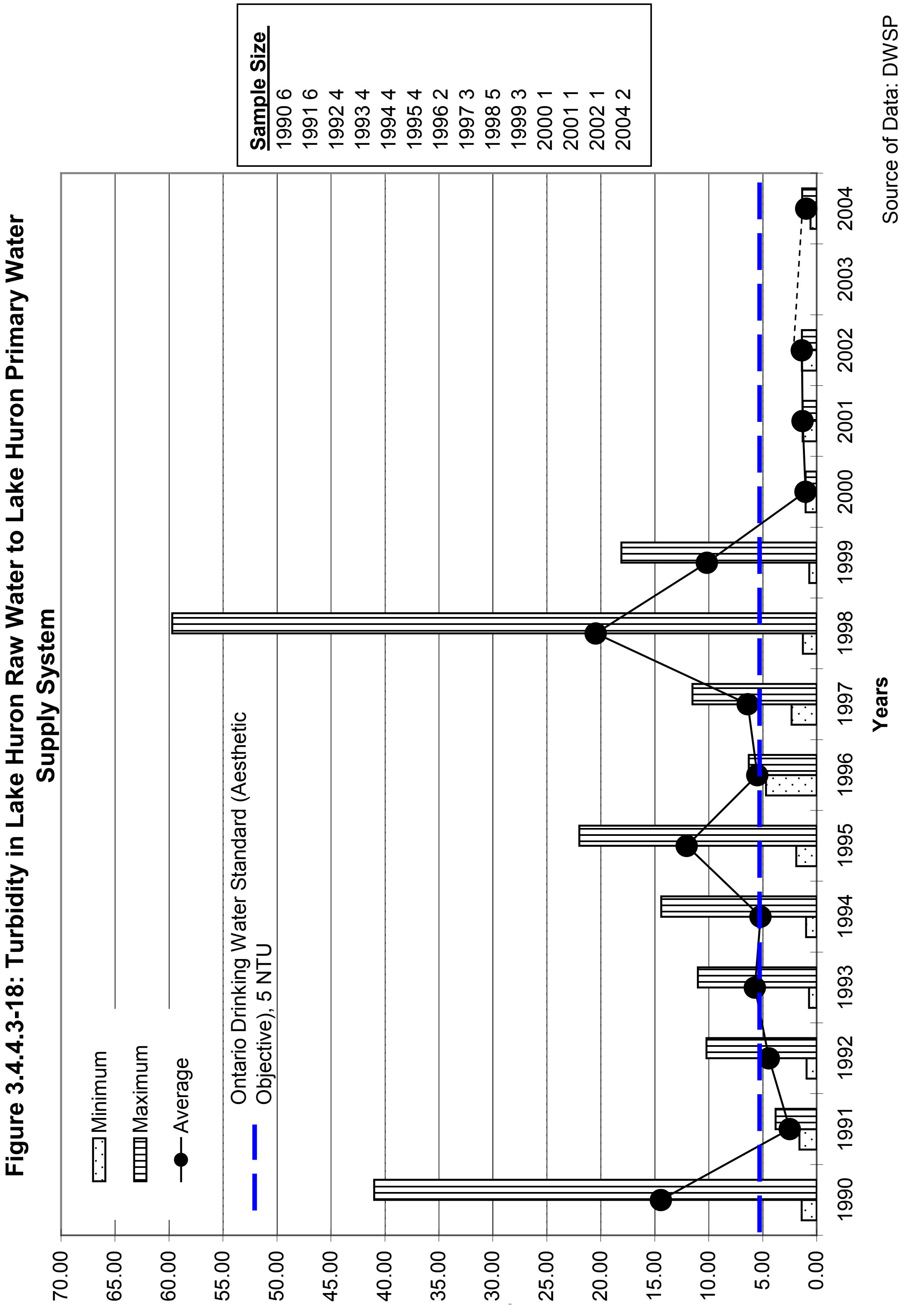
Source of Data: DWSP

Figure 3.4.4.3-16: **Turbidity in Lake Erie Raw Water to Chatham Water Treatment Plant**



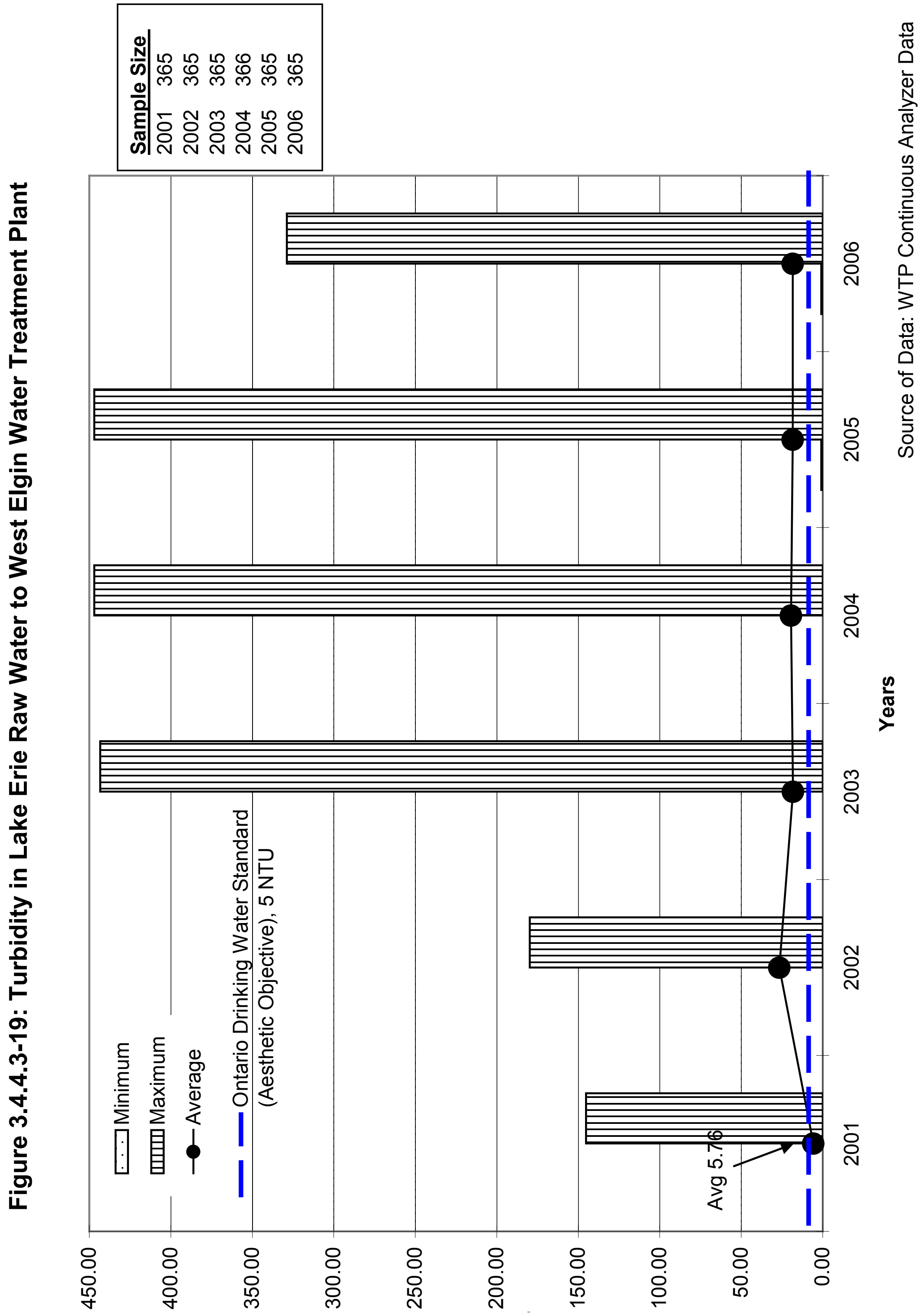
Source of Data: DWSP

Figure 3.4.4.3-17: **Turbidity in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**



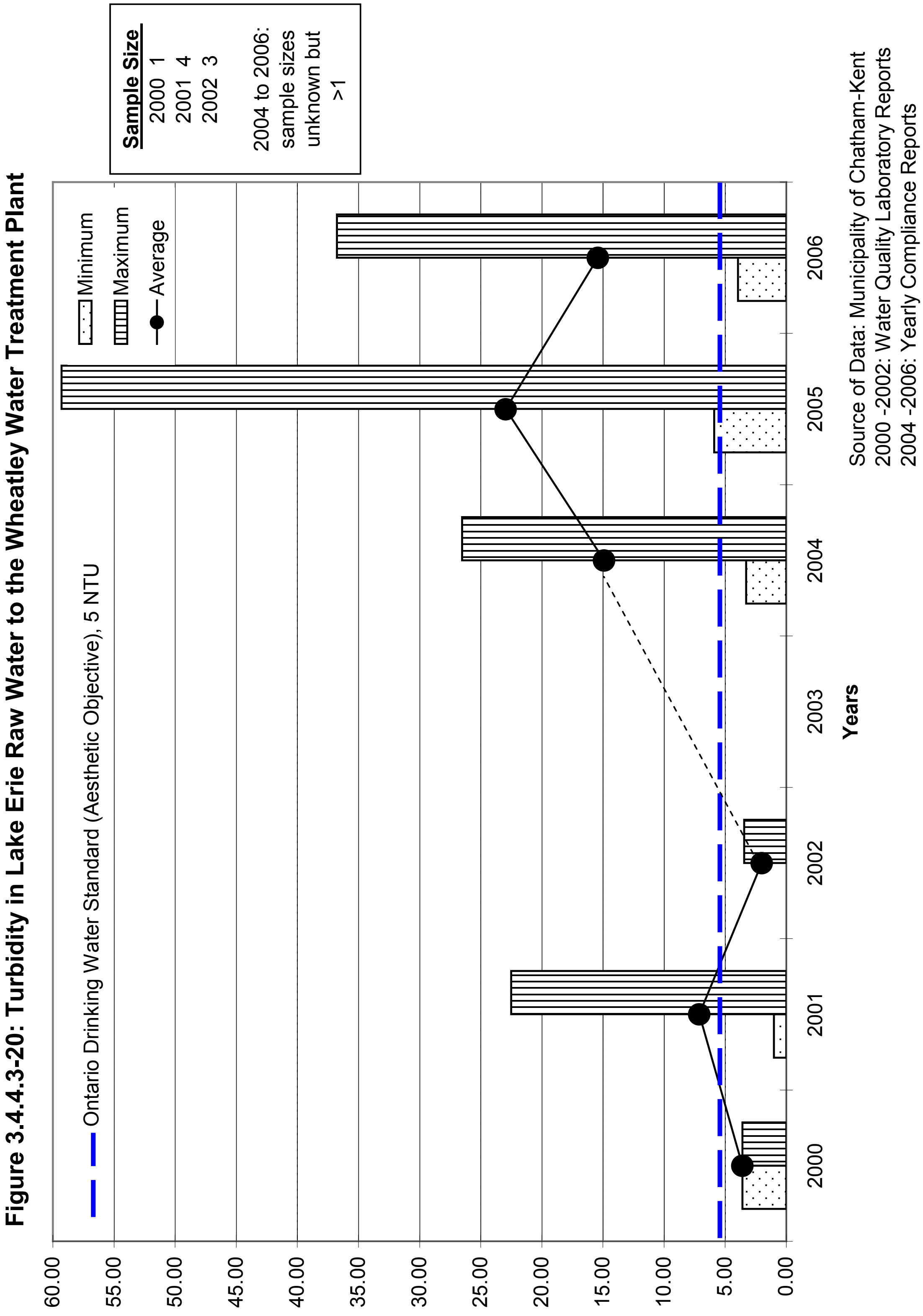
Source of Data: DWSP

Figure 3.4.4.3-18: **Turbidity in Lake Huron Raw Water to Lake Huron Primary Water Supply System**



Source of Data: WTP Continuous Analyzer Data

Figure 3.4.4.3-19: **Turbidity in Lake Erie Raw Water to West Elgin Water Treatment Plant**



Source of Data: Municipality of Chatham-Kent
2000 -2002: Water Quality Laboratory Reports
2004 -2006: Yearly Compliance Reports

Figure 3.4.4.3-20: **Turbidity in Lake Erie Raw Water to the Wheatley Water Treatment Plant**

(5) pH

Behaviour: pH is a physical characteristic in drinking water that may have an effect on or be associated with other aesthetic parameters. At pH levels above 8.5, mineral incrustations and bitter tastes can occur. Corrosion is commonly associated with pH levels below 6.5 and elevated levels of certain undesirable chemical parameters may result from corrosion of specific types of pipe. With pH levels above 8.5, there is also a progressive decrease in the efficiency of chlorine disinfection and alum coagulation[138].

pH is defined as the negative logarithm of hydrogen ion concentration. In a water sample, it provides a measure of the activity of the hydrogen ion, and is reported on a scale of 0 to 14. Typically, pH levels of 0, 7 and 14 are considered to be acidic, neutral, and basic respectively.

Standards: pH in raw water is measured at most WTPs using a continuous data analyzer as this parameter is an 'operational parameter'. The measure on raw water provides an assessment and allows the adjustment of treatment processes. An Ontario Drinking Water Standard (ODWS) operational guideline of 6.5 to 8.5 has been established for pH.

(a) Lake Erie Raw Water to the Chatham WTP:

Figure 3.4.4.3-21 shows the pH levels in the raw water to the Chatham WTP. The minimum, maximum and average pH levels are within the ODWS of 6.5 to 8.5 from 1990 to 2005, with only one exception in 2004 where the maximum pH was 8.7. The pH values vary little throughout the monitoring period.

(b) Lake Erie Raw Water to the Elgin Area PWSS:

Figure 3.4.4.3-22 shows the pH levels in the raw water to the Elgin Area PWSS. The minimum, maximum and average pH levels are within the ODWS range of 6.5 to 8.5 from 1990 to 2004 (2001 and 2003 data missing). The average pH levels are between 7.5 and 8 from 1990 to 1998 but are higher (between 8 and 8.5) from 1999 to 2004.

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Figure 3.4.4.3-23 shows the pH levels in the raw water to the Lake Huron PWSS. The minimum, maximum and average pH levels are within the ODWS range of 6.5 to 8.5 from 1990 to 2004 (2003 data missing). There is a slight increase in average pH values over time from 1990 to 2001 with the pH levels increasing from 7.8 to 8.4. In 2002 and 2004, pH values decreased to about 8.1.

(d) Lake Erie Raw Water to the West Elgin WTP:

Figure 3.4.4.3-24: pH of Lake Erie Raw Water to West Elgin Water Treatment shows the pH levels in the raw water to the West Elgin WTP from 2001 to 2006. All of the average pH values are within the ODWS range of 6.5 to 8.5. However, as previously explained in more detail in the Special Case section, the maximum and minimum pH values of the raw water must be considered with caution since extremely high or low pH data values may be recorded by the continuous pH meter for brief periods of time.

From 2005 to 2006, trending software and log book information allowed the validated exclusion of the extremely high and low pH values. As shown in the figure, all values are within the ODWS guideline range. The average pH was 6.9 in both years and the maximum and minimum values were also close (similar).

The average pH values for 2001 to 2004 also lie in the ODWS guideline range of 6.5 to 8.5. However, trending of the pH values could not be done for the data from 2001 to (September) 2004. While the operator log books provided possible causes for the high and low pH values, the pH values could not be conclusively linked to the causes due to lack of the trending analysis. The maximum and minimum values

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[138] OMOE. 2003. Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines. www.ene.gov.on.ca/envision/gp/4449e.pdf

for 2001 to 2004 are retained on **Figure 3.4.4.3-24** but they must be considered with caution as they are extreme values and range from over 11.0 to less than 1.0.

(e) Lake Erie Raw Water to the Wheatley WTP:

Figure 3.4.4.3-25 shows the pH levels in the raw water to the Wheatley WTP from 2000 to 2006 (2003 data missing). The minimum, maximum and average pH levels are within the ODWS range of 6.5 to 8.5, and all values are close to a pH of 8.0.

(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

The following text is taken from Chapter 2 of the ERCA Watershed Characterization Report[128]. "In general pH of the raw water at the six WTPs was found to be within stipulated range of 6.5 to 8.5, except single incidences of the PWQO exceedence at the Belle River, the Harrow-Colchester and the Essex-Union WTP intakes during the five year period. In all these incidences pH was marginally higher than the limit".

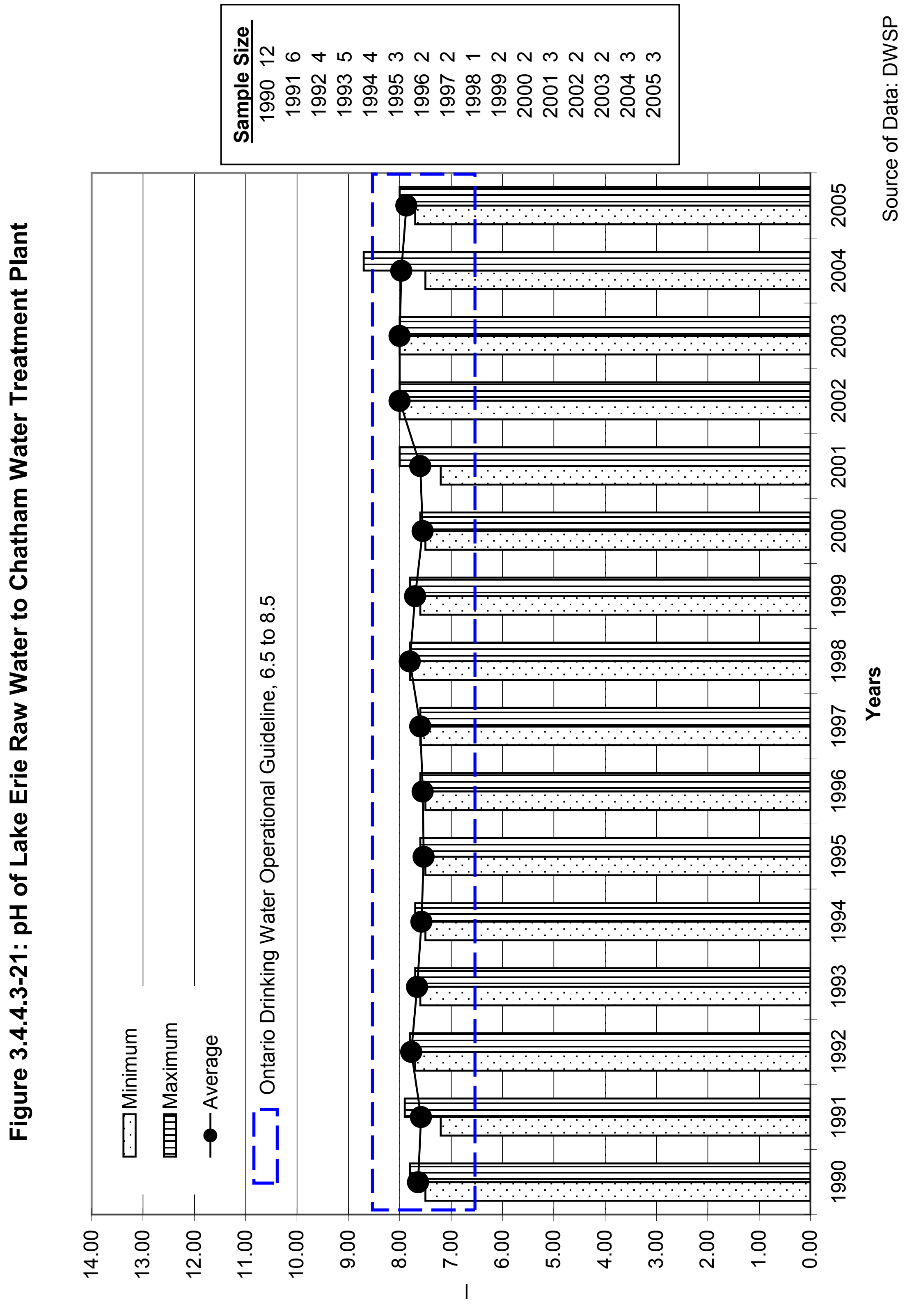
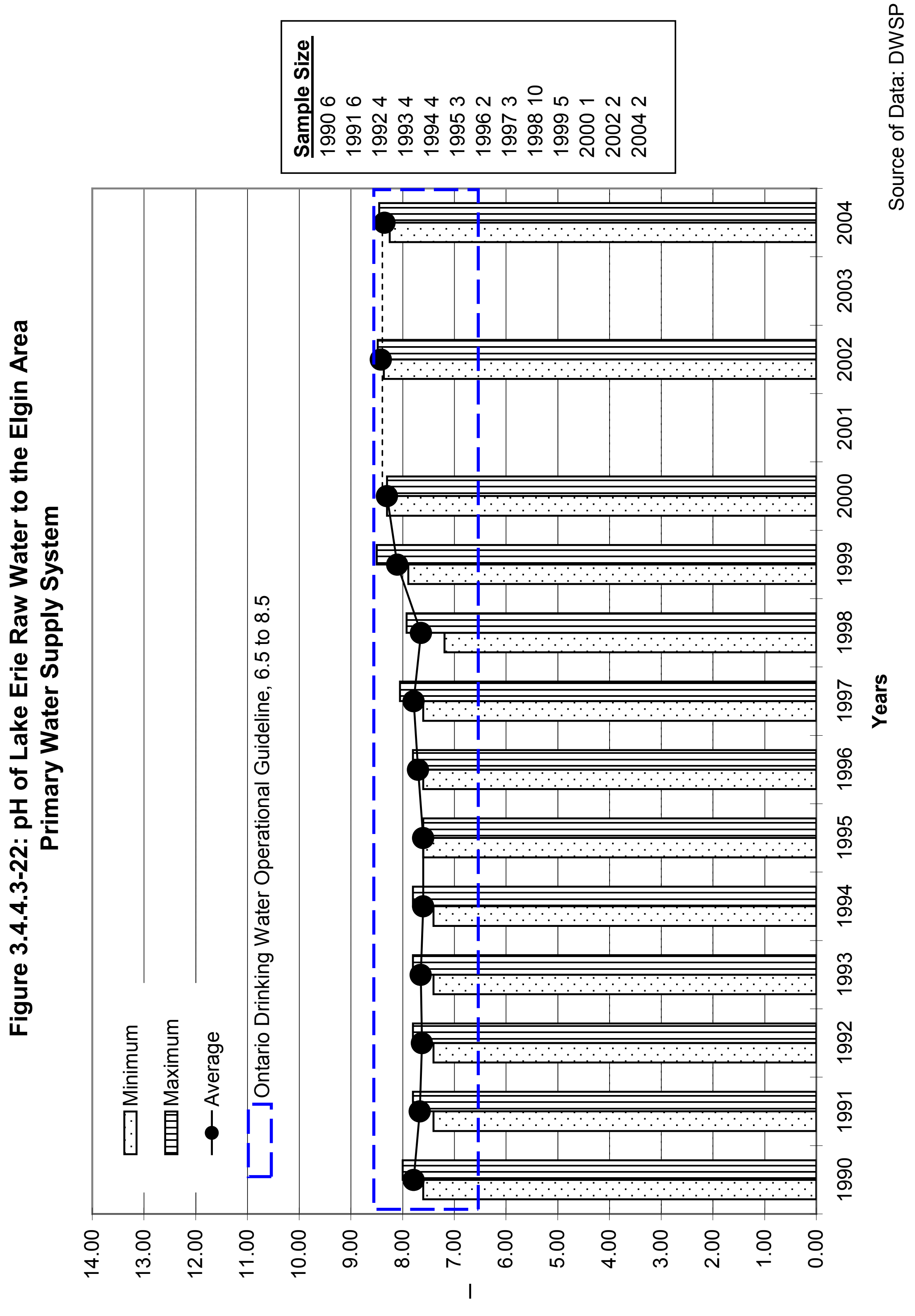


