Otter Lake RDF
2014 Annual Operational Monitoring Report

April 2015

MIRROR NS

11-4873-4000

Submitted by:

Dillon Consulting Limited

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Otter Lake RDF - 2014 Annual Operational Monitoring Report

Dillon Consulting Limited is pleased to submit the above referenced document. Copies have been forwarded to HRM and Nova Scotia Environment on your behalf. Please contact the undersigned if we can be of further assistance.

Yours truly,

DILLON CONSULTING LIMITED

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Table of Contents

Executive Summary iv

1.0 Introduction 1
1.1 Monitoring Background 1

2.0 Project Methodologies 9
2.1 Field Program 9
2.2 Data Assessment and Reporting 10

3.0 Discussion of Results 11
3.1 Groundwater Monitoring Network 11
3.1.1 Hydraulic Head Elevations 16
3.1.2 Groundwater Analytical Results 18
3.1.2.1 Guideline Comparison 18
3.1.2.2 General Groundwater Character 29
3.1.2.3 Organic Chemistry 42
3.2 Surface Water Monitoring Network 43
3.2.1 Surface Water Analytical Results 44
3.2.1.1 Guideline Comparison 44
3.2.1.2 General Surface Water Character 52
3.2.1.3 Organic Chemistry 56
3.3 Sediment Sampling Results 56
3.4 Other Monitoring Results 58
3.4.1 Underdrain Samples 58
3.4.2 Leak Detection Sump Samples 61
3.4.2.1 Inorganic Chemistry Results 61
3.4.2.2 Organic Chemistry Data 64
3.4.3 Leachate Sample Results 64

4.0 Summary and Conclusions 66

5.0 Recommendations 75

List of Figures:

Figure 3-1 Site Location and Surface Water Sampling Locations 12
Figure 3-2 Monitoring Locations and Site Details 13
Figure 3-3 Groundwater Flow Direction Shallow Bedrock (September 2014) 17
Figure 3-4 Iron Concentrations in Select Monitor Wells 20
Figure 3-5 Manganese Concentrations in Select Monitor Wells 22
Figure 3-6 Chloride Concentrations in Till Wells 31
Figure 3-7 Chloride Concentrations in Shallow Bedrock Wells 32
Figure 3-8 Chloride Concentrations in Intermediate to Deep Bedrock Wells 33
Figure 3-9 TDS Concentrations in Till Wells 34
Figure 3-10 TDS Concentrations in Shallow Bedrock Wells 35
Figure 3-11 TDS Concentrations in Deep Bedrock Wells 36
Figure 3-12 Chloride Concentrations in Surface Water – Otter Lake and FEP Stations 53
Figure 3-13 Chloride Concentrations in Surface Water – Nine Mile River and Sedimentation Ponds/ Receiving Waters 53
Figure 3-14 Chloride Concentrations in Surface Water – Duck Pond/Furthest Downstream Nine Mile River Stations 53
Figure 3-15 TDS Concentrations in Surface Water – Otter Lake and FEP Stations 54
Figure 3-16 TDS Concentrations in Surface Water – Nine Mile River and Sedimentation Ponds/ Receiving Waters 54
Figure 3-17 TDS Concentrations in Surface Water – Duck Pond/Furthest Downstream Nine Mile River Stations 54

List of Tables:

Table 1-1 Summary of Monitoring 2
Table 3-1 2014 Groundwater Sampling Program 14
Table 3-2 Summary of Arsenic Exceedances in Groundwater 26
Table 3-3 Summary of Uranium Guideline Exceedances in Groundwater 28
Table 3-4 Summary of Indicator Parameters in Select Groundwater Samples 37
Table 3-5 2014 Surface Water Sampling Program 43
Table 3-6 Summary of Exceedances to FWAL Guideline for Selected Parameters 49
Table 3-7 Summary of Surface Water Indicator Parameters 55
Table 3-8 Summary of Metals Exceedances in Sediment 57
Table 3-9 Cell 3 Underdrain Samples - Summary of Indicator Parameters 59
Table 3-10 Cell 4B Underdrain Samples - Summary of Indicator Parameters 60
Table 3-11 Cell 5 Underdrain Samples - Summary of Indicator Parameters 60
Table 3-12 Cell 6 Underdrain Sample - Summary of Indicator Parameters 61
Table 3-13 Leak Detection Cell 1&2 Sump - Summary of Indicator Parameters 62
Table 3-14 Leak Detection Sump 3 - Summary of Indicator Parameters 62
Table 3-15 Leak Detection Sump 4 - Summary of Indicator Parameters 63
Table 3-16 Leak Detection Sump 5 - Summary of Indicator Parameters 64
Table 3-17 Leak Detection Sump 6 - Summary of Indicator Parameters 64

Table 4-1 Summary of 2014 Groundwater Exceedances 68
Table 4-2 Summary of 2014 Surface Water Exceedances 71
Table 5-1 Groundwater Sampling Recommendations 77
Table 5-2 Surface Water Sampling Recommendations 81
Table 5-3 Other Environmental Quality Monitoring Recommendations 83

Appendices:

Appendix A Field Methodology
Appendix B Hydraulic Head Data and Site Analytical Results

Executive Summary

The 2014 monitoring program at the Otter Lake Solid Waste Management Facility was a continuation of groundwater and surface water monitoring associated with the long-term operation of the site. Quarterly monitoring events were undertaken in April, June, September and December. In general, three of the events focused on down gradient and/or cross-gradient areas of the site; therefore, select groundwater and surface water locations were sampled. The cell underdrains, leak detection sumps and leachate from the collection tank were also sampled quarterly. The September (low flow) event included collection of samples from all monitoring locations, as well as sediment samples from select surface water stations. Sampling parameters in water included general inorganic chemistry and metals during each event, and organics (TPH/BTEX, VOCs and PAHs) at select groundwater and surface water locations, as well as cell underdrains, leak detection sumps and leachate, in September. Sediment samples were analyzed for metals only. Water level measurements were recorded on a quarterly basis (select locations) and annually in order to evaluate changes in hydraulic head elevations over time.