Figure 3.4.4.3-21: **pH of Lake Erie Raw Water to Chatham Water Treatment Plant**



Source of Data: DWSP

Figure 3.4.4.3-22: **pH of Lake Erie Raw Water to the Elgin Area Primary Water Supply System**

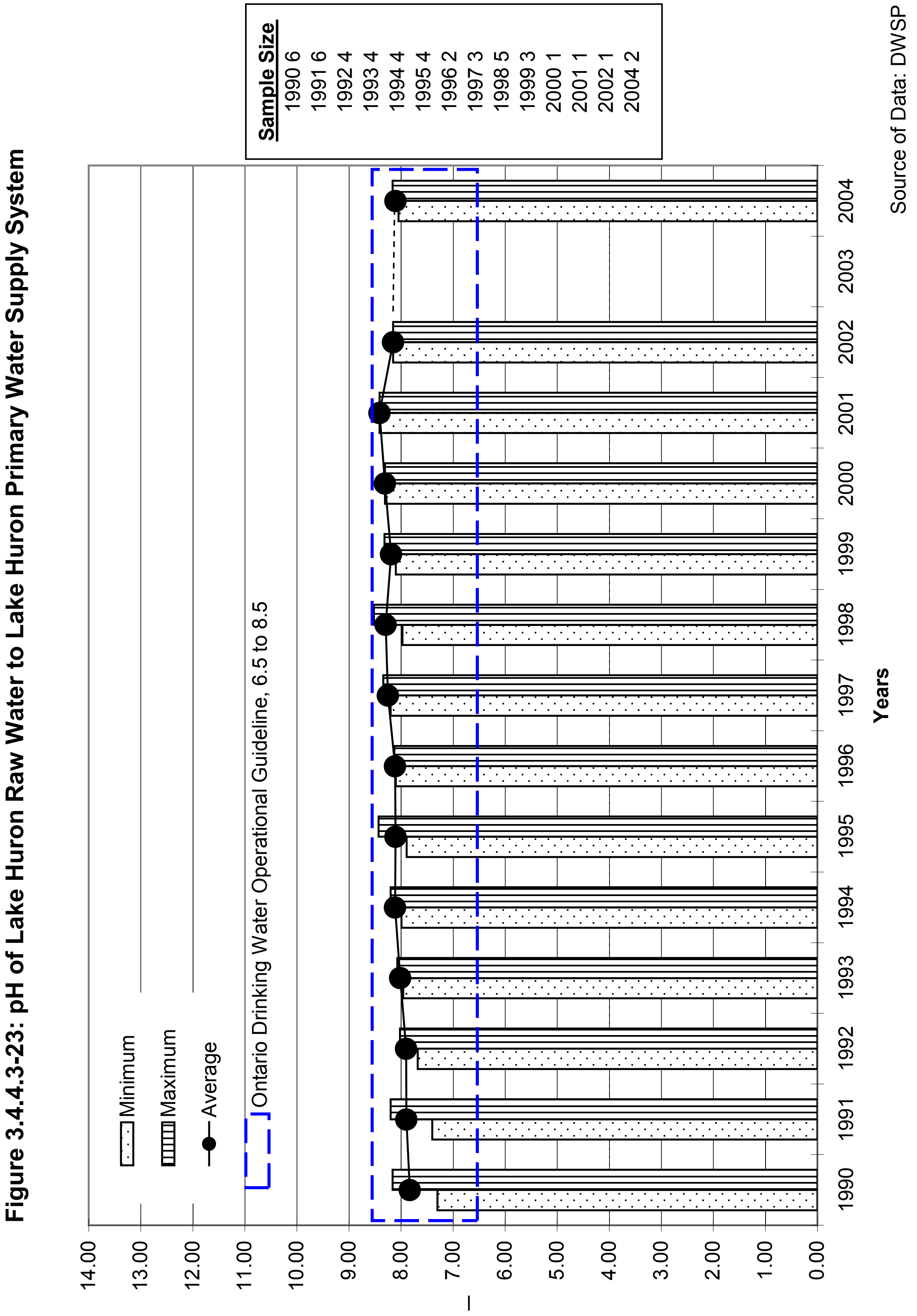
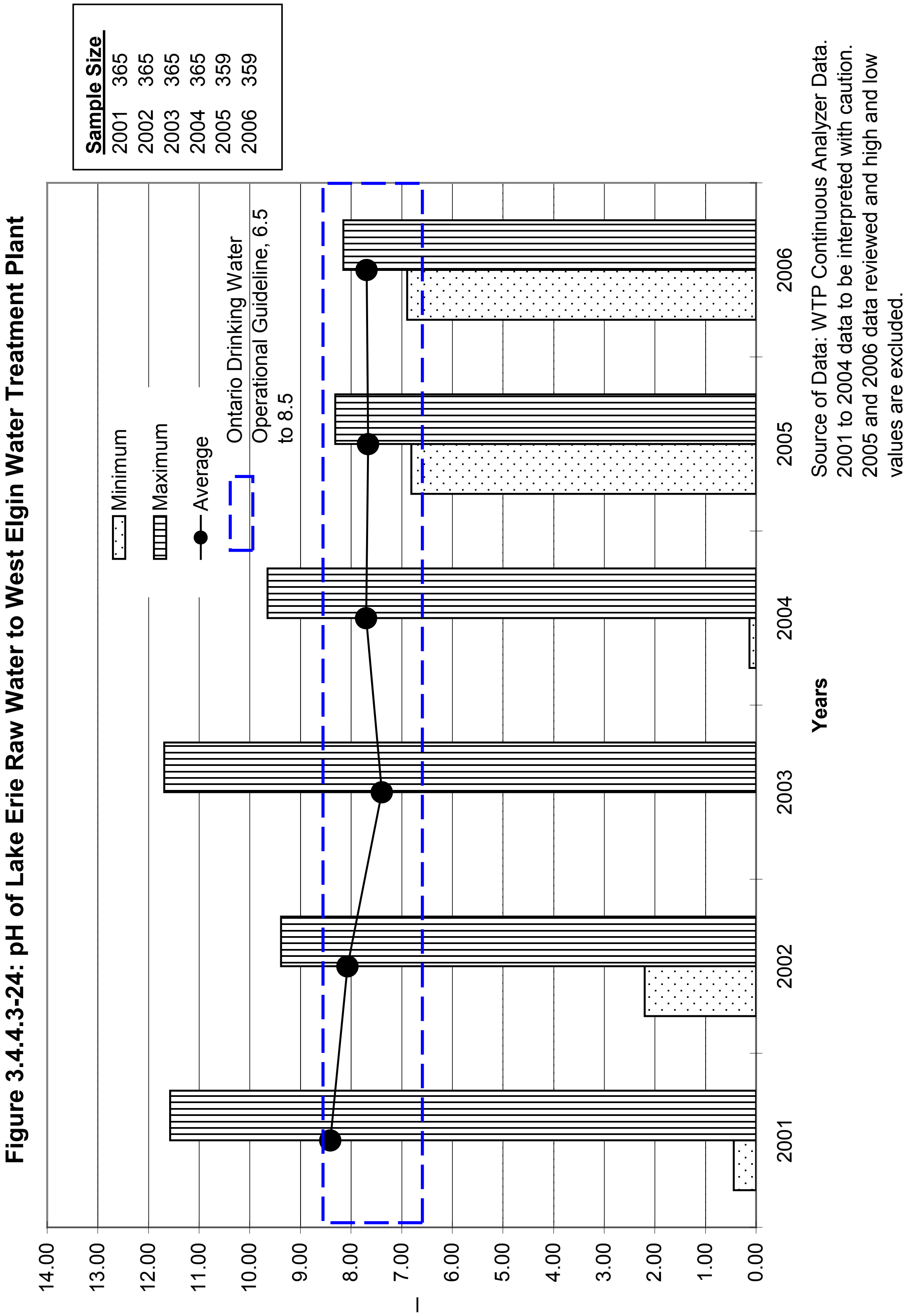
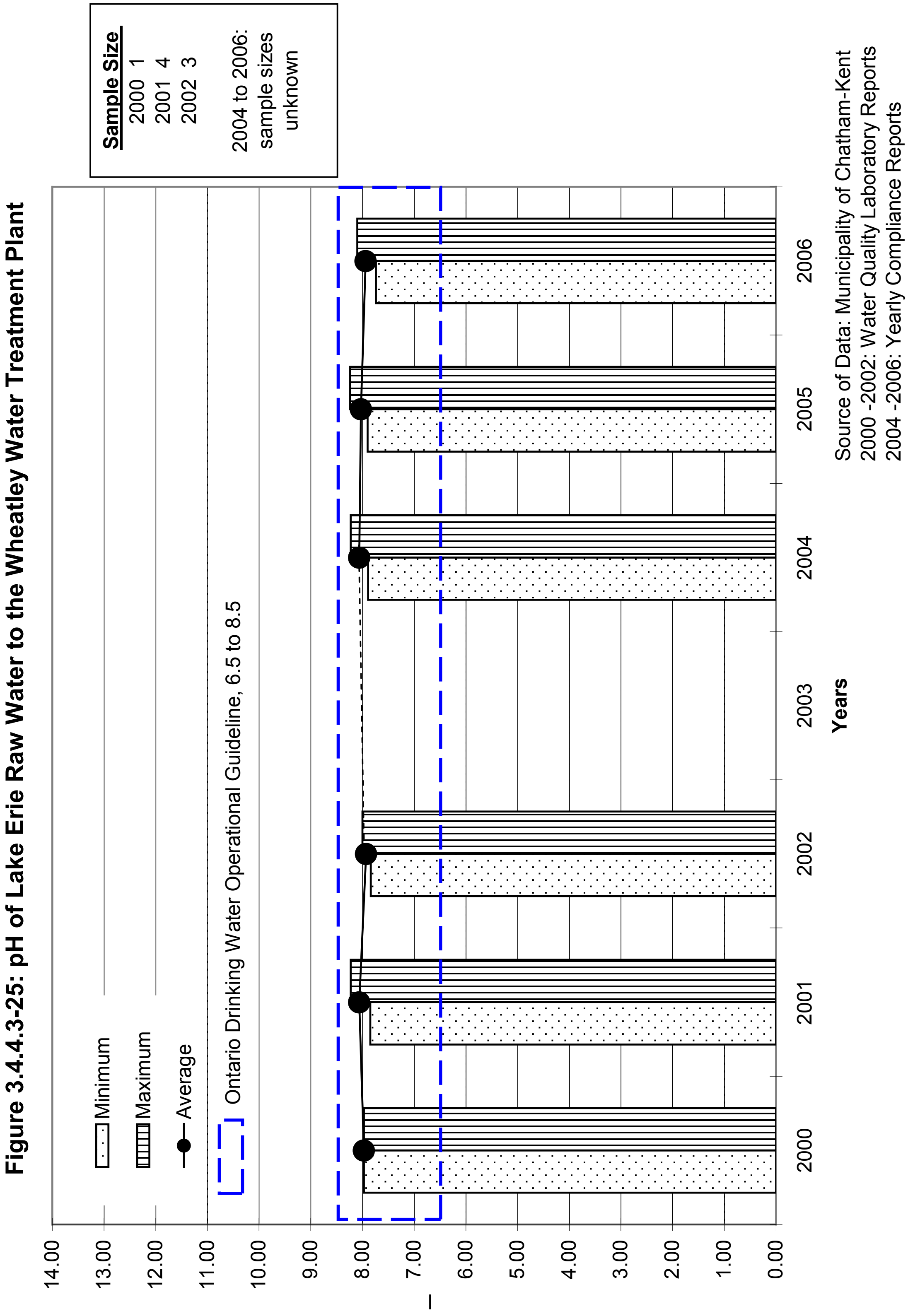


Figure 3.4.4.3-23: **pH of Lake Huron Raw Water to Lake Huron Primary Water Supply System**



Source of Data: WTP Continuous Analyzer Data. 2001 to 2004 data to be interpreted with caution. 2005 and 2006 data reviewed and high and low values are excluded.

Figure 3.4.4.3-24: pH of Lake Erie Raw Water to West Elgin Water Treatment Plant



Source of Data: Municipality of Chatham-Kent
2000 -2002: Water Quality Laboratory Reports
2004 -2006: Yearly Compliance Reports

Figure 3.4.4.3-25: **pH of Lake Erie Raw Water to the Wheatley Water Treatment Plant**

(6) Temperature

Behaviour: Temperature is a physical characteristic in drinking water that may have an effect on or be associated with other aesthetic parameters. Temperature affects taste and odour perceptions and the rate of growth of micro-organisms. It is desirable that the temperature of drinking water not exceed 15^0C because the palatability of water is enhanced by its coolness. Low water temperatures offer a number of other benefits. A temperature below 15^0C will tend to reduce the growth of nuisance organisms and, hence, minimize associated taste, colour, odour and corrosion problems. In summer and fall, water temperatures may increase in the distributed water due to the warming of the soil and/or as a result of higher temperatures in the water source. Low temperature facilitates maintenance of a free chlorine residual by reducing the rates of decay of the chlorine[138].

Standards: Temperature in raw water is measured at most WTPs using a continuous data analyzer as this parameter is an 'operational parameter'. The measure on raw water provides an assessment and allows the adjustment of treatment processes. Also, an aesthetic objective is set for maximum water temperature to aid in selection of the best water source or the best placement for a water intake. An Ontario Drinking Water Standard (ODWS) aesthetic objective of 15^0C has been established for temperature[138].

(a) Lake Erie Raw Water to the Chatham WTP:

Figure 3.4.4.3-26 shows the temperature of the raw water to the Chatham WTP. From 1990 to 2001 and in 2005, the average temperatures are lower than the ODWS of 15^0C and range from 9 to 11.7^0C. From 2002 to 2004, the water temperatures were the highest with average values at or slightly over the aesthetic objective of 15^0C. From 1990 to 2005, most of the maximum temperatures are above the ODWS of 15^0C and overall range between 14 and 22^0C. Minimum water temperatures range between 2 and 11^0C.

(b) Lake Erie Raw Water to the Elgin Area PWSS:

Figure 3.4.4.3-27 shows the temperature of the raw water to the Elgin PWSS from 1990 to 2004, with 2001 and 2003 data missing. All average temperatures are lower than the ODWS of 15^0C and for most of the monitoring period, range between 8 and 12.25^0C. The average temperatures were close to the ODWS in 1998 and 2002. Most of the maximum temperatures are higher than the ODWS of 15^0C and range between 8 and 24^0C. Minimum water temperatures range between 1 and 8.5^0C.

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Figure 3.4.4.3-28 shows the temperature levels of the raw water to the Lake Huron PWSS from 1990 to 2004, with 2003 data missing. The average temperatures are lower than the ODWS of 15^0C from 1990 to 1999 and in 2004, ranging between 8.5 and 11.7^0C. Most of the maximum temperatures are higher than the ODWS of 15^0C and range between 10 and 22^0C. Minimum water temperatures range between 1 and 21^0C. From 2000 to 2002, only one sample per year was analyzed and, while temperatures ranged between 19 to 22^0C (higher than the ODWS), sampling bias may be a factor.

(d) Lake Erie Raw Water to the West Elgin WTP:

Figure 3.4.4.3-29 shows the temperature levels of the raw water to the West Elgin WTP from 2001 to 2006. The average temperatures are all below the ODWS of 15^0C and do not fluctuate much, ranging between 11.1 and 12.8^0C. All maximum temperatures are above the ODWS. Maximum temperatures of around 30^0C are observed in 2001 to 2003, while decreased maximum temperatures of around 20^0C are seen in 2004 to 2006. The minimum temperatures from 2001 to 2004 (0.7 to 2.3^0C) are much lower than those of 2005 and 2006 (8.5 and 8.2^0C).

(e) Lake Erie Raw Water to the Wheatley WTP:

Table 3.4.4.3-6 shows the temperature levels of the raw water to the Wheatley WTP from 2004 to 2006. All maximum temperatures (around 20^0C) are above the ODWS of 15^0C, while all average (around 10^0C) and minimum temperatures are well below the ODWS.

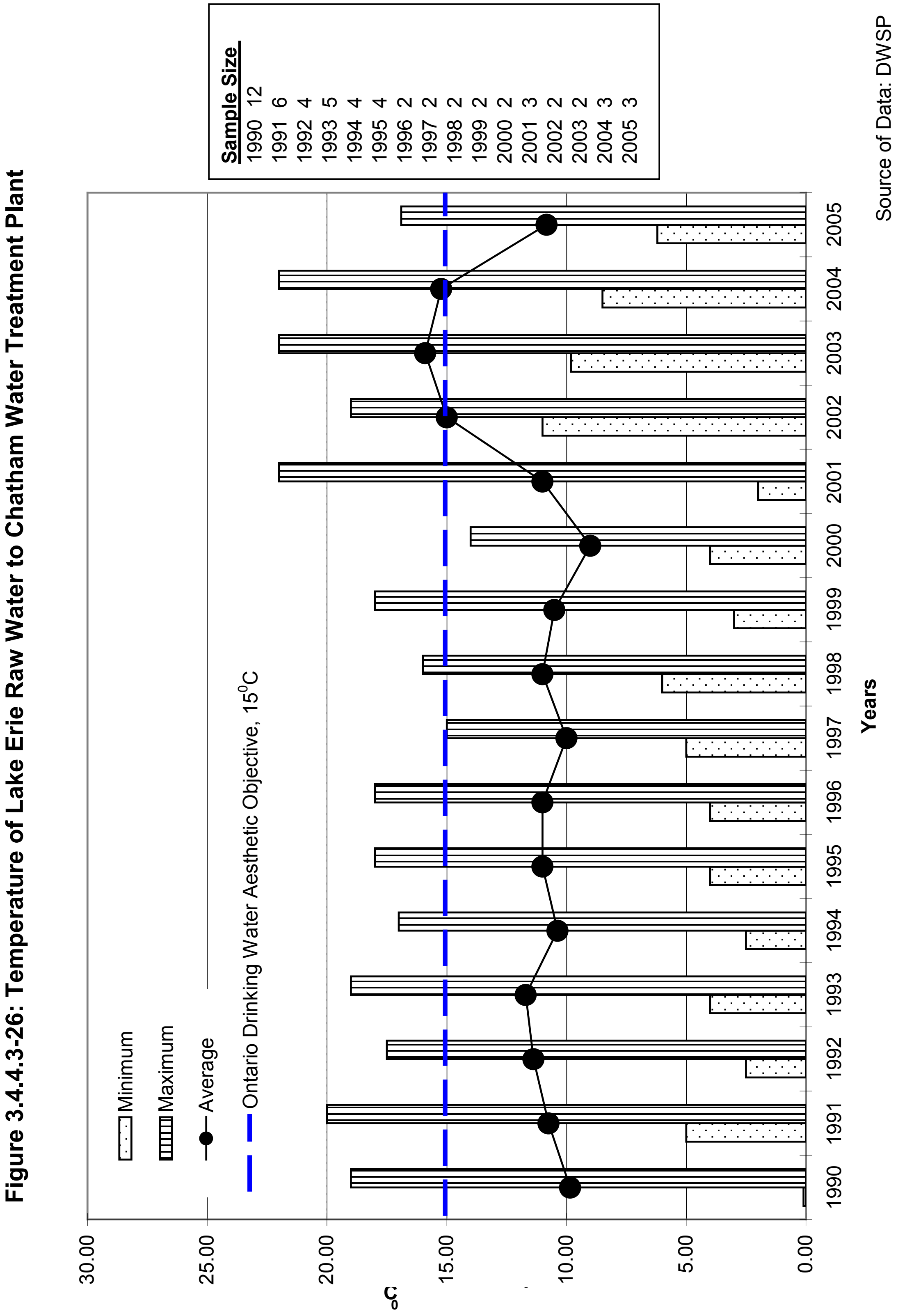
Table 3.4.4.3-6: Temperature of Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	Temperature, deg. C			n
	Min	Max	Avg	
2004	1.27	19.78	10.76	*
2005	0.51	21.75	10.09	*
2006	0.76	21.51	10.27	*

*Sample size unknown
Source of Data: Municipality of Chatham-Kent Yearly Compliance Reports

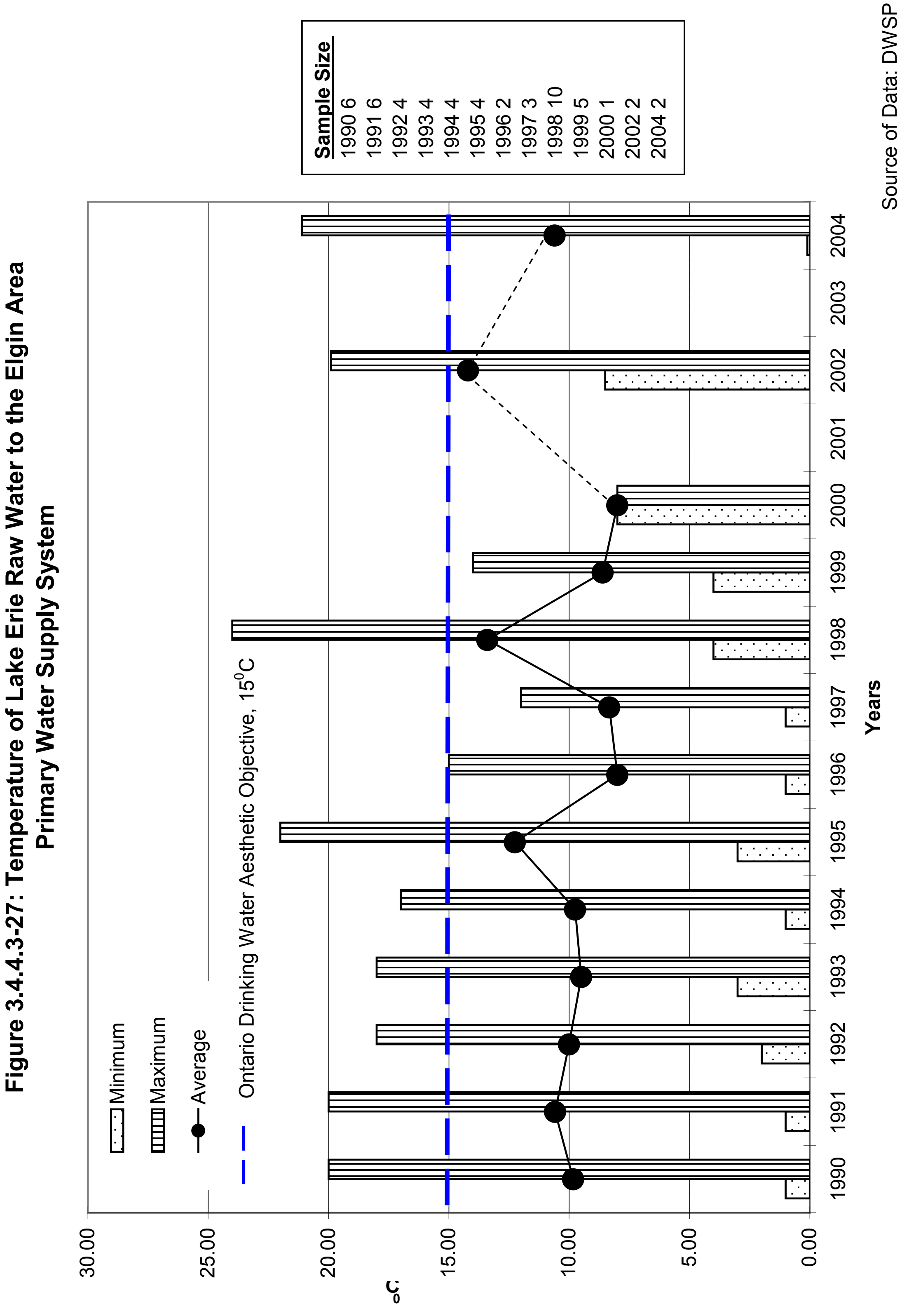
(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

The analysis of temperature data for these intakes was not done at the time of writing of this report.



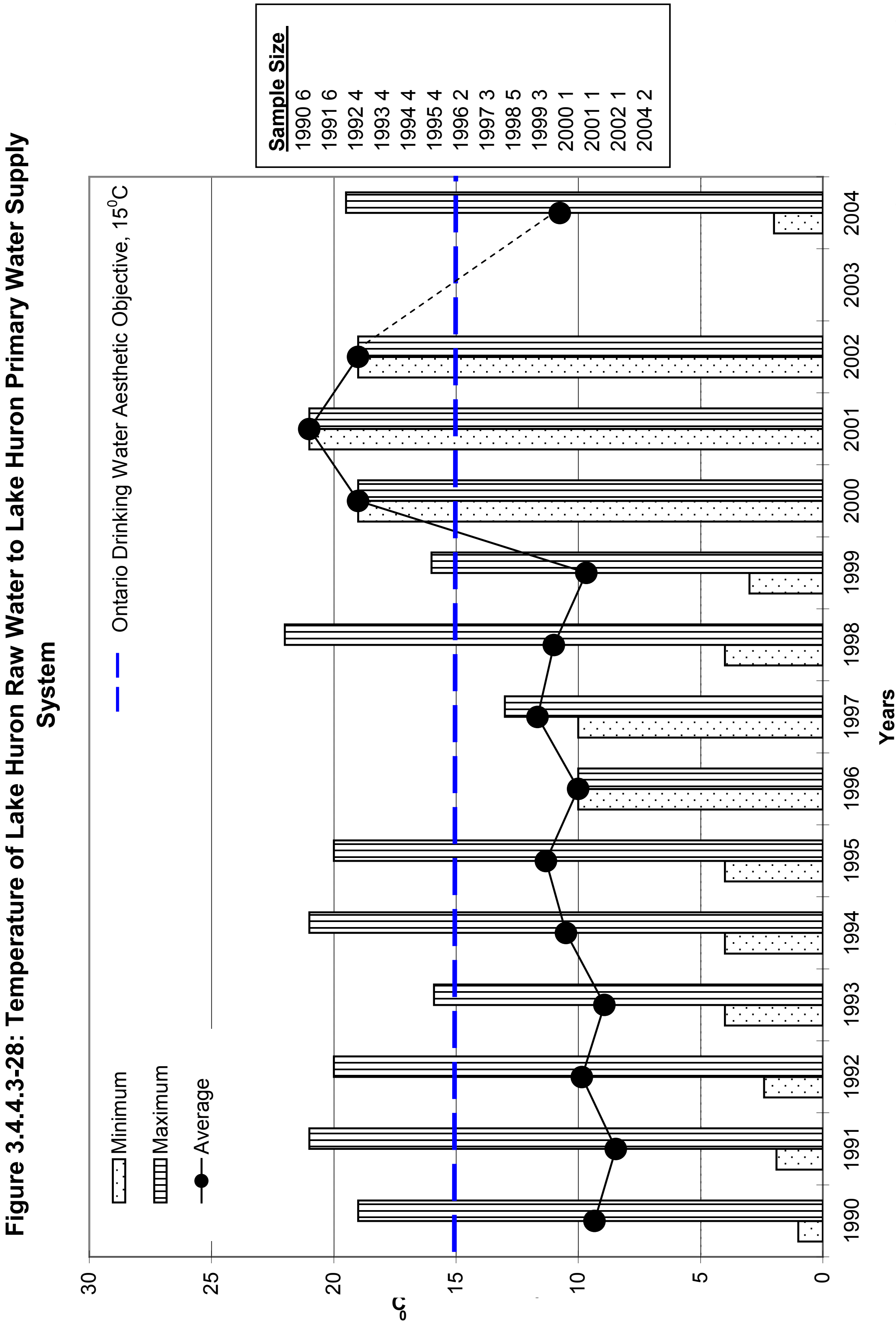
Source of Data: DWSP

Figure 3.4.4.3-26: **Temperature of Lake Erie Raw Water to Chatham Water Treatment Plant**



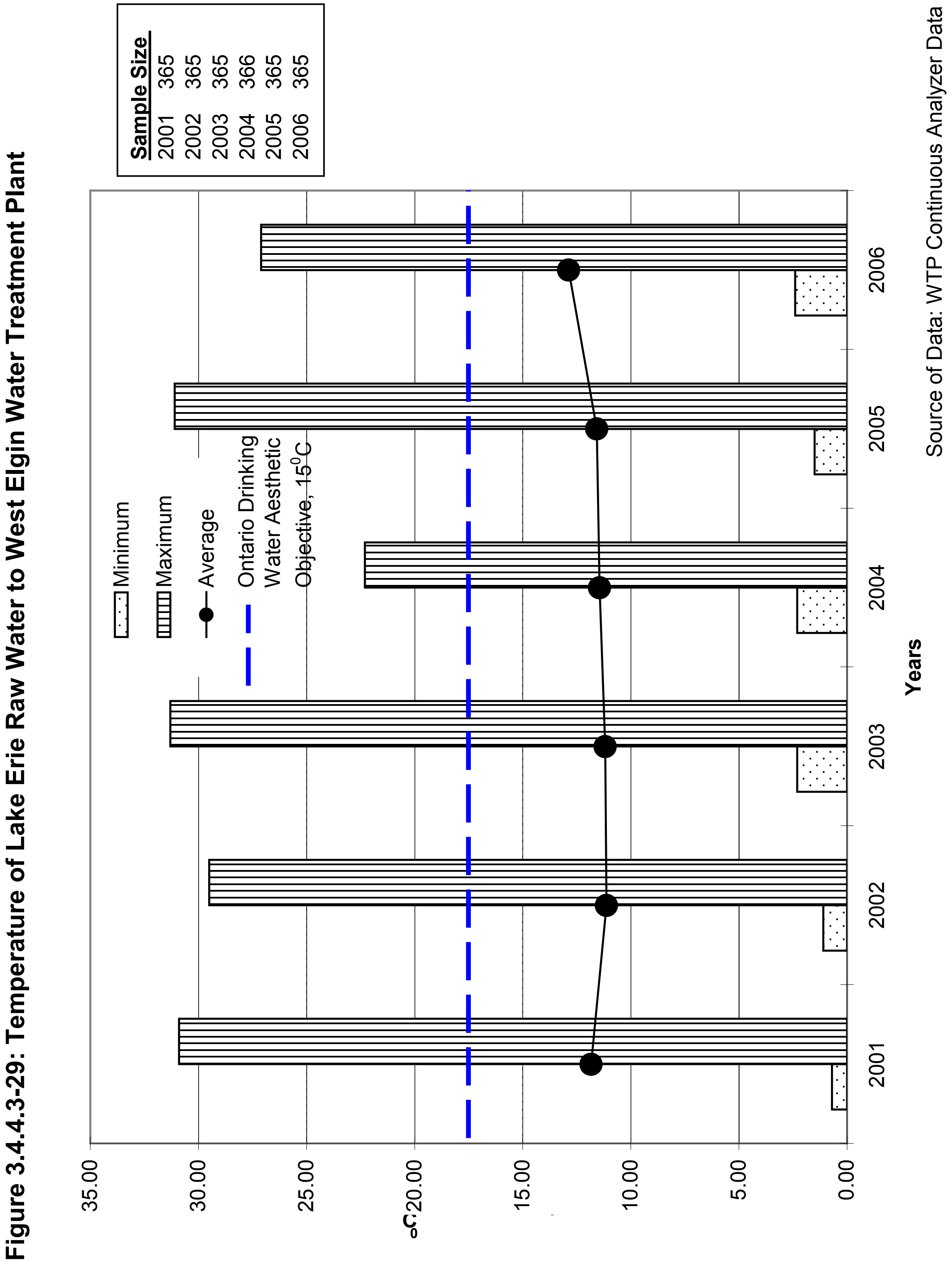
Source of Data: DWSP

Figure 3.4.4.3-27: **Temperature of Lake Erie Raw Water to the Elgin Area Primary Water Supply System**



Source of Data: DWSP

Figure 3.4.4.3-28: **Temperature of Lake Huron Raw Water to Lake Huron Primary Water Supply System**



Source of Data: WTP Continuous Analyzer Data

Figure 3.4.4.3-29: **Temperature of Lake Erie Raw Water to West Elgin Water Treatment Plant**

(7) Coliform Bacteria

The two microbiological indicator parameters used in this Report to assess intake (raw) water quality are *Escherichia coli* (*E. coli*) and total coliform. Historically, fecal coliform, a type of coliform bacteria, was monitored in Ontario by the OMOE as an indicator of fecal contamination. The OMOE changed the indicator in 1994 to *E. coli*, a type of fecal coliform.

Sources: Total coliform are bacteria present in the environment and in fecal matter. Fecal coliform are a type of total coliform from human and animal fecal matter only. *E. coli* is a type of fecal coliform. *E. coli* and other fecal coliform bacteria are found in the fecal matter of humans, animals and birds. Potential sources include runoff from biosolids/sewage or livestock waste application, faulty private septic systems, inadequate manure storage and urban stormwater runoff.

E. coli is a fecal coliform bacterium that is monitored as an indicator of other pathogens present in human and animal (domestic and wildlife) waste. A positive *E. coli* test implies sewage contamination which can include pathogenic bacteria and viruses, such as *Giardia* and *Cryptosporidium*, that are much more difficult to detect than *E. coli*. Bacteria can survive for many months, especially in nutrient-rich sediments. In addition to affecting surface water quality, *E. coli* can contaminate groundwater and put well water sources at risk.

Standards: The Ontario Drinking Water Standards (ODWS) for total coliform and *Escherichia coli* are Maximum Acceptable Concentrations (MAC) of "not detectable". In other words, there must be zero counts of total coliform and *E. coli* in drinking water.

(a) Lake Erie Raw Water to the Chatham WTP:

Table 3.4.4.3-7 provides a summary of annual fecal coliform from 1990 to 1993, and a summary of *E. coli* and total coliform data from 2001 to 2006. The highest total coliform count in the source water occurred in 2003 (25000 counts/100 mL) and the highest *E. coli* count occurred in 2005 (2000 counts/100 mL). There appears to be an increase in the maximum *E. coli* counts from the early 1990s to recent years.

Table 3.4.4.3-7: Coliform Summary Data for Lake Erie Raw Water to the Chatham Water Treatment Plant

Year	*Escherichia coli**, counts/100 mL				Total coliform, counts/100 mL			
	Min	Max	Avg	n	Min	Max	Avg	n
1990	2	2	2	6				
1991	1	4	2.6	5				
1992	2	3	2.5	2				
1993	2	2	2	3				
2001	<1	91		52	<1	9		52
2002	0	15		52	0	3000		52
2003	0	2	1	33	0	25000	817	33
2004	0	100	5	48	0	1400	151	48
2005	0	2000	80	51	0	2300	143	51
2006	0	33	5	38	0	570	67	38

*Note: From 1990 to 1993, fecal coliform was analyzed
Source of Data:
1990 to 1993: DWSP data
2001 to 2002: Chatham-Kent Municipality Chatham WTP Lab Reports

2003 to 2006: DWIS data
Blank fields are data gaps

Figure 3.4.4.3-30 shows the *E. coli* counts from June 2003 to September 2006. Most 2003 data points are zero, agreeing with the Ontario Drinking Water Standard of 'not detectable'. In 2004, *E. coli* in the raw water is not detected from January to March but begins to be present in April and goes up to as high as 100 counts/100 mL in November. In 2005, most zero counts were in the first half of the year up to the beginning of June and the high counts are in the later half of the year. The highest *E. coli* counts in the source water occurred in 2005. In 2006 the presence of *E. coli* is seen throughout the period from January to September, but there appears to be a decrease in *E. coli* counts in June.

Figure 3.4.4.3-31 shows the total coliform counts from June 2003 to September 2006. The highest count in the source water occurred in 2003. In all years, total coliform counts have varied monthly but overall, the counts in 2004, 2005 and 2006 seem to decrease in late May and early June.

(b) Lake Erie Raw Water to the West Elgin WTP:

Table 3.4.4.3-8 provides a summary of annual *E. coli* and total coliform data from 2001 to 2006. The highest total coliform count in the source water occurred in 2003 (91000 counts/100 mL) and the highest *E. coli* count occurred in 2005 (1400 counts/100 mL). The highest coliform count occurred in 2003 which is the same as the raw water to the Chatham WTP.

Table 3.4.4.3-8: Coliform Summary Data for Lake Erie Raw Water to the West Elgin Water Treatment Plant

Year	*Escherichia coli*, counts/100 mL				Total coliform, counts/100 mL			
	Min	Max	Avg	n	Min	Max	Avg	n
2001	<1	91		52	<1	9		52
2002	0	15		52	0	3000		52
2003	0	16	4	33	0	91000	3665	33
2004	0	20	2	48	0	20000	748	48
2005	0	1400	35	51	0	3200	277	51
2006	0	148	9	38	0	2040	189	38

Sources of Data:
2001-2002: Water Treatment Plant Laboratory Monitoring Data
2003-2006: DWIS
Blank fields are data gaps

Figure 3.4.4.3-32 shows the *E. coli* counts from May 20, 2003 to September 2006. In 2003, monitoring data starts from June, and *E. coli* is not detected in that month, agreeing with the Ontario Drinking Water Standard of 'not detectable'. In 2004, *E. coli* is detected throughout the year but with zero counts in most of July. The highest *E. coli* counts in the source water occurred in 2005 and the counts at the start of 2006 are also high. The 2005 and 2006 *E. coli* counts in the raw water seem to decrease in June.

Figure 3.4.4.3-33 shows the total coliform counts from May 20, 2003 to September 2006. The highest counts in the source water seem to occur in the winter months: January to March and November to December. In all years, total coliform counts have varied monthly but overall, the counts seem to decrease in June for all years.

(c) Lake Erie Raw Water to the Elgin Area PWSS:

Table 3.4.4.3-9 provides a summary of annual fecal coliform from 1990 to 1994, and a summary of *E. coli* and total coliform data from 2003 to 2006. A high count of 1500 fecal coliform occurred in 1993 and the highest *E. coli* count occurred in 2003 (>5000 counts/100 mL). The highest total coliform count in the source water occurred in 2005 (70000 counts/100 mL).

Table 3.4.4.3-9: Coliform Summary Data for Lake Erie Raw Water to the Elgin Primary Area Water Supply System

Year	*Escherichia coli**, counts/100 mL				Total coliform**			
	Min	Max	Avg	n	Min	Max	Avg	n
1990	1	28	9.25	4				
1991	2	28	8.4	5				
1992	1	8	3.25	4				
1993	4	1500	454.5	4				
1994	10	10	10	2				
2003	0	>5000		228	0	500		228
2004	0	200		254	0	8000		254
2005	0	600	14	123	0	70000	2102	123
2006	0	170	12	105	0	48000	1795	105

*Note: From 1990-1994, fecal coliform was analyzed
**Total coliform data contain instances of OG (overgrowth) on January 13, 2005 and counts>2000 on February 2, 2006Sources of Data:
Sources of Data:
1990-1994: DWSP
2003 and 2004: DWS Annual Reports
2005 and 2006: Water Treatment Plant Laboratory Monitoring Data
Blank fields are data gaps

Figure 3.4.4.3-34 shows the *E. coli* counts from 2005 to 2006. Several zero counts of *E. coli* in the source water are seen throughout 2005 and 2006, agreeing with the Ontario Drinking Water Standard of 'not detectable'. The highest counts in both years have been in winter months of January to February and November to December. The lowest counts are in June, similar to the *E. coli* counts in the raw water to West Elgin WTP in 2005 and 2006.