Consistent with previous results parameters above the Health Canada Drinking Water Quality (DWQ) Guidelines in 2014 included colour, turbidity, iron, manganese, arsenic and/or uranium, as well as pH below the recommended range, at one or more locations. Surface water parameters above the FWAL Guidelines included aluminum, arsenic, cadmium, chromium, copper, iron, lead and/or zinc, as well as pH below the recommended range, at one or more locations consistent with previous results. TSS was above the Nova Scotia Pit and Quarry Guidelines discharge limit in two on-site samples. The generally higher metals concentrations in the June 2014 FEP surface water samples were reflective of increased flow conditions, as a significant rainfall event commenced immediately prior to sample collection at these particular stations, and concentrations in subsequent samples were significantly lower.

For sediment (tested annually), arsenic was above the applicable Canadian Sediment Quality (CSQ) Guidelines in the three sediment samples, and cadmium, chromium, copper, lead, mercury and/or zinc were above the guidelines in two samples. Mercury was above the guideline in the sediment sample collected downstream of the North Sedimentation Pond for the first time; however, the concentration was only slightly higher than the guideline and previous results.

Consistent with previous results, TPH/BTEX and VOCs were not detected in the surface water samples and one PAH compound, phenanthrene, was detected in SW-3 and SW-4 at low concentrations (well below the FWAL Guideline). Phenanthrene is naturally occurring in surface water and has been found to be present in background soil concentrations in Nova Scotia.

With the exception of one well, TPH/BTEX and VOCs were not detected in the September 2014 groundwater samples. Petroleum hydrocarbons in the fuel and lube oil ranges, as well as toluene in the TPH/BTEX and VOC analyses, were detected in one down gradient monitor well sample. This well has frequently been noted as containing organics and/or a stagnant odour; and, as previously reported, the well has undergone testing (in 2013) with a silica gel clean-up conducted by the lab prior to analysis with the results (non-detect) indicating that the presence of these compounds at this location was naturally occurring and non-petrogenic in nature. In 2014, the detected concentration of toluene did not correlate with the concentration recorded in the TPH/BTEX analysis, which was lower and below the guideline. PAHs were not detected in groundwater samples, with the exception of one parameter. Phenanthrene was detected at low concentrations in samples from nine wells. The low concentrations detected in the samples are presumably attributed to the presence of sediment in the samples. There is no DWQ Guideline for this parameter.

TPH/BTEX, PAHs and VOCs were not detected in the underdrain samples analyzed in September. TPH/BTEX, PAHs and VOCs were not detected in the leak detection sumps, with the exception of one or two PAH compounds (detected in the Cell 3, Cell 5 and Cell 6 sumps) and a low concentration of petroleum hydrocarbons in the fuel oil range (recorded in the Cell 6 sump). This is generally similar to previous findings.

Localized areas (down gradient of the landfill and in the vicinity of the FEP) with elevated levels of indicator parameters are most likely reflective of site operations (i.e., roadway drainage and earthworks) rather than the disposal cells, and the area down gradient of Cells 5 and 6 continue to show influence from routine site operations since construction of Cell 5 in 2008 and Cell 6 in 2011/2012. Concentrations of metals from the South Sedimentation Pond and downstream receiving waters during 2014 remained lower than the levels observed in 2011/2012, coincident with Cell 6 construction, and the sediment control measures undertaken at the site during 2014 (including construction of a sediment basin at the foot of future Cell 7 and hydro-seeding the slopes of Cells 4 and 5) will reduce runoff to this area. Groundwater immediately up gradient of the landfill appears to be exhibiting influence from roadway runoff and/or site operations; however, this

influence is not apparent in the further up gradient wells. Most of these wells are adjacent to a roadway subject to increased truck traffic during the construction of Cell 5 in 2008 and Cell 6 in 2012, and other potential sources of influence include an operational white goods area up gradient of Cell 2 and a grubbing area up gradient of Cells 5 and 6 that was active during construction of these cells (between 2008 and 2012). Finally, it is noted that the two wells in the northeast corner of the landfill/topographically up gradient of the FEP, which were sampled quarterly in 2014 at NSE's request, are located in a ditch that receives drainage from roadway runoff.

Recommendations for the 2015 monitoring program have not changed from the 2014 monitoring program. That is, monitoring should continue to be on a quarterly basis, with additional parameters collected during the low flow (or annual) event conducted in the fall, and the two wells sampled quarterly in 2014 (at NSE's request) will continue to be sampled quarterly in 2015.

Overall, there is no significant indication of off-site environmental impacts to either the surface or groundwater as a result of either site operations or recent construction activities.

1.0 Introduction

The Otter Lake Solid Waste Management Facility includes the Residual Disposal Facility (RDF), the Front End Processor (FEP) and the Waste Stabilization Facility (WSF). The site, managed by MIRROR Nova Scotia, receives, sorts and disposes of waste generated from within Halifax Regional Municipality (HRM). Construction of the RDF began in spring/summer of 1997. It is a second-generation landfill equipped with a single composite liner and leak detection system. The first disposal cell (Cell 1) was completed at the end of 1998. Cells 2, 3, 4 and 5 were opened between 2000 and 2008. Cell 6 was constructed during 2011/2012 and became operational in October 2012. Landfill gas collection systems have been installed in the completed cells (Cells 1, 2, 3, 4 and 5, which have been capped). In addition, although Cell 6 is still in operation, landfill gas collection systems were installed within portions of the cell (near the northwest end) in late 2013 and in late 2014.

On October 18, 2012, the Approval to Operate was amended to incorporate the operation of Cell 6 (Approval No. 2008-065580-A01). Similar to prior approvals, the amended approval references that quarterly monitoring will be conducted in accordance with the site operations manual.