Figure 3.4.4.3-35 shows the total coliform counts from 2005 to 2006. The highest counts in the source water seem to occur in the winter months: January, February, November and December. There is a clear downward trend from the beginning of June in both 2005 and 2006 with an increasing trend thereafter. In April and November 2006, there are no zero counts at all. Conversely several of the samples tested in May to October 2006 conformed to the Ontario Drinking Water Standard of 'not detectable'. Some samples in 2005 also conformed to the ODWS in June to November and a few at the beginning of the year. However, the highest counts are also observed at the beginning of the year.

(d) Lake Huron Raw Water to the Lake Huron PWSS:

Table 3.4.4.3-10 provides a summary of annual fecal coliform from 1990 to 1994 and summaries of *E. coli* and total coliform data from 2003 to 2006. In the past, a high count of 18 fecal coliform occurred in 1993. In recent years, the highest total coliform count in the source water occurred in 2005 (9600 counts/100 mL) and the highest *E. coli* count occurred in 2004 (150 counts/100 mL).

Table 3.4.4.3-10: **Coliform Summary Data for Lake Huron Raw Water to the Lake Huron Primary Water Supply System**

Year	*Escherichia coli**, counts/100 mL				Total coliform**			
	Min	Max	Avg	n	Min	Max	Avg	n
1990	2	8	4	6				
1991	2	2	2	4				
1992	2	9	5	3				
1993	2	18	10	2				
1994	1	1	1	1				
2003	0	10		199	0	5000		199
2004	0	150		197	0	9000		197
2005	0	100	1	103	0	9600	101	103
2006	0	17	1	101	0	7200	189	101

*Note: From 1990-1994, fecal coliform was analyzed
**One instance of overgrowth on January 18, 2005
Sources of Data:
1990-1994: DWSP
2003 and 2004: DWS Annual Reports
2005 and 2006: Water Treatment Plant Laboratory Monitoring Data
Blank fields are data gaps

Figure 3.4.4.3-36 shows the *E. coli* counts from 2005 to 2006. The microbial quality of the source water seems to be very good in the last two years with most samples having 'non detectable' results that comply with the Ontario Drinking Water Standard. In both years, there were no detects from January to June except once in 2005. From July to December, the *E. coli* counts are below 20 counts/100 mL with many samples still agreeing with the Ontario Drinking Water Standard of 'not detectable'.

Figure 3.4.4.3-37 shows the total coliform counts from 2005 to 2006. In 2005 from May to July and in 2006 from February to April, the source water conforms to the ODWS of 'not detectable'. In 2005, the highest counts occur in the first half of the year. However in 2006, the highest counts occur in November and December. Most of the samples that had total coliform present have values that range between 1 and 100 counts/100 mL.

Figure 3.4.4.3-38 shows the *Escherichia coli* concentrations (mg L^{-1}) at the LHPWSS (Port Blake) Water Intake from January 2005 to September 2006. "Raw water concentrations of the fecal waste indicator organism, *E. coli*, were typically low at both water intake facilities. Concentrations of *E. coli* in the raw water samples did however, exceed the Ontario Drinking Water Standard (ODWS = 0 *E. coli* cfu/100 mL) at both locations on more than one occasion. The frequency with which the ODWS was exceeded was greater at the Goderich Facility compared to that number for the Port Blake Facility. Further, the raw water concentration of *E. coli* was greater at the Goderich Facility (median *E. coli* concentration = 4 cfu/100 mL) compared to the raw water concentration of *E. coli* at the Port Blake Facility (median *E. coli* concentration = 0 cfu/100 mL; Mann-Whitney U statistic 28331.5; $p < 0.001$). Although, the raw water is treated within both treatment facilities the raw water at the Goderich Facility had higher concentrations of *E. coli* more frequently than did the Port Blake Facility." (Figure and text taken from Chapter 2 of the ABCA Report[129].)

(e) Lake Erie Raw Water to the Wheatley WTP:

Table 3.4.4.3-11 provides a summary of annual fecal *E. coli* and total coliform data from 2000 to 2006. The highest total coliform count in the source water appears to be in 2003 (15000 counts/100 mL) and the highest *E. coli* count occurred in as recent as 2006 (680 counts/100 mL). Total coliform counts appear to have increased since 2000 and there were no zero counts in 2004 and 2005. There were no zero counts of *E. coli* in 2000 but there have been since then.

Table 3.4.4.3-11: Coliform Summary Data for Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	***Escherichia coli*, counts/100 mL**				**Total coliform, counts/100 mL**			
	Min	**Max**	**Avg**	**n**	**Min**	**Max**	**Avg**	**n**
2000	1	200		25	0	>200		26
2001	0	48		110	0	>200		60
2002	0	>100		68	0	1000		61
2003	0	50		53	0	15000		53
2004	0	150		52	6	9800		52
2005	0	28		52	3	6100		52
2006	0	680		51	0	5600		51

Sources of Data:
2000 -2003: Annual DWS Reports and WTP laboratory Reports
2004 -2006: C-K Municipality Yearly Compliance Reports
Blank fields are data gaps

(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS:

Table 3.4.4.3-12 provides a summary of annual fecal *E. coli* and total coliform data from 2005 to 2006 for raw water to the Union WSS. *E. coli* levels for these two years are similar with a maximum of 70 counts/100 mL. For the same years, there have been no non-detects of total coliform which shows a decrease from 2005 to 2006.

Table 3.4.4.3-12: Coliform Summary Data for Lake Erie Raw Water to the Union Water Supply System

Year	***Escherichia coli*, counts/100 mL**			**Total coliform, counts/100 mL**		
	Min	**Max**	**n**	**Min**	**Max**	**n**
2005	0	70	52	2	2500	52
2006	0	68	52	2	1200	52

Source of Data: Annual DWS Reports

Table 3.4.4.3-13 provides a summary of annual fecal *E. coli* and total coliform data from 2004 to 2006 for raw water to the Stoney Point WTP. *E. coli* and total coliform have been detected throughout the monitoring period. *E. coli* ranges between 1 (in 2005) and 220 (in 2004) counts/100 mL. Total coliform ranges between less than 10 (in 2004) to 200,000 (in 2005).

Table 3.4.4.3-13: Coliform Summary Data for Lake St. Clair Raw Water to the Stoney Point Water Treatment Plant

Year	*Escherichia coli*, counts/100 mL			Total coliform, counts/100 mL		
	Min	Max	n	Min	Max	n
2004	<4	220	52	<10	18000	52
2005	1	140	52	10	200000	52
2006	2	50	52	10	80000	52

Source of Data: Annual DWS Reports

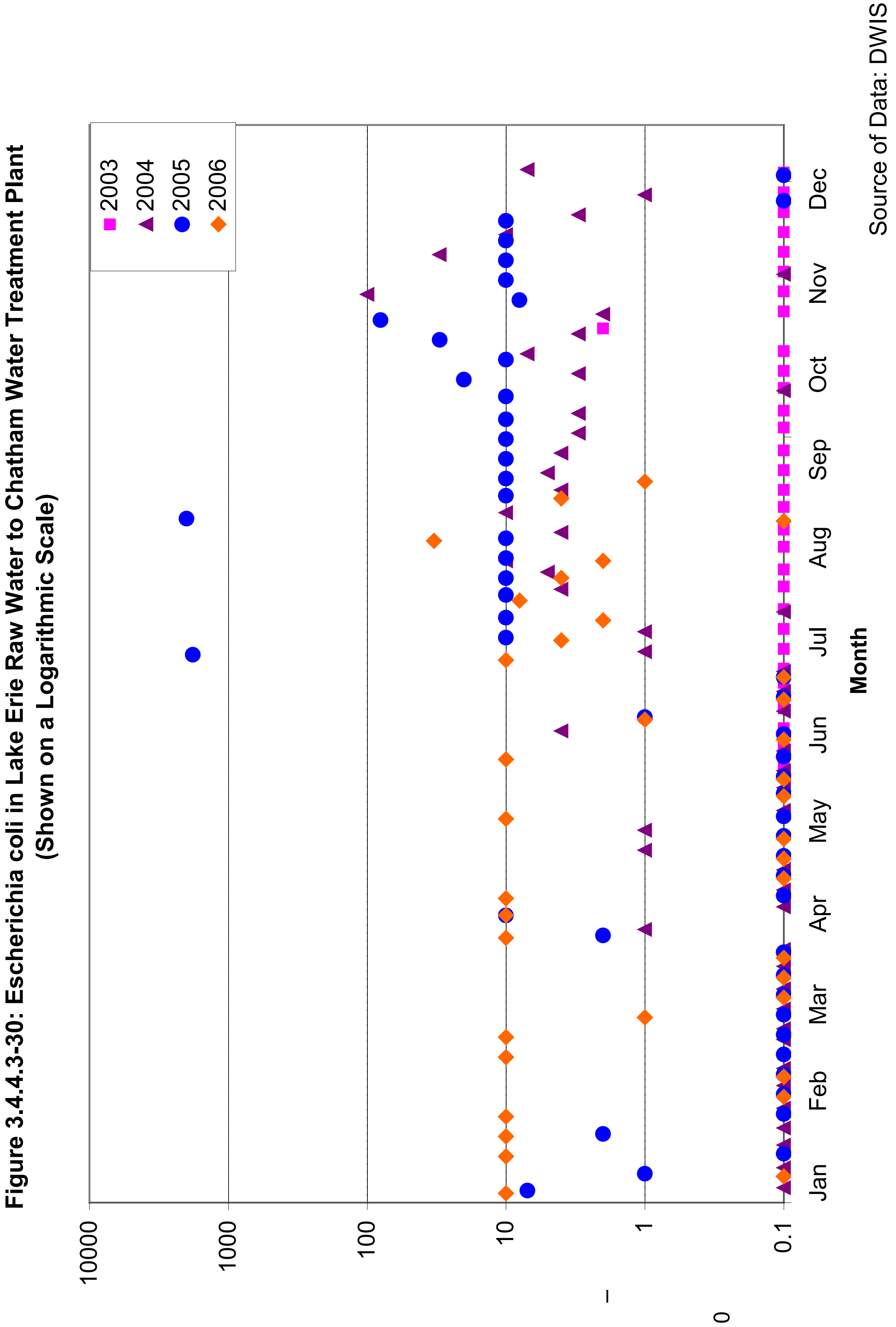


Figure 3.4.4.3-30: ***Escherichia coli*** **in Lake Erie Raw Water to Chatham Water Treatment Plant**

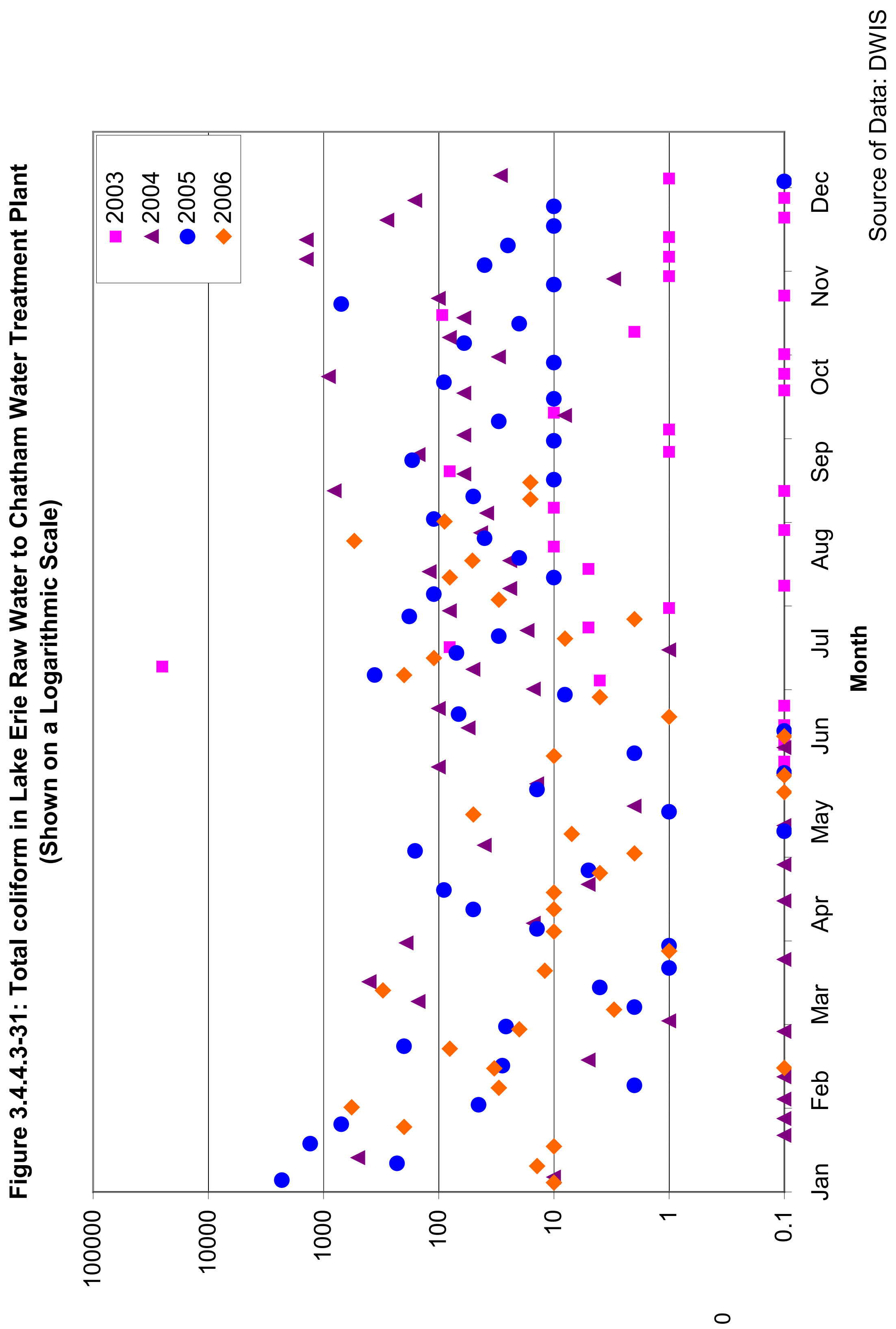
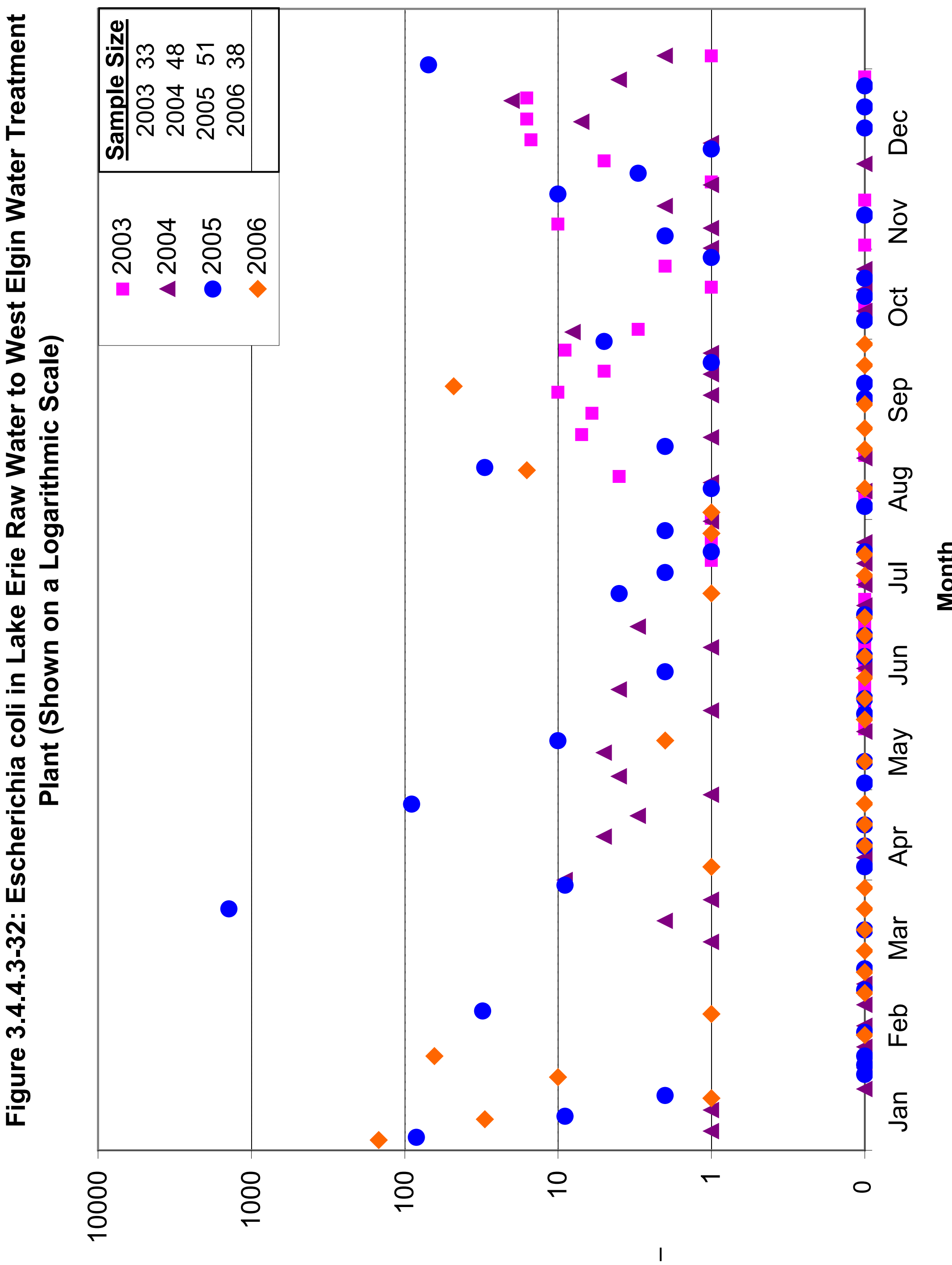
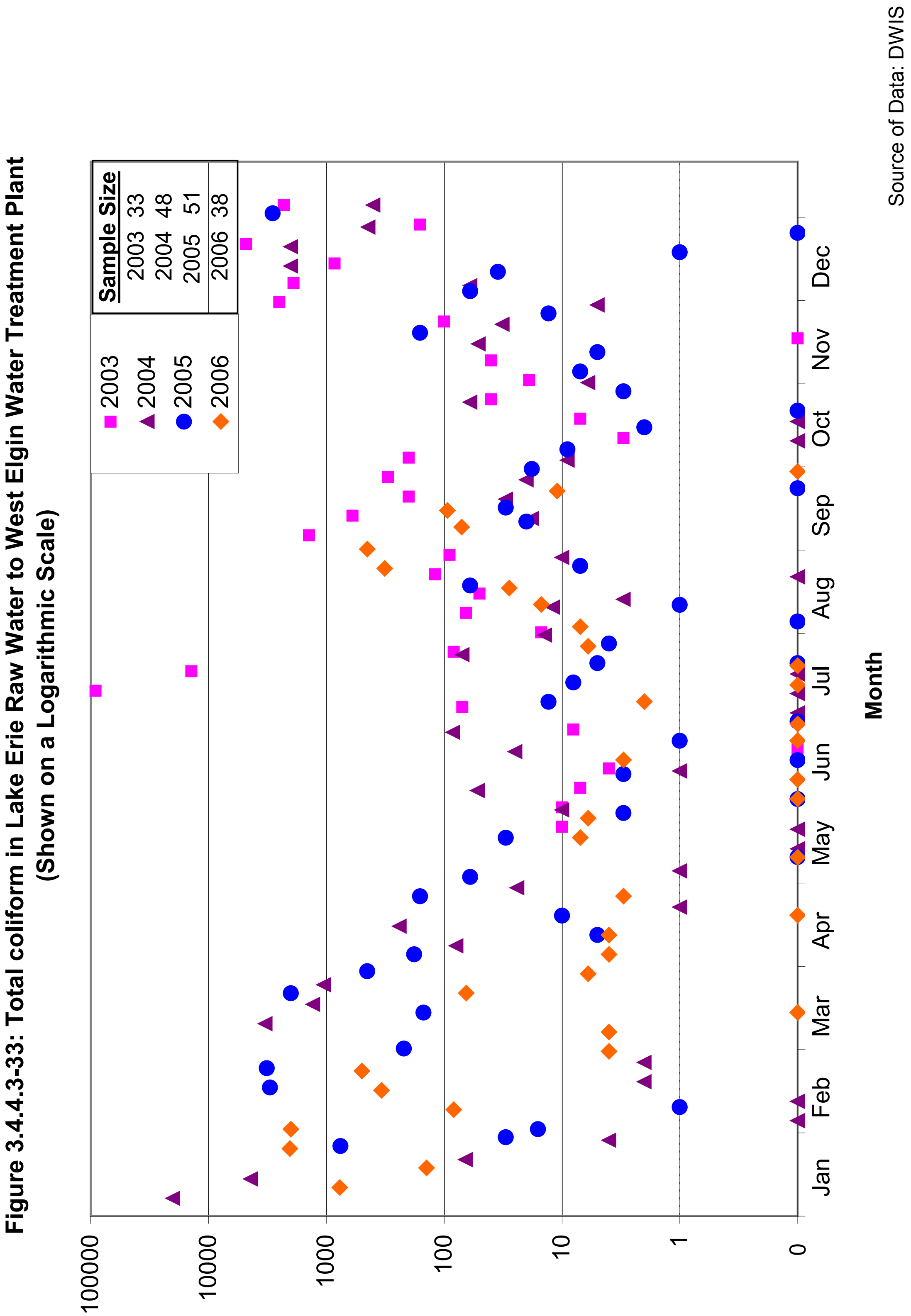


Figure 3.4.4.3-31: **Total coliform in Lake Erie Raw Water to Chatham Water Treatment Plant**



Source of Data: DWIS

Figure 3.4.4.3-32: ***Escherichia coli*** **in Lake Erie Raw Water to West Elgin Water Treatment Plant**



Source of Data: DWIS

Figure 3.4.4.3-33: **Total coliform in Lake Erie Raw Water to West Elgin Water Treatment Plant**

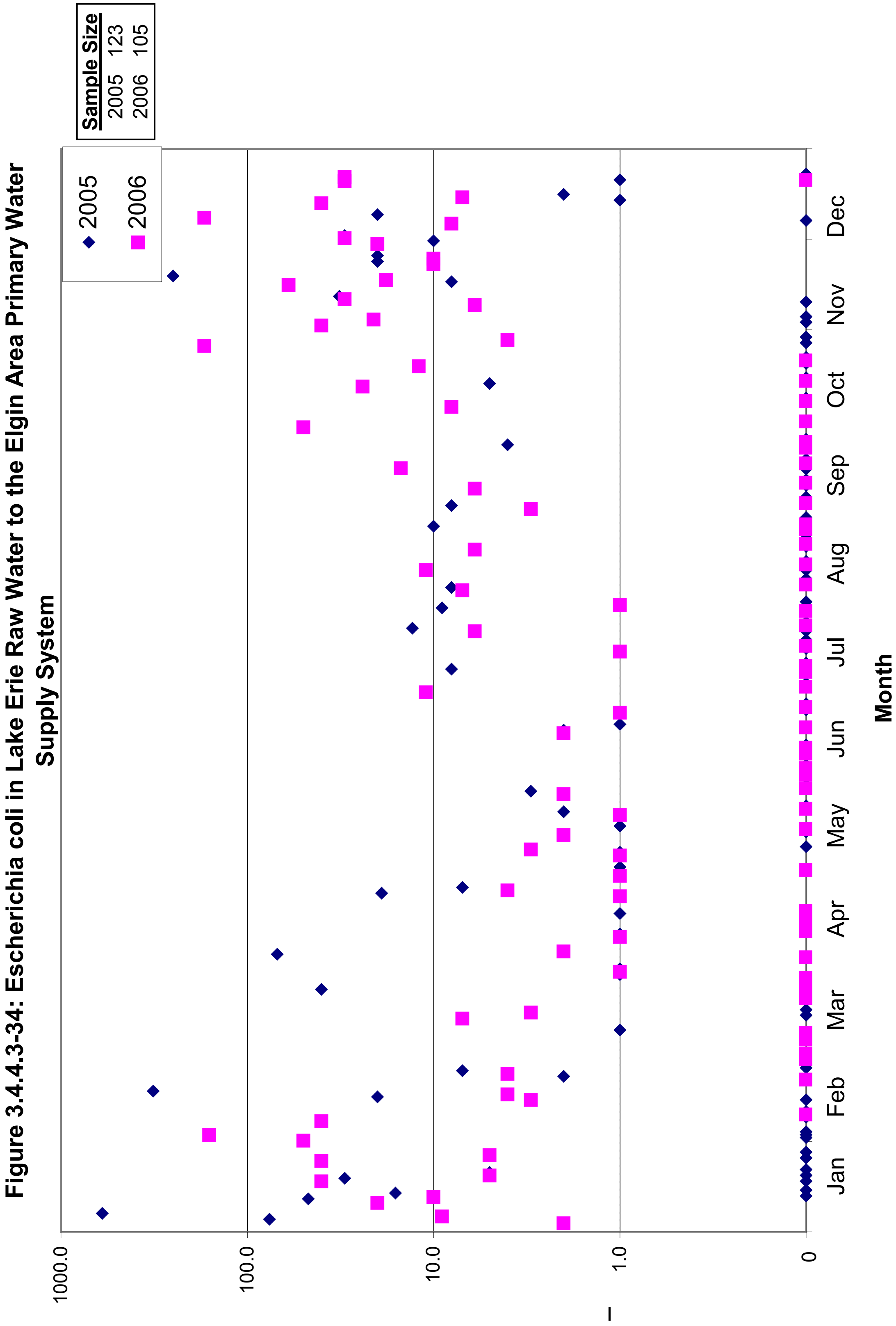


Figure 3.4.4.3-34: ***Escherichia coli*** **in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**

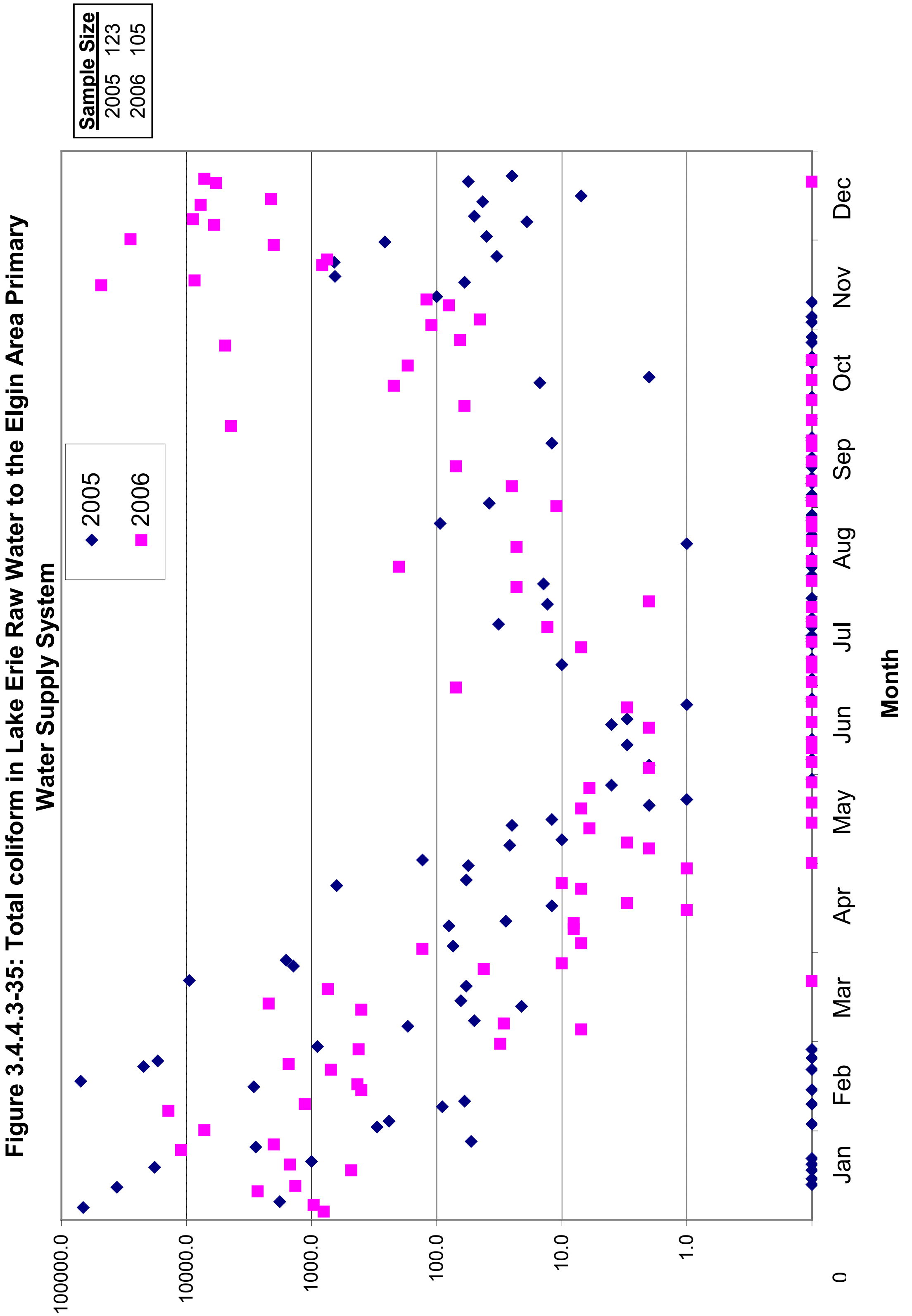
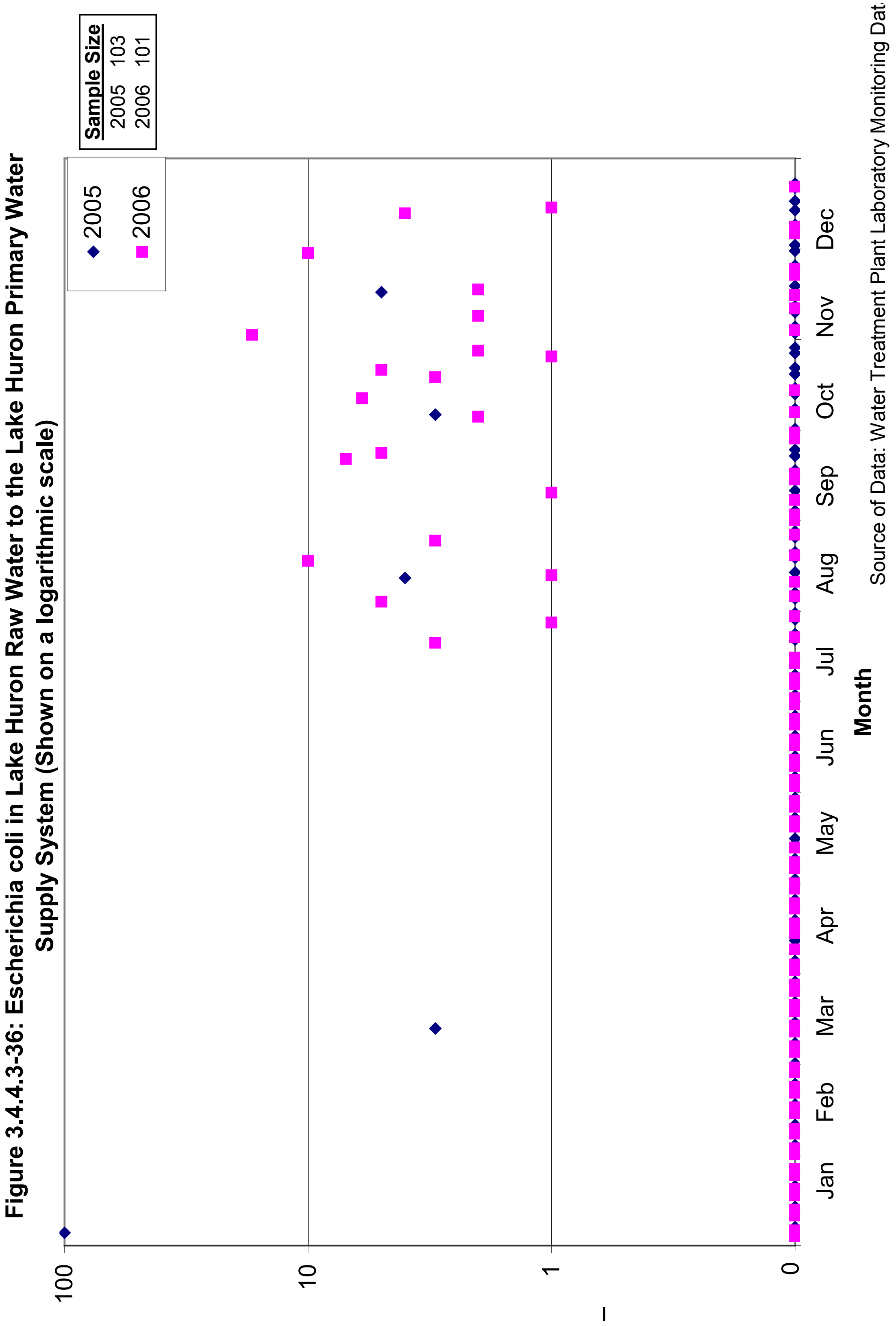
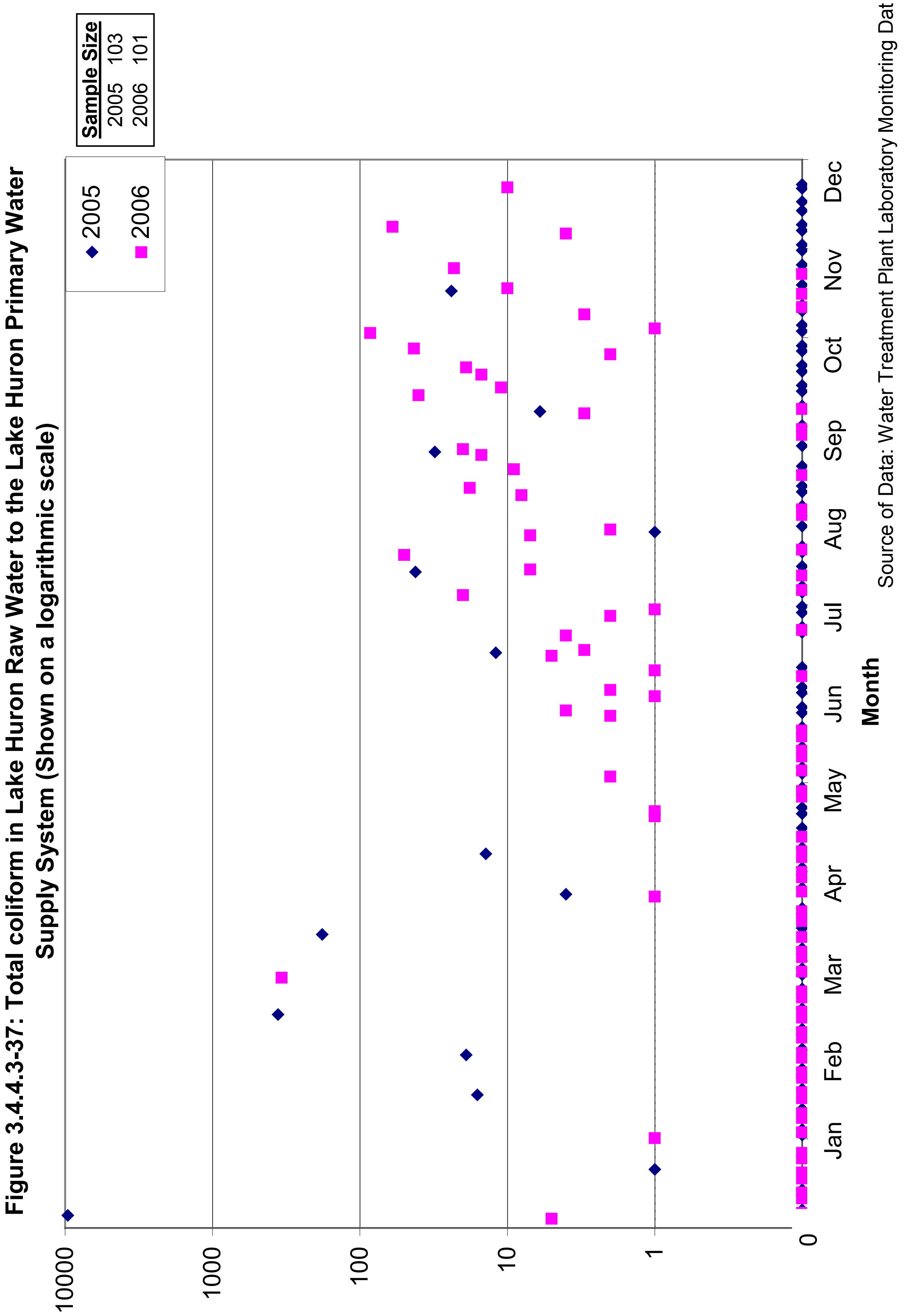


Figure 3.4.4.3-35: Total coliform in Lake Erie Raw Water to the Elgin Area Primary Water Supply System



Source of Data: Water Treatment Plant Laboratory Monitoring Dat

Figure 3.4.4.3-36: ***Escherichia coli*** **in Lake Huron Raw Water to the Lake Huron Primary Water Supply System**



Source of Data: Water Treatment Plant Laboratory Monitoring Dat

Figure 3.4.4.3-37: **Total coliform in Lake Huron Raw Water to the Lake Huron Primary Water Supply System**

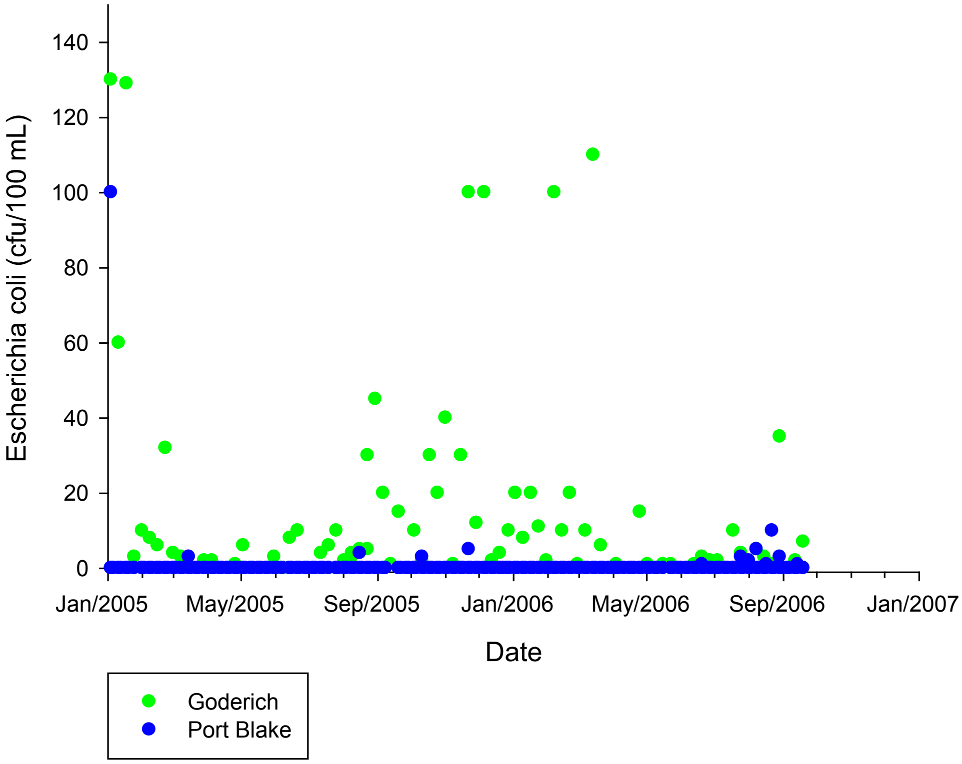


Figure 3.4.4.3-38*:* ***Escherichia coli*** **Concentrations in Raw Water Samples Collected for the Lake Huron Intakes at the Goderich and Port Blake Water Treatment Facilities (ABCA)**

One value (y=700) missing from the Goderich Facility data (September 27, 2005)

(B) OTHER PARAMETERS

These parameters are the Regulation 170/03 Schedule 23 Inorganic, Regulation 170/03 Schedule 24 Organic, SOLEC, IJC, Lake specific and WTP/WSS specific parameters that are listed or described in **Section 3.4.3: Water Quality Parameter Selection**.

Using DWSP data sets from 2000 to 2005, a total of 88 parameters are analyzed for the intake raw water to the Chatham WTP, Elgin Primary Area WSS and Lake Huron Primary WSS.

Water treatment plant laboratory monitoring data was used to analyze 'other parameters' for raw water to the West Elgin WTP (data for 2001 to 2003) and Wheatley WTP (data from 2000 to 2002). The hardness and aluminum data for the Wheatley WTP raw water was obtained from Municipality of Chatham-Kent Water Quality Laboratory Reports for 2000 to 2002.

The results of the above WTP and WSS intake raw water quality are presented in the form of tables with the top row indicating the total number of samples (n). Each column shows how many samples (maximum, average or minimum concentrations) are higher than the standard, half standard or detection limit of a chemical parameter.

The analyses of raw water to the remaining plants, the Stoney Point WTP and Union WSS, are taken from Chapter 2 of the Essex Region Conservation Authority (ERCA) Watershed Characterization Report[128]. Parameters analyzed are ammonium, aluminum, copper, iron and zinc.

The results for mirex must be analyzed with caution since the detection limit itself is higher than the aquatic life toxicity standard; therefore, mirex detected in a sample is automatically considered above the standard even though it may not be so.

(a) Lake Erie Raw Water to the Chatham WTP:

Table 3.4.4.3-14 shows the results of the analysis of 88 parameters in the raw water to the Chatham WTP from 2000 to 2005.