This report presents the results of the 2014 environmental monitoring program. The document also incorporates data collected/compiled since the initiation of sampling at the facility in 1996 and provides recommendations regarding the 2015 monitoring program. It includes the following sections:

Section 1: Introduction and Monitoring Background
Section 2: Program Methodologies
Section 3: Discussion of Results
Section 4: Summary and Conclusions
Section 5: Recommendations

1.1 Monitoring Background

Hydrogeological and hydrological assessments were completed during 1995/1996 as part of the initial site evaluation and in support of engineering design. Groundwater quality data was collected on three occasions during 1996 and surface water and sediment sample data collected on one occasion. Construction monitoring undertaken during 1997 and 1998 involved monthly sampling events. The 1996 through 1998 data provide the baseline for which operational monitoring data are compared.

The purpose of monitoring is to identify environmental impact that may be attributed to landfilling activities. There are essentially two levels of monitoring. One level is associated with the day-to-day operation of the site and typically

addresses "one off" situations. The other level (discussed within this document) is associated with the long term operation of the site and addresses broader or wider scale implications.

Operational monitoring initiated in 1999 and carried through 2014 has included quarterly surface water and groundwater sampling, collection of samples from the leak detection sumps associated with Cells 1&2, 3, 4, 5 and 6, and liquids collected and contained within the leachate holding tank. Sediment samples have been collected on one occasion during each year. More frequent sampling of select monitor wells has been undertaken over the years in association with construction of new landfill cells (i.e., Cells 2, 3, 4, 5 and 6).

Analysis to date has focused primarily on general inorganic chemistry and trace metals parameters. Other parameters tested on occasion have included petroleum hydrocarbon components (TPH/BTEX), volatile organic compounds (VOC), polycyclic aromatic hydrocarbons (PAH), bromide (Br), fluoride (F) and mercury (Hg). A summary of sampling undertaken since 1996 is provided in Table 1-1. It is noted that sampling from 1996 through 1998 was conducted by Jacques Whitford and Associates, and subsequent sampling has been carried out by Dillon Consulting Limited (formerly Porter Dillon Limited). It is also noted that groundwater elevation data has been recorded on a more frequent basis throughout cell construction periods.

Table 1-1 Summary of Monitoring

Date	Status	Water Levels	Sampling Program
Feb/96	Baseline	6	6 groundwater - GC & metals
Mar/96	Baseline	17	
Apr/96	Baseline	43	
May/96	Baseline	63	17 groundwater - primarily GC & metals, select EPA 608 & BOD/COD
June/July 96	Baseline	87	34 groundwater - primarily GC, metals & radon, select samples for VOC, PAH, OC Pesticides & BOD/COD 12 surface water - primarily GC & metals, select samples for VOC, PAH, OC Pesticides & BOD/COD 9 sediment - primarily metals, select samples for VOC, PAH &s OC Pesticides
Aug/96	Baseline	87	
Apr/97	Baseline	85	
Sept/97	Construction	67	23 groundwater - primarily GC & metals, select samples for BOD/COD
Oct/97	Construction	65	24 groundwater - primarily GC & metals, select samples for BOD/COD
Nov/97	Construction	66	45 groundwater - primarily GC & metals, select samples for BOD/COD 12 surface water - GC, metals, radon & BOD/COD 11 sediment – metals
Dec/97	Construction	65	22 groundwater - primarily GC & metals, select samples for OC Pesticides & BOD/COD
June/98	Construction	71	50 groundwater - primarily GC & metals, select samples for OC Pesticides & BOD/COD 12 surface water - GC, metals, radon & BOD/COD
Sept/98	Construction	73	49 groundwater - primarily GC & metals, select samples for OC Pesticides & BOD/COD) 12 surface water - GC, metals, radon & BOD/COD
Dec/98	Post Construction	73	46 groundwater - primarily GC & metals, select samples for BOD/COD
Mar/99	Operational	62	35 groundwater - GC & metals 14 surface water - GC, metals, TSS; select samples for BOD/COD
May/Jun/99	Operational	76	35 groundwater - GC & metals 13 surface water - GC, metals, TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate – GC, metals & TSS
Jul/99	Construction	65	14 groundwater - GC & metals

Date	Status	Water Levels	Sampling Program
Aug/99	Construction/ Operational	65	53 groundwater – GC & metals; select samples for VOC, PAH, BTEX/ TPH, OC Pesticides & PCBs 13 surface water - GC, metals, TSS; select samples for VOC, PAH, BTEX/ TPH, OC Pesticides, PCBs & BOD/COD 4 sediment -metals 1 leak detection sump - GC, metals, VOC, PAH, BTEX/ TPH, OC Pesticides & PCBs 1 leachate - GC, metals, TSS, VOC, PAH, BTEX/ TPH & PCBs
Sept/99	Construction	34	16 groundwater - GC & metals
Oct/99	Construction	36	16 groundwater - GC & metals
Dec/99	Construction/ Operational	73	35 groundwater - GC & metals 12 surface water - GC, metals, TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
Feb/Mar/00	Operational	61	27 groundwater - GC & metals 11 surface water - GC, metals, TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
June/July/ 00	Operational	73	34 groundwater – GC & metals 12 surface water - GC, metals, TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
Sept/00	Operational	73	52 groundwater - GC, metals; select samples for BTEX/ TPH, VOC, PAH, OC Pesticides & PCBs 15 surface water - GC, metals, TSS; select samples for BTEX/ TPH, VOC, PAH, OC Pesticides, PCBs & BOD/COD 3 sediment – metals 1 leak detection sump - GC, metals, BTEX/ TPH, VOC, PAH, OC Pesticides & PCBs 1 leachate - GC, metals, BTEX/ TPH, VOC, PAH, OC Pesticides & PCBs
Nov/Dec/00	Operational	71	32 groundwater - GC, metals; select samples for VOCs, BTEX/TPH 12 surface water - GC, metals, TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
Mar/Apr/01	Operational	48	33 groundwater - GC, metals & Hg 13 surface water - GC, metals, TSS, HG & BOD/COD 1 leak detection sump – GC, metals, TSS & Hg 1 leachate - GC, metals, TSS & Hg
May/01	Construction	64	
June/01	Construction/ Operational	33	34 groundwater – GC & metals 12 surface water - GC, metals, TSS & BOD/COD 1 leak detection sump – GC & metals 1 leachate – GC, metals, TSS & Hg
July/01	Construction	57	16 groundwater - GC, Br, F & sulphur
August/01	Construction	66	16 groundwater - GC, Br & F
Sept/01	Construction/ Operational	55	50 groundwater - GC, metals; select Samples for Br, F, BTEX/TPH VOC & PAH 12 surface water - GC, metals, TSS, Hg; select samples for BOD/COD BTEX/TPH, VOC & PAH 3 sediment - metals 1 leak detection sump – GC, metals, Hg, BTEX/TPH, VOC & PAH 1 leachate – GC, metals, Hg, BTEX/TPH, VOC & PAH
Oct/01	Construction	17	16 groundwater - GC, Br & F
Nov/01	Construction	17	16 groundwater - GC, Br & F
Dec/01	Construction/ Operational	62	36 groundwater - GC, metals, Hg, Br & F 11 surface water – GC, metals, TSS & BOD/COD 1 leak detection sump - GC, metals & Hg
April/02	Operational	63	29 groundwater – GC & metals 10 surface water – GC, metals & TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
June/02	Operational	64	27 groundwater – GC & metals 9 surface water - GC, metals & TSS; select samples for BOD/COD 1 leak detection sump – GC & metals 1 leachate - GC, metals & TSS

Date	Status	Water Levels	Sampling Program
Sept/02	Operational	52	51 groundwater - GC, metals; select samples for BTEX/TPH, VOC & PAH 12 surface water - GC, metals, TSS, Hg; select samples for BTEX/TPH, VOC, PAH & BOD/COD 4 sediment – metals 1 leak detection sump - GC, metals, Hg, BTEX/TPH, VOC & PAH 1 leachate- GC, metals, TSS, Hg, BTEX/TPH, VOC & PAH
Dec/02	Operational	49	27 groundwater – GC & metals 10 surface water - GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate – GC, metals & TSS
Mar/03	Operational	23	25 groundwater – GC & metals 10 surface water - GC, metals, TSS; select samples for BOD/COD 2 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
June/03	Operational	30	25 groundwater – GC & metals 10 surface water - GC, metals, TSS; select samples for BOD/COD 2 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
Sept/Oct/03	Operational	59	52 groundwater - GC, metals; select samples for BTEX/TPH, VOC & PAH 15 surface water - GC, metals, TSS; select samples for BTEX/TPH, VOC, PAH & BOD/COD 3 sediment – metals, VOC & PAH 2 leak detection sumps - GC, metals, BTEX/TPH, VOC & PAH 1 leachate - GC, metals, TSS, Hg, BTEX/TPH,
Nov/Dec/03	Operational	25	25 groundwater – GC & metals 10 surface water - GC, metals & TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
Apr/04	Operational	25	25 groundwater – GC & metals 8 surface water - GC, metals, TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
June/04	Operational	29	25 groundwater – GC & metals 10 surface water - GC, metals, TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
Sept/04	Operational	61	51 groundwater - GC, metals; select Samples for BTEX/TPH, VOC & PAH 15 surface water - GC, metals, TSS; select samples for BTEX/TPH, VOC,PAH & BOD/COD 3 sediment – metals 2 leak detection sumps - GC, metals, BTEX/TPH, VOC & PAH 2 leachate - GC, metals, BTEX/TPH, VOC & PAH
Dec/04	Operational	30	25 groundwater – GC & metals 10 surface water - GC, Metals, TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
Mar/05	Operational	21	25 groundwater – GC & metals 6 surface water – GC, metals & TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
May/05	Construction	11	6 groundwater - GC/ & metals
June/05	Construction/ Operational	36	26 groundwater - GC & metals 10 surface water - GC, metals & TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
July/05	Construction	15	8 groundwater – GC & metals
Aug/05	Construction	13	8 groundwater – GC & metals
Sept/05	Construction/ Operational	59	55 groundwater – GC & metals; select samples for VOC & PAH 14 surface water – GC, metals & TSS; select samples for VOC, TPH/BTEX & BOD/COD 3 sediment – metals & mercury 2 leak detection sumps - GC, metals, VOC & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX
Oct/05	Construction	15	8 groundwater – GC & metals
Nov/05	Construction	18	8 groundwater – GC & metals

Date	Status	Water Levels	Sampling Program
Dec/05	Construction/ Operational	23	28 groundwater – GC & metals 9 surface water - GC, metals & TSS; select samples for BOD/COD 2 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
Mar/Apr/06	Operational	26	26 groundwater – GC & metals 10 surface water – GC, metals & TSS; select samples for BOD/COD 2 leak detection sump – GC & metals 1 leachate - GC, metals & TSS
June/06	Operational	31	27 groundwater – GC & metals 10 surface water – GC, metals & TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals; Cell 4 also sampled for PAH & BTEX/TPH 1 leachate - GC, metals & TSS
Sept/06	Operational	60	48 groundwater – GC & metals; select samples for VOC & PAH 14 surface water - GC, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 3 leak detection sumps – GC & metals 1 leachate - GC, metals, TSS, VOC, PAH & BTEX/TPH
Dec/06	Operational	28	27 groundwater – GC & metals 10 surface water – GC, metals & TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
April/07	Operational	26	24 groundwater – GC & metals 10 surface water – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
June/07	Operational	26	24 groundwater – GC & metals 10 surface water – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
Sept/07	Operational	61	51 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC/, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & BTEX/TPH
Dec/07	Operational	26	24 groundwater – GC & metals 10 surface water – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS
Apr/May/08	Operational	29	26 groundwater – GC & metals 10 surface water – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 1 underdrain – GC & metals
June/08	Construction/ Operational	37	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 1 underdrain – GC & metals
July/08	Construction	12	7 groundwater – GC & metals
Aug/08	Construction	12	7 groundwater – GC & metals
Sept/08	Construction/ Operational	64	52 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 3 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX 2 underdrain – GC & metals, VOC, PAH & TPH/BTEX
Oct/08	Construction	12	7 groundwater – GC & metals
Nov/08	Construction	10	7 groundwater – GC & metals 2 leak detection sumps – GC, metals, TSS & BOD/COD