Table 3.4.4.3-14: Analysis of 'Other Parameters' in Lake Erie Raw Water to the Chatham Water Treatment Plant

Parameter (n=13)	Max>Std	Max>1/2 Std	Min>DL	Max>DL	Avg>DL
MIREX*	6	6	0	0	0
ANTIMONY	0 (None)	0 (None)	6	6	6
ARSENIC			6	6	6
BARIUM			6	6	6
BORON			6	6	6
CADMIUM			1	2	2
DISSOLVED ORGANIC CARBON			6	6	6
CHROMIUM			4	6	6
COPPER			6	6	6
DICHLOROETHANE 1,2			3	3	3
LEAD			6	6	6
MALATHION			2	3	3
METHYLENE CHLORIDE			3	3	3
NICKEL			6	6	6
URANIUM			6	6	6
ZINC			6	6	6
SELENIUM			0	2	2

*Detection limit (5 ng/L) is larger than aquatic toxicity standard (1 ng/L), consider result with caution
Source of Data: DWSP for 2000 to 2005

Mirex (a pesticide) is shown as being higher than the half standard and standard, but the result must be considered with caution as stated above. Of the parameters analyzed, other than mirex, three organics, 12 inorganics/metals and dissolved organic carbon are detected in the source water. All are below the relevant half standard. The organics detected are malathion (a pesticide), methylene chloride and dichloroethane-1,2 (volatile organics). The inorganics are antimony, arsenic, barium, boron, cadmium, chromium, copper, lead, nickel, uranium, zinc and selenium.

Figure 3.4.4.3-39 shows the aluminum levels in the Chatham WTP raw water from 1990 to 2005. The Ontario Drinking Water Standard (operational guideline) for aluminum is 100 µg/L. Half of the average aluminum levels from 1990 to 2005 are below the ODWS. However, most maximum values are above the ODWS. From 1999 to 2005, the average values are below the ODWS with the exception of 2002 (average 103 µg/L) and considerably high peak in 2003 (average 365.5 µg/L).

Figure 3.4.4.3-40 shows the hardness (as calcium carbonate) levels in the Chatham WTP raw water from 1990 to 2005. All minimum, maximum and average levels of hardness are above the Ontario Drinking Water Standard (operational guideline) of 80 to 100 mg/L from 1990 to 2005. Average levels range between 108 to 127 mg/L. Hardness levels were at the lowest in 1999 and 2000, and have been at consistent average levels (116 to 118 mg/L) thereafter up to 2005.

(b) Lake Erie Raw Water to the Elgin Area PWSS:

Table 3.4.4.3-15 shows the results of the analysis of 88 parameters in the raw water to the Elgin Area PWSS from 2000 to 2005.

Table 3.4.4.3-15: Analysis of 'Other Parameters' in Lake Erie Raw Water to the Elgin Area Primary Water Supply System

Parameter (n=7)	Max>Std	Max>1/2 Std	Min>DL	Max>DL	Avg>DL
MIREX*	4	4	0	0	0
ANTIMONY	0 (None)	0 (None)	4	4	4
ARSENIC			4	4	4
BARIUM			4	4	4
BORON			4	4	4
CADMIUM			1	1	1
DISSOLVED ORGANIC CARBON			4	4	4
CHROMIUM			3	4	4
COPPER			4	4	4
DICHLOROETHANE 1,2			3	3	3
LEAD			4	4	4
MALATHION			2	2	2
METHYLENE CHLORIDE			3	3	3
NICKEL			4	4	4
URANIUM			4	4	4
ZINC			4	4	4
SELENIUM			0	0	0

*Detection limit (5 ng/L) is larger than aquatic toxicity standard (1 ng/L), consider result with caution
Source of Data: DWSP for 2000 to 2005

Mirex (a pesticide) is shown as being higher than the half standard and standard, but the result must be considered with caution as stated above. Of the parameters analyzed, other than Mirex, three organics, 11 inorganics, and dissolved organic carbon are detected in the source water. All are below the relevant half standard. The organics detected are malathion (a pesticide), methylene chloride and dichloroethane-1,2. The inorganics are antimony, arsenic, barium, boron, cadmium, chromium, copper, lead, nickel, uranium and zinc. Unlike the Chatham WTP raw water, selenium was not detected.

Figure 3.4.4.3-41 shows the aluminum levels in the Elgin Area PWSS raw water from 1990 to 2004 (2003 data missing). The Ontario Drinking Water Standard (operational guideline) for aluminum is 100 µg/L. From 1990 to 1995, all of the average and maximum aluminum levels are above the ODWS. There is a general decrease in both average and maximum levels beginning in 1996. From 1996 to 2004, average aluminum levels range between 66 and 189.8 µg/L, whereas from 1990 to 1995, they ranged between 177.7 and 610 µg/L. Similarly, maximum levels range between 320 and 1335 µg/L in 1990 to 1995 but range from 66 to 341µg/L in 1996 to 2004.

Figure 3.4.4.3-42 shows the hardness (as calcium carbonate) levels in the Elgin Area PWSS raw water from 1990 to 2004 (2003 data missing). All minimum, maximum and average levels of hardness are above the Ontario Drinking Water Standard (operational guideline) of 80 to 100 mg/L. Average levels range between 113 to 126.9 mg/L. The average hardness levels were at the lowest in 1997 to 2001 (around 113 mg/L), and have increased slightly thereafter. The maximum levels range between 113 to 136 mg/L.

(c) Lake Huron Raw Water to the Lake Huron PWSS:

Table 3.4.4.3-16 shows the results of the analysis of 88 parameters in the raw water to the Lake Huron PWSS from 2000 to 2005.

Table 3.4.4.3-16: Analysis of 'Other Parameters' in Lake Huron Raw Water to the Lake Huron Primary Water Supply System

Parameter (n=5)	Max>Std	Max>1/2 Std	Min>DL	Max>DL	Avg>DL
MIREX*	4	4	0	0	0
ANTIMONY	0 (None)	0 (None)	4	4	4
ARSENIC			4	4	4
BARIUM			4	4	4
BORON			4	4	4
DISSOLVED ORGANIC CARBON			4	4	4
CHROMIUM			2	2	2
COPPER			4	4	4
DICHLOROETHANE 1,2			3	3	3
LEAD			3	3	3
MALATHION			1	1	1
METHYLENE CHLORIDE			3	3	3
NICKEL			4	4	4
URANIUM			4	4	4
ZINC			4	4	4

*Detection limit (5 ng/L) is larger than aquatic toxicity standard (1 ng/L), consider result with caution
Source of Data: DWSP for 2000 to 2005

Mirex (a pesticide) is shown as being higher than the half standard and standard, but the result must be considered with caution as stated above. Of the parameters analyzed, other than Mirex, three organics, 10 inorganics and dissolved organic carbon are detected in the source water. All are below the relevant half standard. The organics detected are malathion (a pesticide), methylene chloride and dichloroethane-1,2. The inorganics are antimony, arsenic, barium, boron, copper, chromium, lead, nickel, uranium and zinc. Unlike the Chatham WTP raw water, cadmium and selenium were not detected.

(d) Lake Erie Raw Water to the West Elgin WTP:

Table 3.4.4.3-17 shows the results of the analysis of Schedule 23 and 24 parameters in the raw water to the West Elgin WTP from 2001 to 2003. Two inorganics (boron and uranium), dissolved organic carbon and Dinoseb (a pesticide) were detected. All are below the respective half standards. From the West Elgin WTP DWS 2005 Annual Report, the treated water analysis results show that all Schedule 23 and 24 parameters are below detection limits. The treatment process is conventional: pre-chlorination, screening, flocculation, sedimentation, filtration and post-chlorination. No activated carbon is used at this plant since at least 2000[139]. Hence, it may be assumed that little or no organic pollutants would be removed and the treated water analysis results are reflective of the raw source water.

Table 3.4.4.3-17: Analysis of 'Other Parameters' in Lake Erie Raw Water to the West Elgin Water Treatment Plant

Parameter	Max>Std	Max>1/2 Std	Min>DL	Max>DL	Avg>DL
BORON (n=3)	0 (None)	0 (None)	0	2	2
DISSOLVED ORGANIC CARBON (n=6)			6	6	6
URANIUM (n=4)			2	3	3
DINOSEB (n=5)			0	1	1

Source of Data: Water Treatment Plant Laboratory Monitoring Data for 2001 to 2003

(e) Lake Erie Raw Water to the Wheatley WTP:

Table 3.4.4.3-18 shows the results of the analysis (from DWS annual reports) of some of the Schedule 23 and 24 parameters (data available was not a complete set of Schedule 23 and 24 parameters) in the raw water to the Wheatley WTP from 2000 to 2002. Dissolved organic carbon (a SOLEC parameter) was detected during this period but was below the half standard. From the Wheatley WTP DWS annual reports of 2003 to 2005, the treated water analysis results show that all Schedule 23 and 24 parameters are below detection limits. However, this WTP uses activated carbon to remove dissolved organic matter that cause taste, odour and colour in drinking water[140]. This may also remove organic chemicals from the drinking water. Hence, it cannot be concluded from the treated water analyses that the Schedule 23 and 24 parameters in the source (raw) water are also below detection limits or absent.

Table 3.4.4.3-18: Analysis of 'Other Parameters' in Lake Erie Raw Water to the Wheatley Water Treatment Plant

Parameter	Max>Std	Max>1/2 Std	Min>DL	Max>DL	Avg>DL
DISSOLVED ORGANIC CARBON (n=3)	0 (None)	0 (None)	3	3	3

Source of Data: Water Treatment Plant Laboratory Monitoring Data for 2000 to 2002

Table 3.4.4.3-19 shows the results of the analysis of aluminum in the raw water to the Wheatley WTP from 2000 to 2002. The Ontario Drinking Water Standard (operational guideline) for aluminum is 100 µg/L. In 2001, the maximum and average aluminum levels were above the ODWS, at 600 and 190 µg/L.

Table 3.4.4.3-19: Analysis of 'Other Parameters' (Aluminum) in Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	n	Aluminum, µg/L		
		Min	Max	Avg
2000	1	100	100	100
2001	4	0	600	190
2002	3	0	0	0

Source of Data: Municipality of Chatham-Kent Water Quality Laboratory Reports (2000 to 2002)

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[139] West Elgin Water Treatment Plant staff. January 2007. Personal communication.

[140] Wheatley Water Treatment Plant. Drinking Water Systems Regulation 170/03 Annual Report of 2004.

Table 3.4.4.3-20 shows the results of the analysis of hardness in the raw water to the Wheatley WTP from 2000 to 2002. All minimum, maximum and average levels of hardness are above the Ontario Drinking Water Standard (operational guideline) of 80 to 100 mg/L. The hardness levels varied little in this period from a minimum level of 113 mg/L in 2002 to a maximum level of 130 mg/L in 2001.

Table 3.4.4.3-20: Analysis of 'Other Parameters' (Hardness) in Lake Erie Raw Water to the Wheatley Water Treatment Plant

Year	n	Hardness, mg/L		
		Min	Max	Avg
2000	1	121	121	121
2001	4	120	130	125.25
2002	3	113	124	120.3

Source of Data: Municipality of Chatham-Kent Water Quality Laboratory Reports (2000 to 2002)

(f) Lake Erie Raw Water to Stoney Point WTP and Union WSS

The following figures and the statements in quotations are taken from Chapter 2 of the ERCA Watershed Characterization Report[128]. The ERCA report uses Provincial Water Quality Objectives (PWQO) to evaluate water quality. Where it is available, the drinking water standard for each parameter has been added below each statement.

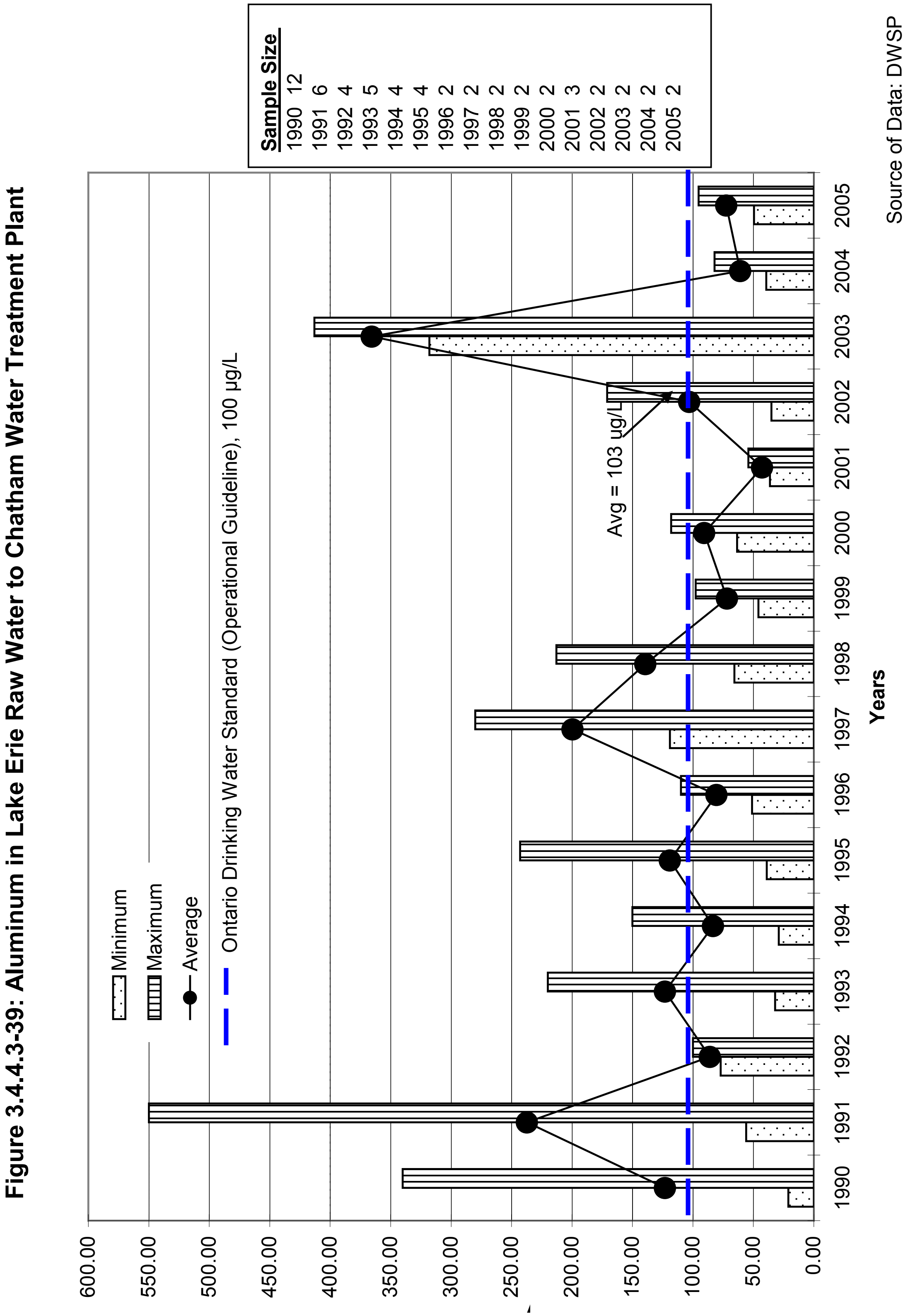
Figure 3.4.4.3-43 shows the average ammonium concentrations of ERCA watershed intakes. "In general average ammonium concentrations were above a bench mark level of 0.0165 mg/L at all of the six intake points".

Figure 3.4.4.3-44 shows the aluminum concentrations of ERCA watershed intakes. "Aluminum concentrations were very high at all of the six intakes. Mean aluminum concentrations were well above the PWQO (75 µg/L) at all the intakes. Aluminum concentration ranged from as low as 21 µg/L (Stoney Point intake) to as high as 633 µg/L (Belle River intake)." (The ODWS operational guideline for aluminum is 1.0 mg/L or 100 µg/L.)

Figure 3.4.4.3-45 shows the copper concentrations of ERCA watershed intakes. "Mean concentrations of copper were lower at both the intakes at the Lake St. Clair and also at the intake of Union WTP. No violations of the PWQO limit for copper were observed at the intakes of the Stoney Point, the Belle River and the Union WTP, at the times when data was collected". (The ODWS aesthetic objective for copper is 1000 µg/L.)

Figure 3.4.4.3-46 shows the iron concentrations of ERCA watershed intakes. "Mean iron concentrations at all the intakes except at the Belle River WTP were well below the PWQO of 300 µg/L. Average values ranged from 123 µg/L (±116) to as high as 377 µg/L (±249). The Tukey's test indicated that the mean values for the intakes of the Belle River, Windsor and Amherstburg WTPs are statistically the same and significantly different than those of the Stoney Point, the Harrow-Colchester and the Union WTP". (The ODWS aesthetic objective for iron is 0.3 mg/L or 300 µg/L.)

Figure 3.4.4.3-47 shows the zinc concentrations of ERCA watershed intakes. "Mean zinc concentrations for the period of 1998 to 2002 were well below the PWQO of 30 µg/L at all of the six intake sites. Average zinc values ranged from 3.24 µg/L (±1.46) to 5.07 µg/L (±4.53). The Tukey's test indicated that all these means are statistically the same. This means average zinc concentrations were about the same at all the intake points". (The ODWS aesthetic objective for zinc is 5 mg/L or 5,000 µg/L.)

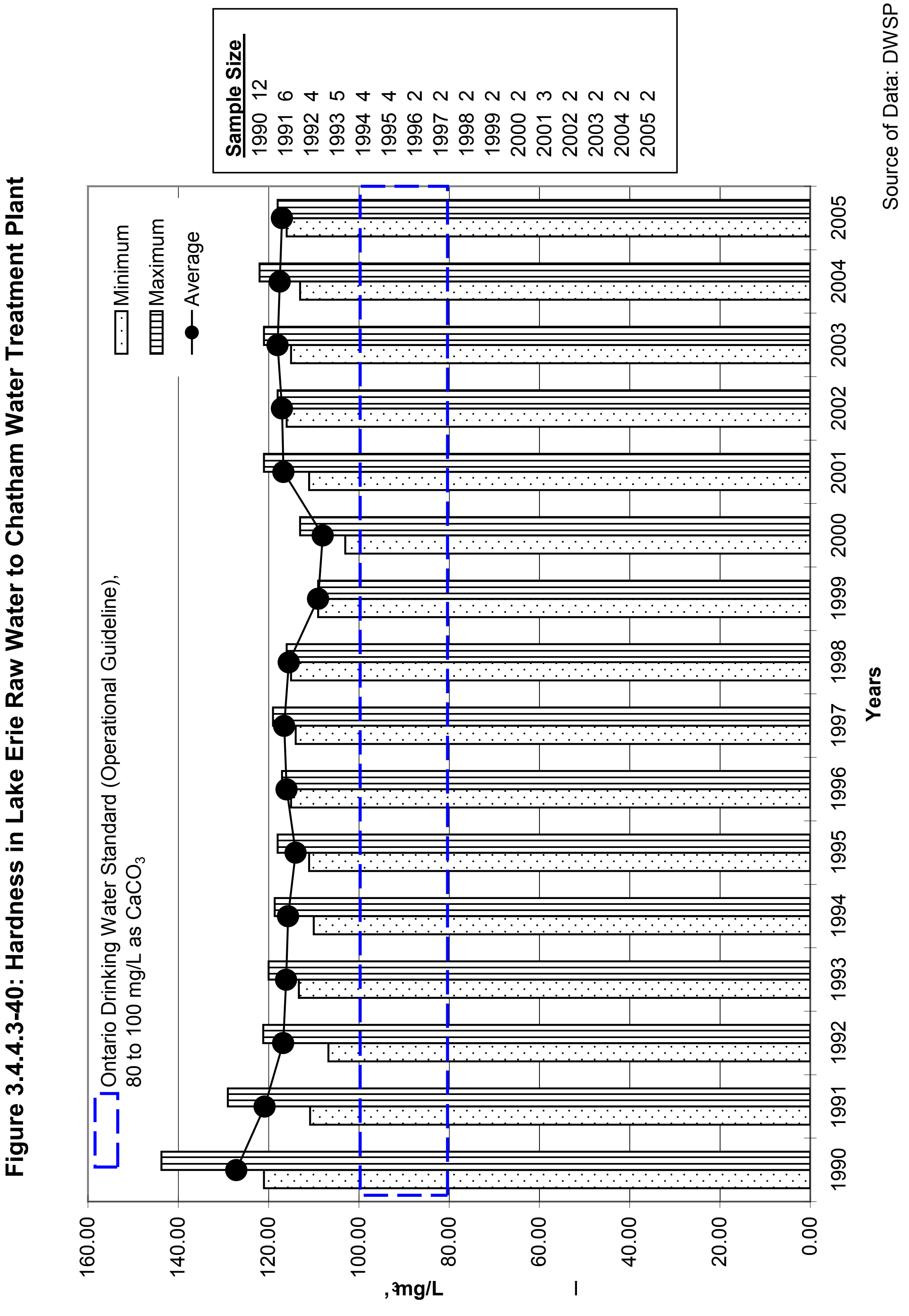


Sample Size

1990	12
1991	6
1992	4
1993	5
1994	4
1995	4
1996	2
1997	2
1998	2
1999	2
2000	2
2001	3
2002	2
2003	2
2004	2
2005	2