Date	Status	Water Levels	Sampling Program
Dec/08	Construction/ Operational	37	29 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 2 underdrains– GC & metals
Apr/09	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Jun/09	Operational	64	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Sept/09	Operational	64	52 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC, metals & TSS, select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 4 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX 3 underdrain – GC & metals, VOC, PAH & TPH/BTEX
Dec/09	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Mar/10	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 2 underdrains– GC & metals
Jun/10	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Sept/10	Operational	64	52 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC, metals & TSS, select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 4 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX 3 underdrain – GC & metals, VOC, PAH & TPH/BTEX
Dec/10	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
May/11	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Aug/11	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals

Date	Status	Water Levels	Sampling Program
Oct-Nov/11	Construction/ Operational	64	51 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 4 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX 2 underdrain – GC & metals, VOC, PAH & TPH/BTEX
Nov/11	Construction	12	7 groundwater – GC & metals
Dec/11	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Apr/12	Operational	30	26 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 2 underdrains– GC & metals
May/12	Construction	12	7 groundwater – GC & metals
Jun/12	Construction/ Operational	39	31 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 2 underdrains– GC & metals
Jul/12	Construction	12	6 groundwater – GC & metals
Aug/12	Construction	12	6 groundwater – GC & metals
Sept/12	Construction/ Operational	62	51 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 4 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX 2 underdrain – GC & metals, VOC, PAH & TPH/BTEX
Dec/12	Operational	30	26 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 3 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 4 underdrains– GC & metals
Apr/13	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 5 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals
Jun/13	Operational	30	27 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 4 underdrains– GC & metals
Sept/13	Operational	63	49 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX 15 surface water - GC, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD 3 sediment – metals & mercury 5 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals, TSS, VOC, PAH & TPH/BTEX 3 underdrains – GC & metals, VOC, PAH & TPH/BTEX
Dec/13	Operational	29	29 groundwater – GC & metals; TPH/BTEX at MW97-23A1 10 surface waters – GC, metals, TSS; select samples for BOD/COD 4 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals

Date	Status	Water Levels	Sampling Program
Apr/14	Operational	32	29 groundwater – GC & metals (see note 3) 9 surface waters – GC, metals, TSS; select samples for BOD/COD (see note 4) 5 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 3 underdrains– GC & metals (see note 5)
Jun/14	Operational	28 (note 6)	28 groundwater – GC & metals (see note 7) 10 surface waters – GC, metals, TSS; select samples for BOD/COD 5 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 2 underdrains– GC & metals (see note 5)
Sept/14	Operational	61 (note 6)	48 groundwater - GC, metals; select samples for VOC, PAH & TPH/BTEX (see note 7) 14 surface water - GC, metals & TSS; select samples for VOC, PAH, BTEX/TPH & BOD/COD (see note 4) 3 sediment – metals & mercury 5 leak detection sumps – GC, metals, VOC, PAH & TPH/BTEX 1 leachate - GC, metals & TSS 3 underdrains – GC & metals, VOC, PAH & TPH/BTEX (see note 3)
Dec/14		28 (note 6)	29 groundwater – GC & metals 10 surface waters – GC, metals, TSS; select samples for BOD/COD 5 leak detection sumps – GC & metals 1 leachate - GC, metals & TSS 4 underdrains– GC & metals

Notes:

1. Information presented to and including Sept. 1998 was obtained from JWA report (Project No. 12340 Quarterly Report No. 3 December 7, 1998). GC refers to general inorganic chemistry parameters.
2. Groundwater elevation data have been recorded on a more frequent basis during construction periods.
3. MW96-16A/16B, which were sampled annually prior to 2014, sampled quarterly in 2014 at NSE's request.
4. In April 2014, a sample could not be collected from SW-4 as the area was flooded and the sample station inaccessible. In September 2014, SW-16 was dry (noting that this station had been scheduled for VOC, PAH & TPH/BTEX analyses).
5. In April, June and September 2014, there was no flow at the Cell 4 Underdrain (4B location), and in June 2014, a sample was inadvertently not collected from Cell 3. It is noted that, to date, there has not been any flow at Cell 1&2 and Cell 4A Underdrain locations.
6. Piezometers C8, C9 and C10 were inadvertently not gauged in June 2014. Also in June 2014, a blockage was observed in MW97-2B1 and, therefore, water level measurements could not be obtained in June or subsequent events (however, the well was sampled as scheduled). In Sept. 2014, one piezometer (BHRD-30) was not located for gauging.
7. In June 2014, MW96-5A contained insufficient water to sample; and in September 2014, MW96-5A, MW96-20A and MW97-24A were dry or contained insufficient water to sample.

2.0 Project Methodologies

The 2014 Otter Lake operational monitoring program, as approved by Nova Scotia Environment (NSE), included four sampling events undertaken in the months of April, June, September and December. Field testing involved: inspection of monitor well sites, measurement of hydraulic head levels and the collection of surface water, surface water sediments, groundwater, cell underdrains, leak detection sump water and leachate samples. The results were compiled and evaluated in comparison to applicable guidelines and existing data. A general description of these tasks is provided in the following sections. A detailed field methodology is found in Appendix A.

2.1 Field Program

Monitor well inspections, conducted as part of each sampling event, involved an assessment of the physical integrity of the sampling station, specifically, the condition of the riser pipe, sampling tube and protective cover. Minor repairs, such as replacement of the sampling tubes, covers and locks, were completed as deemed necessary. Water levels were recorded as measurement of depth to water from the surveyed referenced lip on the PVC riser pipe.

Wells were developed using polyethylene tubing and a foot valve pumping unit dedicated to each well. A minimum of three casing volumes of water were removed from each well. Surface water samples were collected as whole water grab samples. Sediments were collected as a grab sample from the top five to ten centimetres of substrate.

As indicated above, the primary focus of analysis (both historically and as part of this event) has been general inorganic chemistry and metal parameters. In addition, all surface waters were sampled for total suspended solids (TSS) and select surface waters sampled for BOD/COD. Leachate was also sampled for TSS. Select surface water and groundwater samples, as well as the leak detection sumps, underdrains and leachate, were analyzed for TPH/BTEX, VOCs and PAHs, during the annual event (conducted in September).