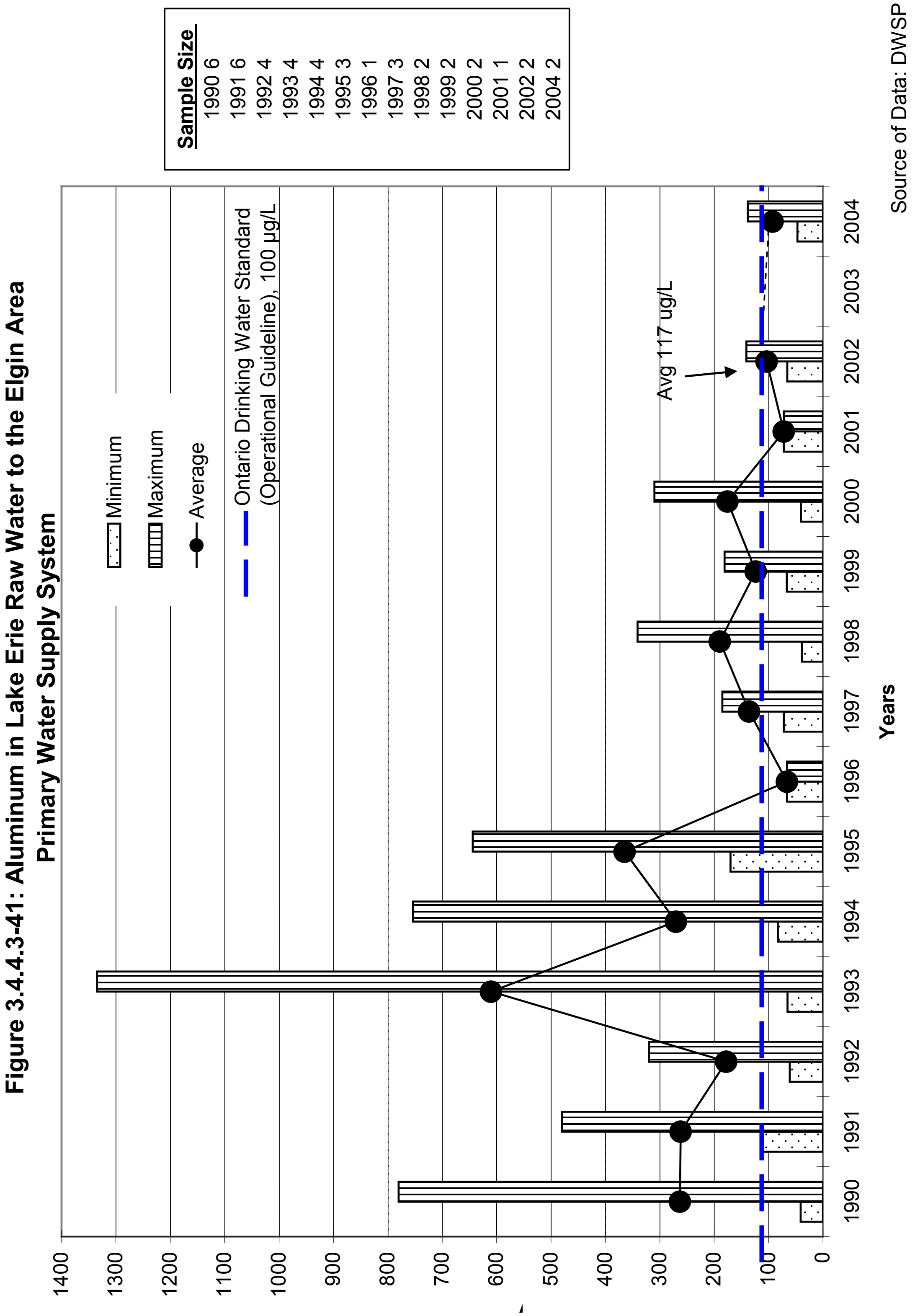
Source of Data: DWSP

Figure 3.4.4.3-39: **Aluminum in Lake Erie Raw Water to Chatham Water Treatment Plant**



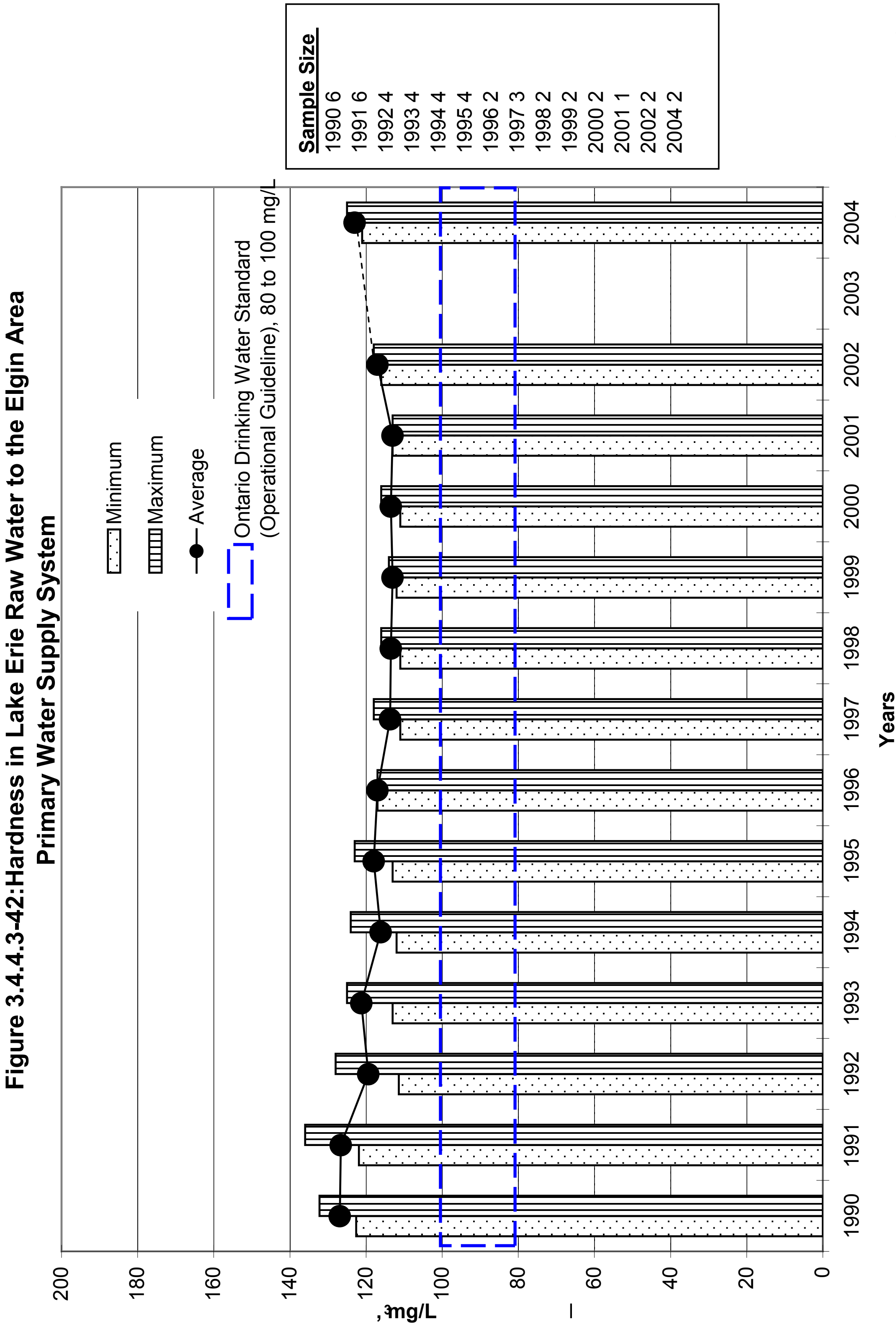
Source of Data: DWSP

Figure 3.4.4.3-40: **Hardness in Lake Erie Raw Water to Chatham Water Treatment Plant**



Source of Data: DWSP

Figure 3.4.4.3-41: **Aluminum in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**



Source of Data: DWSP

Figure 3.4.4.3-42: **Hardness in Lake Erie Raw Water to the Elgin Area Primary Water Supply System**

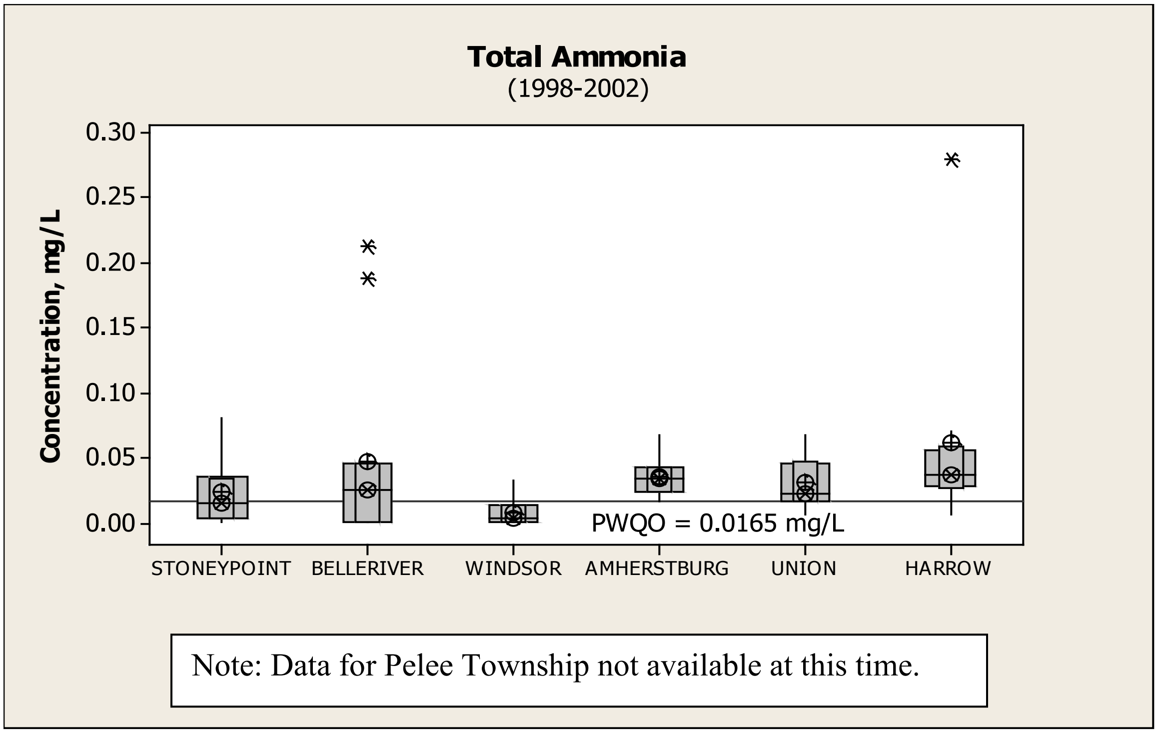


Figure 3.4.4.3-43: **Total Ammonium Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 14 (3 to 3 samples per year).

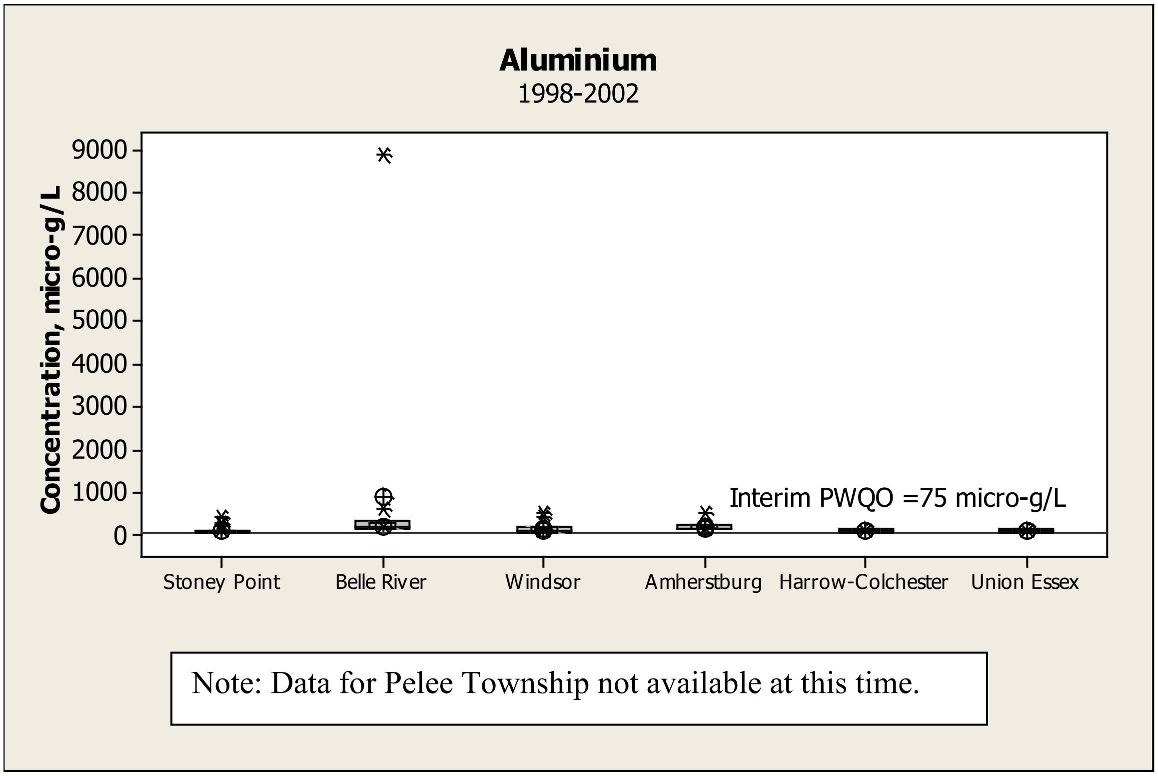


Figure 3.4.4.3-44: **Aluminum Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year).

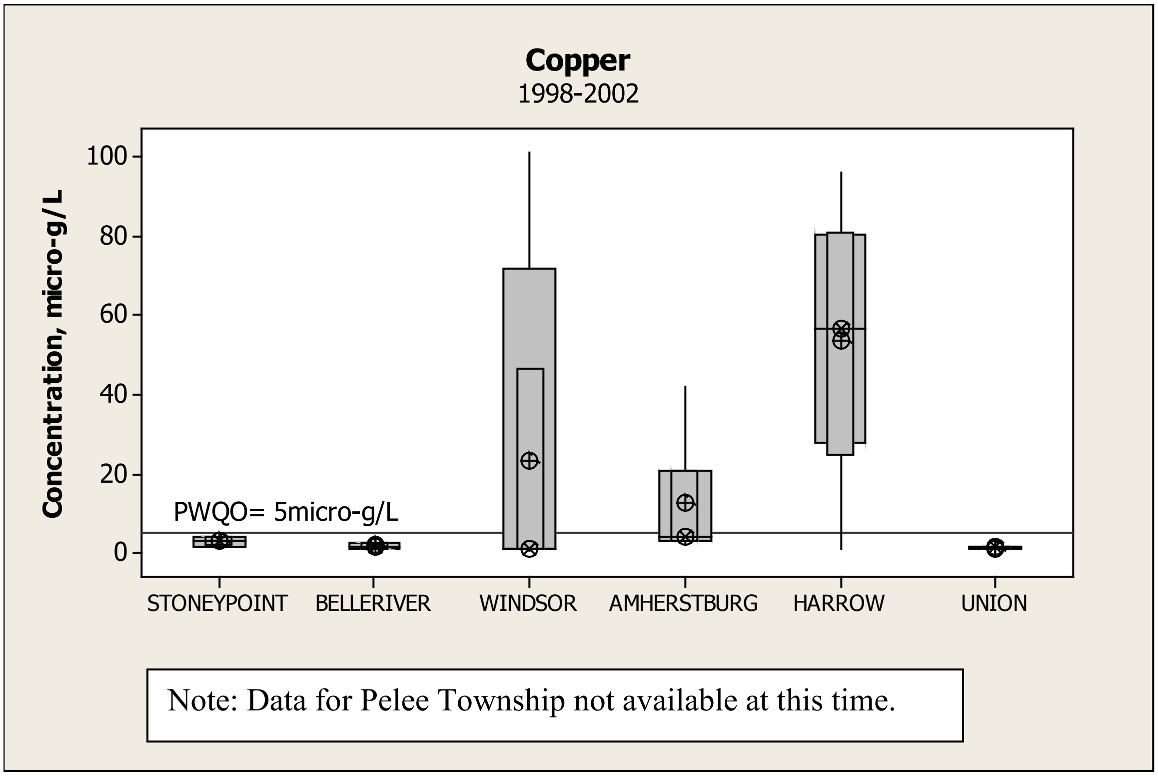


Figure 3.4.4.3-45: **Copper Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year).

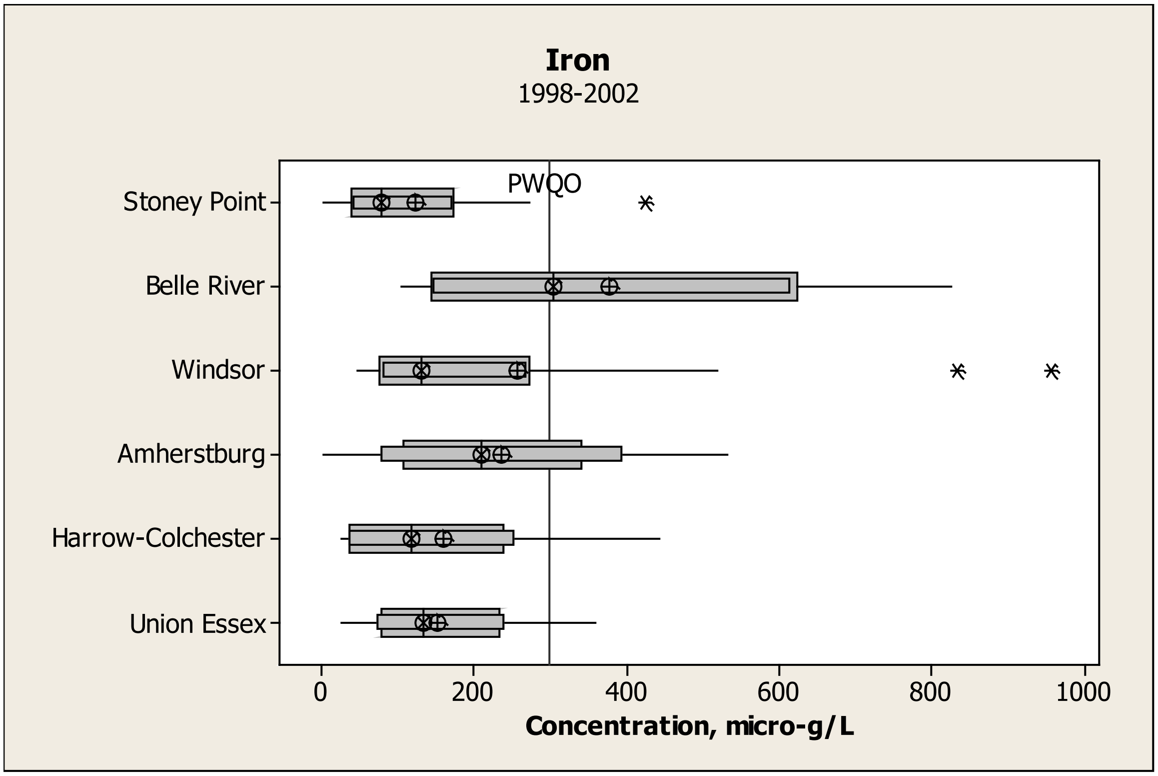


Figure 3.4.4.3-46: **Iron Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year). Note: Data for Pelee Township not available at this time**.**

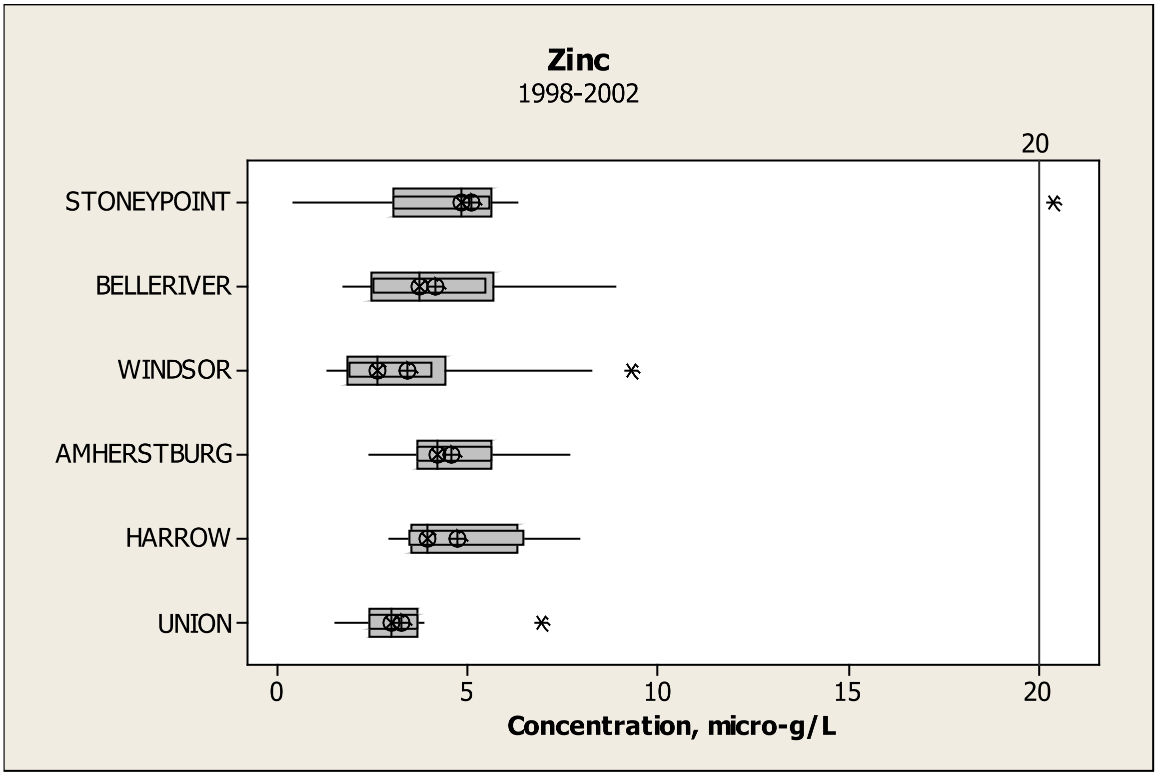


Figure 3.4.4.3-47: **Zinc Concentrations for Drinking Water Intakes in the Essex Region Watershed (ERCA)**

Data were collected as part of the Drinking Water Surveillance Program (DWSP). The number of samples collected at each location ranges from 10 to 15 (3 to 5 samples per year). Note: Data for Pelee Township not available at this time.