General inorganic chemistry and metal samples collected from the monitor wells were field filtered and the metals aliquots acidified with nitric acid. Filtration removes fine sediment which may be present due to turbulence created during sporadic well development. Unfiltered samples may exhibit elevated concentrations of some parameters, specifically colour, turbidity and metals, due to either presence of, or adherence to suspended matter. Acidification ensures that the metals remain in solution. Water from the underdrain, surface water, leak detection sump and the leachate samples were not filtered, but the metals aliquots were acidified. Surface waters were collected as unfiltered grab samples and, similar to groundwater, the metals aliquots preserved with nitric acid. Sediment samples were collected at three surface water sampling stations during the annual (September) event and analyzed for metals (including mercury).

It is noted that sample frequency for two wells (MW96-16A/16B) increased from annual to quarterly during 2014 at the request of NSE. These wells are located at the northeast corner of the landfill and southeast/topographically up gradient of the FEP compound.

Laboratory analyses were contracted to Maxxam Analytics Inc. (Maxxam) in Bedford, Nova Scotia. Maxxam is accredited with the Standards Council of Canada. In addition to strict sampling, handling and shipment protocols, QA/QC procedures included the collection of field duplicates and laboratory replicate sample analysis.

2.2 Data Assessment and Reporting

The 2014 analytical data were compiled in tables and spreadsheets in conjunction with existing data. Hydraulic head levels were evaluated to identify changes in groundwater flow that could reflect either seasonal influences or earthworks activities. Groundwater analytical results were compared to the Health Canada Drinking Water Quality (DWQ) Guidelines and surface water analytical results to the Canadian Council of Ministers of the Environment (CCME) Freshwater Aquatic Life (FWAL) Guidelines and the provincial "Pit and Quarry Guidelines" discharge limit. In addition, select parameters (specifically chloride, ammonia, total dissolved solids, total organic carbon (TOC), hardness and pH) were evaluated to identify changes in concentration that could potentially be indicative of early signs of impact. Sediment sample results were compared to the CCME Canadian Sediment Quality (CSQ) Guidelines – Interim Sediment Quality Guidelines.

The Year 16 first, second and third quarter results were provided in three reports submitted in May 2014, September 2014 and December 2014, respectively. The annual report is a more comprehensive document inclusive of information collected throughout the entire year.

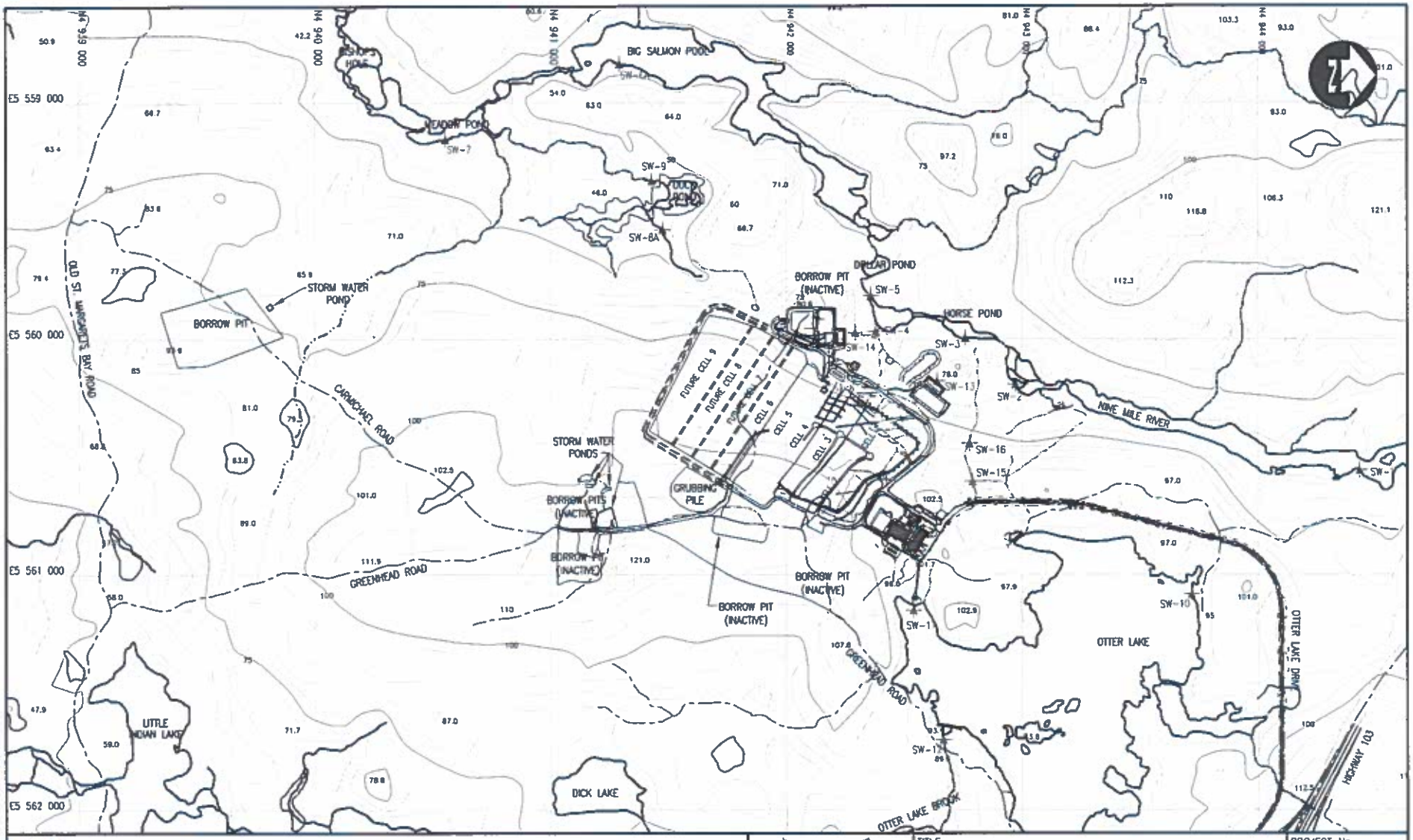
3.0 Discussion of Results

Site details are provided on Figure 3-1. During late 2014, methane extraction wells, part of the landfill gas collection system, were installed in a portion of Cell 6, as noted above. The borrow pit located on Carmichael Road continues to be operational. Short term and long term sediment control measures were implemented in 2014. This included the construction of a sediment basin at the foot of future Cell 7, as well as sodding and hydro-seeding the slopes of Cells 4 and 5. A temporary landfill gas flaring system, which was constructed during 2012/2013, was completed and commissioned in 2014. This is located to the south of the South Sedimentation Pond and down gradient of future Cell 7. There were no other significant site changes during 2014.

3.1 Groundwater Monitoring Network

The current groundwater monitoring network consists of 51 wells at 30 locations around the perimeter of the landfill. Several piezometers within or at the edge of the landfill footprint are used for the purpose of collecting groundwater elevation data only. The majority of piezometers have, however, been decommissioned over the years as part of cell construction activities. Monitor well and piezometer locations are shown on Figure 3-2.

A summary of the 2014 groundwater monitoring program, including well identifications, general location and the scheduled sampling events are presented in Table 3-1. Comments pertaining to the absence of data in instances where a sample was not collected as intended are also provided in the notes.



LEGEND:

SURFACE WATER SAMPLING LOCATION

SCALE: 1:1500

DILLON CONSULTING

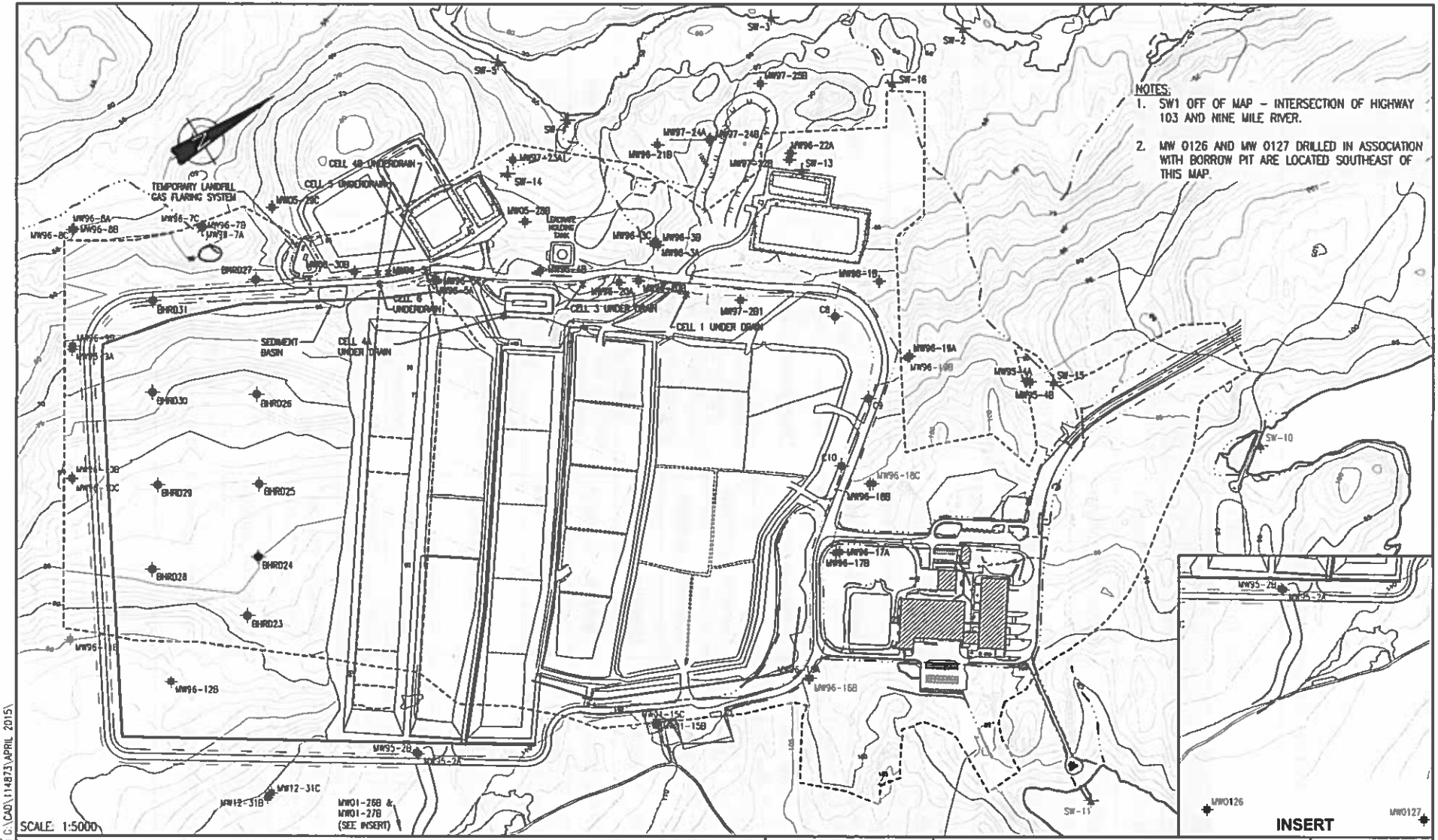
DATE APRIL 2015

TITLE **SITE LOCATION AND SURFACE WATER SAMPLING**

PROJECT **RESIDUALS DISPOSAL FACILITY OPERATIONAL SURFACE & GROUNDWATER MONITORING 2014 ANNUAL REPORT**

PROJECT No. 11-4873

FIGURE No. 3-1



LEGEND:

- BOREHOLES/PIEZOMETERS (GENERALLY ONLY USED FOR WATER LEVELS)
- MONITOR WELL (DECOMMISSIONED)
- SURFACE WATER SAMPLING LOCATION
- MONITOR WELL
- SAMPLE COLLECTION QUARTERLY
- SAMPLE COLLECTION ANNUALLY
- WATER LEVEL ONLY