3.4.5 Data Gaps

There is no DWSP data (physical and chemical parameters) available for the characterization of raw water to West Elgin WTP and Wheatley WTP. For WTP and WSS that have DWSP data, some recent years' data were not found in the DWSP database. For Stoney Point WTP and Union WSS raw water intakes, characterization results for 1998 to 2002 data was obtained from ERCA, but data from 2003 to present is not characterized at the time of writing of this report.

The data gaps per parameter and year can be seen from **Table 3.4.4.1-1** and **Tables 3.4.4.1-2a** and **b.** For the basic parameters, phosphorus is a data gap for the raw water to the West Elgin WTP. For the same WTP, there are only two to three years nitrate and chloride data available. Similarly, the Wheatley WTP has several years' data gaps as well. For both plants, no data from the 1990s was available for analysis.

For the West Elgin WTP and Wheatley WTP the Schedule 23 and 24 parameters results were obtained from laboratory analyses sheets (raw water analyses) and annual DWS reports (treated water analyses) with some years' data missing. However SOLEC, IJC, Lake specific parameters not already in the Schedules were not analyzed due to lack of data.

There is no DWIS data (microbial parameters) available for the Wheatley WTP, Elgin WSS, Lake Huron WSS, Stoney Point WTP and Union WSS raw water intakes. Alternate less comprehensive data sets were utilized to assess microbial characteristics of the raw water to the first three plants. Some months' data is missing from the scatter plots created for the raw water to the Chatham and West Elgin WTPs. Data for the former is from June 2003 to September 2006 while data for the latter is from May 20, 2003 to September 2006. For Stoney Point WTP intake, microbial data from 2004 to 2006 Annual DWS Reports is analyzed. For the Union WSS intake, microbial data from 2005 and 2006 Annual DWS Reports was used.

Comprehensive data on *cyanobacteria*, or blue-green algae, is lacking at this point in time. This algae can produce toxic substances of which *microcystins* are the most common found in water and most often responsible for poisoning animals and humans who come into contact with it.

3.5 Data and Knowledge Gaps for Water Quality

3.5.1 Data Gaps Overview

As part of the water quality assessment, several data gaps were identified. In some cases, data did not exist since sampling had not been done as part of past or current monitoring programs. In other cases, data was sparsely populated or not available. Also, several sources of data were identified as having the potential to supply additional information but were not reviewed as part of this report.

In this section, data gaps in the surface water quality data sources used to characterize inland water bodies and raw water intakes in the Thames Watershed and Region are discussed. The data gaps in groundwater quality data are also discussed.

Our review of the water quality data obtained, whether raw or treated samples, is to characterize the raw (untreated) source of drinking water. Differences in the period of the data sets reviewed are identified as 'data gaps.' The specific reasons for these gaps in data are not ascertained and are not relevant to the characterizing of the water source. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the only reason for identifying these ‘data gaps.’ The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

Much of the surface water quality monitoring in the Thames Watershed & Region has focused on aquatic ecology and has not been specific to drinking water sources and human health issues. With source protection a priority, water quality monitoring programs will need to be reviewed to address information gaps related to drinking water sources. The pollutant-type, location of sampling, and frequency of sampling are issues that will need to be addressed. As well, there is limited long-term groundwater quality data compared to long-term data available for surface water quality.

3.5.2 Data Gaps - Inland Surface Water Quality

(1) Provincial Water Quality Monitoring Network (PWQMN)

The source of information used to assess the inland surface water quality was the data from the Provincial Water Quality Monitoring Network (PWQMN). At the time this report was prepared, PWQMN data were available up to and including the year 2004.

Most of the monitoring stations were established from 1964-1975. However, monitoring at most of the stations was stopped in 1996 when the Ministry of the Environment (OMOE) withdrew the monitoring program. The OMOE restarted the program in 2002. As a result, most of the stations have data gaps at least between 1996 and 2002. As discussed in **Section 3.2.3, Table 3.2.3-2: Sample Size in UTRCA Watershed** and **Table 3.2.3-3: Sample Size in LTVCA Watershed** show the years of data per parameter and number of samples taken from each station.

In the Lower Thames Valley Conservation Authority (LTVCA) watershed, in 2002, sampling at five of the historic stations was restarted and three new stations were established. Only one station, the Thames River at Jacob Road, has continuous monitoring data including the period of 1996-2002.

For the time block 2000-2004, seven of eight stations monitored in the LTVCA watershed have only four to five samples per parameter. Only Thames at Jacob Road has above 50 samples per parameter.

Historically, the OMOE analysis included bacterial counts. However, the PWQMN program, as revived in 2002, did not include any bacterial analyses. There is no PWQMN data from 1996 onwards for fecal coliform bacteria in the LTVCA watersheds. However for the UTRCA watersheds, Ministry of Health (MOH) provided *E. coli* (a fecal coliform) data for the years 2002 to 2004.

(2) Historic and Ongoing Research and Monitoring

One immediate information gap involves compiling all relevant surface water and groundwater studies ongoing and completed in the Thames Watershed & Region. Many agencies including Environment Canada, National Water Research Institute, Agriculture Canada, academic institutions and consultancies have conducted water-related research in the Thames watershed that may support information needs of the source protection process.

Examples of a few historic studies include the 1993 ‘Phase-I aquatic-biology components of the London Subwatershed Project’ by the Upper Thames River Conservation Authority and the City of London[141]; ‘Agriculture Impacts on Groundwater in Southwestern Ontario’, 1990 by OMOE; and ‘Ontario Farm Groundwater Quality Survey’, 1992 by Agriculture Canada.

Examples of recent studies include the 2006 ‘Reservoir Water Quality Treatment Study II: Water Quality Assessment Modelling for the North Thames River watershed, including its major reservoirs and Pittock

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[141] Tarandus Associates Limited website, Subwatershed and Related Projects. www.tarandus.ca/subwater.htm

Lake on the Thames River' by Gertrude Nurnberg and Bruce LaZerte of Freshwater Research, Ontario and the 2005 Annual Technical Report of the Nutrient Management Monitoring Program by the Environmental Monitoring and Reporting Branch (EMRB) of the OMOE to monitor water chemistry and stream flow.

(3) Health Unit Bacteria (Pathogen) Monitoring

Since the 1970s, the Health Units have monitored bacterial counts for recreational beaches used for swimming. The extent and format of Health Unit data that might relate to inland water quality has not been investigated.

3.5.3 Data Gaps - Groundwater

There is limited long-term groundwater quality data and there is little or no information on groundwater trends over time.

It is difficult to characterize groundwater resources with the existing knowledge. It is challenging or impossible to identify critical areas such as recharge areas; groundwater flow paths; and interaction between aquifers and aquitards to clarify how this affects the groundwater chemical evolution along flow paths.

The public well water used by municipalities in the region is routinely monitored for public health and safety. This information is available in annual reports and other data sets. The physical and chemical water quality data provided to us was mainly for treated well water samples. Limited information was available for a few well supply systems on blended raw water samples. Microbial data, however, was available for raw water samples.

Data sets on private (well) water testing for pathogens (bacteria) are not available as of March 2008. Access to existing information collected by local Health Units and other organizations would help in assessing groundwater quality. Private wells are not regulated systems that are required to routinely monitor water quality. However, Public Health Units with the support of the Ministry of Health and Long Term Care provide free bacterial sample analysis for homeowners on private wells. In fact, the Health Units recommend sampling private wells up to three times per year. All sample analyses are kept by the Public Health Unit and the analyses are provided to the homeowner. Due to confidentiality concerns, the Health Unit database on water quality is not available to the public or Conservation Authorities at this time.

In 2001, the OMOE and Conservation Ontario together initiated a groundwater quality and quantity network called the Provincial Groundwater Monitoring Network (PGMN). Some of the wells have been monitoring water levels since 2001, but most were brought into the system between 2002 and 2004. Monitoring wells are sampled once per year and two rounds of samples have been obtained for each of the existing instrumented monitoring wells in the UTRCA and LTVCA watersheds.

'Groundwater Studies in Ontario' is a large project by the OMOE currently going on, which includes identifying pathways of groundwater source contamination[142]. Potential sources being mapped include rail yards, stormwater ponds, animal feed lots, gas stations, paint shops and car washes.

Table 3.3.4.3-1 to **Table 3.3.4.3-30** list microbial data gaps. Missing months or years of data may be due to reasons such as shut down for well maintenance or decommissioning, or simply due to an incomplete data set from the organization that provided the data to us. In the analysis and reporting of historical data it is important that the data set being reviewed is accurately described. This description of the data is the

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[142] OMOE. March 2004. Groundwater Studies on Ontario: Mapping a hidden treasure. www.ene.gov.on.ca/programs/4197e01.pdf

only reason for identifying these 'data gaps.' The identification of a data gap does not mean that the data *should* exist, nor does it imply that the data *does not* exist.

Given the limited information available to evaluate groundwater, there are some additional monitoring programs that could enhance the groundwater quality database. It is recommended that:

- There should be mandatory monitoring programs and data submission for major groundwater users such as dewatering for quarries, irrigation or construction.
- There should be mandatory water sampling, analysis and data submission for each new domestic well installation.

The current groundwater quality database could also be improved by implementing a sampling program for existing domestic water wells across the region.

3.5.4 Data Gaps - Surface Water Intake Raw Water Quality Data

There is no DWSP data (physical and chemical parameters) available for the characterization of raw water to West Elgin WTP and Wheatley WTP. For the plants that have DWSP data, some recent years' data were not found in the DWSP database. For Stoney Point WTP and Union WSS raw water intakes, characterization results for 1998 to 2002 data was obtained from ERCA, but data from 2003 to present is not characterized at the time of writing of this report.

The data gaps per parameter and year can be seen from the **Tables 3.4.4.1-1,** and **3.4.4.1-2a** and **b.** Amongst the basic parameters, phosphorus is a data gap for the raw water to the West Elgin WTP. For the same WTP, there are only two to three years nitrate and chloride data available. Similarly, the Wheatley WTP has several years' data gaps as well. For both plants, no data from the 1990s was available for analysis.

For the West Elgin WTP and Wheatley WTP, the Ontario Regulation 170/03 Schedule 23 (metals) and Schedule 24 (organic compounds) parameters data were obtained from laboratory analyses sheets (raw water analyses) and annual Drinking Water System (DWS) reports (treated water analyses) with some years' data not available at the time of writing of this report. However, State of the Great Lakes Ecosystem Conferences (SOLEC), International Joint Commission (IJC) and surface water source (and intake) specific parameters not already in the Schedules were not analyzed due to lack of data.

There is no DWIS data (microbial parameters) available for the Wheatley WTP, Elgin Area WSS, Lake Huron PWSS, Stoney Point WTP and Union WSS raw water intakes. Alternate but less comprehensive data sets were utilized to assess microbial characteristics of the raw water to these plants. There are some months' data gaps in the scatter plots created for the raw water to the Chatham and West Elgin WTPs. Data for the former is from June 2003 to September 2006 while data for the latter is from May 20, 2003 to September 2006. For Stoney Point WTP intake, microbial data from 2004 to 2006 Annual DWS Reports is analyzed. For the Union WSS intake, microbial data from 2005 and 2006 Annual DWS Reports was used.

Comprehensive data on *cyanobacteria*, or blue-green algae, is lacking at this point in time. This algae can produce toxic substances of which *microcystins* are the most common found in water and most often responsible for poisoning animals and humans who come into contact with it.

3.5.5 Other Data Gaps

As part of the review of inland water quality and intake (raw) water quality, some potential sources of data and information issues were identified.

(1) Municipal and Industrial Point Source Monitoring

There are several municipal sewage treatment facilities that discharge to the Thames River, and the Great Lakes. Data sets on Certificates of Approvals (CoAs) and Wastewater Discharges (municipal and industrial) are not available as of February 2007.

(2) Great Lakes Monitoring

There are a number of Great Lakes monitoring programs that may provide useful background information for the assessment of intake (raw) water quality. These include:

- Great Lakes Index Station Network
- Great Lakes Nearshore Reconnaissance Monitoring
- Great Lakes Water Intake Biomonitoring

Information from these programs was not included in the review done for this report.

(3) Emerging Contaminants

Concerns have been expressed about many types of emerging water contaminants from sources including agriculture, other industry, and residential outputs. These include pharmaceuticals, hormones and endocrine disrupting compounds, disinfection by-products, brominated flame retardants, algal toxins, sunscreen and other UV filters and pesticide degradation products[143]. The behaviour and health risks of these types of contaminants in water are not fully explored yet. However, there are a number of studies by agencies and academia on specific contaminants in the Thames watersheds. For example, an OMOE, UTRCA and Grand River Conservation Authority Pesticide Study provides some recent information (2004 and 2005) on pesticides in the UTRCA watershed.

(4) Technical Experts Recommendations

The Technical Experts Committee (TEC) Report to the Minister of the Environment formed a framework for threats assessment related to sources of drinking water. TEC has "…recognized that some threats to drinking water sources are likely to pose greater risks to consumers than other threats. Pathogens and dense non-aqueous phase liquids (DNAPLs) were identified as two types of contaminants that are extremely problematic from a human health protection standpoint once they enter the aquifer" [144]. DNAPLS are chemicals, generally solvents that are heavier than water and include chlorinated hydrocarbons such as coal tar or creosote.

In Appendix 6 of the Technical Experts Committee Report, the Pathogens Sub-Committee recommends that microbiological characterization be done on all source waters. The committee recommends a multi-indicator approach including *E. coli,* enterococci, coliphage, and *Cryptosporidium.*

Existing microbial databases are typically limited to traditional indicators such as *E. coli* and laboratory methods for other pathogens are currently cost prohibitive or not readily available.

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[143] Richardson, S.D., and T.A. Temes. June 15, 2005. Water Analysis: Emerging Contaminants and Current Issues. In Analytical Chemistry, Vol. 77.

[144] OMOE. 2004. Watershed-based Source Protection Planning. Science-based Decision-making for Protecting Ontario's Drinking Water Resources: A Threats Assessment Framework. Technical Experts Committee Report to the Minister of the Environment.

(5) Pathways of Contamination

It is important to examine and understand the pathways of source water contamination in order to aid in protecting the drinking water sources. The contamination of drinking water sources may occur due to point (discrete) sources such as industrial effluents or non-point (diffused) sources such as urban runoff. At the time of writing of this Report, pathways of contamination in the watershed are yet to be considered.

Various studies have examined the pathways of typical contaminants such as nutrients, metals and pathogens that enter surface water and groundwater drinking sources. Examples of these studies include:

- 'Waterborne Pathogens in Agricultural Watersheds'[145] and
- 'Sources, pathways, and relative risks of contaminants in surface water and groundwater: a perspective prepared for the Walkerton inquiry'[146].

According to the latter study, there is not enough data available on several contaminants, such as pharmaceuticals in drinking water.

'Groundwater Studies in Ontario' is a large project by the OMOE currently going on, that includes identifying pathways of groundwater source contamination[147]. Potential sources being mapped include rail yards, stormwater ponds, animal feed lots, gas stations, paint shops, car washes, etc.

(6) Sediment Analysis

Contaminated sediments are a concern, as toxic materials may be stored in the sediments for a long period of time at the bottom of a watercourse and may be released into the water column during storm events or other disturbances of the riverbed. A review of any available sediment data would be useful in identifying contaminant locations and potential risks.

An example of a source of data on sediment quality is the OMOE which performs sampling at several index stations[148] throughout the Great Lakes for priority toxic contaminants in sediment and suspended particulate material. Spring, summer, and fall water sampling is done for various physical and chemical measurements.

(7) Bio-accumulation

Bio-accumulation of toxic materials in aquatic species reflects contaminant levels in surface water systems. The Guide to Eating Ontario Sport Fish provides some useful information and tissue analyses for sport fish consumption guidelines. Additional compilation of historic and ongoing research in this area would be of value in highlighting areas of concern and critical contaminants.

3.5.6 Data Gap Summary

The data gaps are summarized in the **Table 3.5.6-1: Data Gaps – Surface Water** and **Table 3.5.6-1: Data Gaps – Groundwater**.

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[145] Rosen, B.H. February 2000. Waterborne Pathogens in Agricultural Watersheds. Watershed Science Institute Technical Note 2.

[146] Ritter, L., K. Solomon, P. Sibley, K. Hall, P. Keen, G. Mattu and B. Linton. Journal of Toxicology and Environmental Health A. 2002 Jan 11;65(1):1-142.

[147] OMOE. March 2004. Groundwater Studies on Ontario: Mapping a hidden treasure. www.ene.gov.on.ca/programs/4197e01.pdf

[148] OMOE. November 1999. Surface Water Monitoring and Assessment, 1997 Lake Ontario Report. www.ene.gov.on.ca/envision/techdocs/3933-1.htm

Table 3.5.6-1: Data Gaps – Surface Water

WC Deliverable	Data Set Name	Data Gap Problem	Comment
Inland surface water quality – physical and chemical	PWQMN data	Partially populated	Data gap for some years for some PWQMN stations
UTRCA Inland surface water quality – microbial	PWQMN data for 1996 to 2002	Does not exist	Data gap for most PWQMN stations
LTVCA Inland surface water quality – microbial	PWQMN data for 1996 to present	Does not exist	Data gap for most PWQMN stations
Intakes surface raw water quality – physical and chemical	DWSP data for West Elgin WTP and Wheatley WTP	Does not exist	Alternate sources of data have been found but they are not as ‘complete’
Intakes surface raw water quality - microbial	DWIS data for Wheatley WTP, Elgin WSS, Lake Huron WSS, Stoney Point WTP and Union WSS	Missing data (does not imply that data does not exist)	Missing data from the DWIS; have let CO know; alternate sources of data have been found
Intakes surface raw water quality –	Other sources of information	Missing data	Great Lakes water and sediment monitoring data not reviewed
Inland and intakes surface water quality	Municipal and Industrial Sewage Treatment	Missing data	Data sets not available
Inland and intakes surface water quality	Emerging pollutants Bio-accumulation Pathogens	Partially populated, too sparse Missing data	Not enough data on emerging contaminants (fire retardants, pharmaceuticals, algae toxins, etc.) Data sets not reviewed

WC – Watershed Characterization, PWQMN – Provincial Water Quality Monitoring Network,
DWSP – Drinking Water Surveillance Program, DWIS- Drinking Water Information System
WTP – Water Treatment Plant, WSS – Water Supply System

Table 3.5.6-2: Data Gaps – Groundwater

WC Deliverable	Data Set Name	Data Gap Problem	Comment
Identify long-term groundwater trends	PGMN and Historic Data	PGMN data starts in 2003 Historic data limited	Difficult to identify groundwater flow paths or interaction of aquifers/aquitards to evaluate groundwater evolution
Evaluate groundwater quality	Health Unit Data Set SOWAQ and 3 CA database compiled be Schlumberger	Private well data not available at this time Lack of information to characterize groundwater	Existing data would help evaluate local water quality At a regional scale, there are some broad statements that can be made but at a local scale, there is little information
Municipal groundwater sources raw water quality – physical and chemical	DWSP data All municipal wells supplies except Dorchester, Ingersoll, Woodstock and Stratford	Missing data (does not imply that data does not exist)	Missing data from the DWSP; limited alternate sources of treated water data have been found
Municipal groundwater sources raw water quality – microbial	DWIS data for Mt Brydges and Mt Elgin well supply systems	Missing data (does not imply that data does not exist)	Alternate sources of data have been found