DILLON CONSULTING

DATE: APRIL 2015

TITLE: MONITORING LOCATIONS AND SITE DETAILS

PROJECT: RESIDUALS DISPOSAL FACILITY
OPERATIONAL SURFACE & GROUNDWATER MONITORING
2014 ANNUAL REPORT

PROJECT No.: 11-4873

FIGURE No.: 3-2

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Table 3-1 2014 Groundwater Sampling Program

Monitor Well ID	Sampling Status	General Location	2014 Monitoring Events
MW96-1B (bedrock)	Operational (quarterly)	North corner and down gradient of Cells 1&2	Apr., June, Sept., Dec.
MW97-2B1 (bedrock)	Operational (quarterly)	Down gradient of Cells 1&2 (replacement of MW96-2B)	Apr., June, Sept., Dec.
MW96-3A (till) MW96-3B (bedrock) MW96-3C (bedrock)	Operational (quarterly)	Down gradient of Cells 1&2 and Cell 3	Apr., June, Sept., Dec.
MW96-4B (bedrock)	Operational (quarterly)	Down gradient of Cell 4; adjacent to leachate holding tank	Apr., June, Sept., Dec.
MW96-5A (till) MW96-5B (bedrock) MW96-5C (bedrock)	Operational (quarterly)	Down gradient of Cells 5 and 6 and up gradient of the South Sedimentation Ponds	Apr., June*, Sept.*, Dec. **MW96-5A dry in June & Sept.*
MW96-7A (till) MW96-7B (bedrock) MW96-7C (bedrock)	Operational (annually)	Down gradient of future cells and south of borrow area	September
MW96-8A (till) MW96-8B (bedrock) MW96-8C (bedrock)	Operational (annually)	Down gradient of future cells	September
MW96-9A (silty sand till) MW96- 9B (bedrock)	Operational (annually)	Southwest of landfill and cross gradient of future cells	September
MW96-10B (bedrock) MW96-10C (bedrock)	Operational (annually)	South/southwest of landfill and cross gradient of future cells	September
MW96-11B (bedrock)	Operational (annually)	South corner of landfill and up gradient of future cells	September
MW96-12B (bedrock)	Operational (annually)	Southeast corner of landfill and up gradient of future cells	September
MW01-15B (bedrock) Note 1 MW01-15C (bedrock)	Operational (annually)	East of Cell 2 and up gradient of landfill	Sept., Dec.
MW96-16A (till) MW96-16B (bedrock)	Operational (annually)	Northeast corner of landfill and topographically up gradient of the FEP compound	Apr., June, Sept., Dec.
MW96-17A (bedrock) MW96-17B (bedrock)	Operational (quarterly)	Between Cell 2 and the FEP compound; down gradient	Apr., June, Sept., Dec.
MW96-18B (bedrock) MW96-18C (bedrock)	Operational (quarterly) Operational (annually)	Cross gradient between Cells 1&2 and the FEP compound	Apr., June, Sept., Dec.
MW96-19A (till) MW96-19B (bedrock)	Operational (quarterly) Operational (annually)	North corner of landfill (Cells 1&2) and down gradient of the FEP compound	Apr., June, Sept., Dec.
MW96-20A (till) MW96-20B (bedrock)	Operational (quarterly)	Down gradient of Cells 1&2 and Cell 3	Apr., June, Sept.*, Dec. **MW96-20A dry in Sept.*
MW96-21B (bedrock)	Operational (quarterly)	Down gradient between North Sedimentation Ponds and Nine Mile River	Apr., June, Sept., Dec.

Monitor Well ID	Sampling Status	General Location	2014 Monitoring Events
MW96-22A (till) MW97-22B (bedrock)	Operational (quarterly)	Down gradient between North Sedimentation Ponds and Nine Mile River	Apr., June, Sept., Dec.
MW97-23A1(till)	Operational (quarterly)	Down gradient just north of South Sedimentation Ponds; between South Sedimentation Ponds and borrow area (replacement of MW 23A)	Apr., June, Sept., Dec.
MW97-24A (till) MW97-24B (bedrock)	Operational (quarterly)	Down gradient of landfill; west of North Sedimentation Ponds	Apr., June, Sept.,* Dec. **MW97-24A dry in Sept.*
MW97-25B (bedrock)	Operational (quarterly)	Below North Sedimentation Ponds	Apr., June, Sept., Dec.
MW01-MW26B (bedrock) Note 2	Operational (annually)	Along Greenhead Road and up gradient of borrow pit	September
MW01-MW27B (bedrock) Note 2	Operational (annually)	Along Greenhead Road and up gradient of borrow pit	September
MW05-MW28B (bedrock) Note 5	Operational (quarterly)	Down gradient of landfill and adjacent to leachate holding tank	Apr., June, Sept., Dec.
MW05-MW29C (bedrock) Note 5	Operational (quarterly)	Down gradient of future cells and south of borrow pit (inactive)	Apr., June, Sept., Dec.
MW08-30B(till/bedrock) Note 7	Operational (quarterly)	Down gradient of Cell 6 and up gradient of South Sedimentation Ponds	Apr., June, Sept., Dec.
MW12-31B (bedrock) Note 8 MW12-31C (bedrock)	Operational (annually)	Up gradient of Cell 6 and future cells	September
MW95-2A (bedrock) MW95-2B (till)	Operational (annually)	Up gradient of Cells 5 and 6	September
MW95-4A (bedrock) MW95-4B (till)	Operational (quarterly)	North of landfill and down gradient of FEP compound; cross gradient to Cells 1&2	Apr., June, Sept., Dec.
C8, C9 and C10 (piezometers)	Operational (annually)	Surrounding Cells 1&2	Apr., Sept., Dec. (water level only) Note 9
BHRD-23 through BHRD-31 (piezometers)	Operational (annually)	Within the landfill footprint	Sept. Note 9 (water level data only)
Cell 3 Underdrain	Operational (quarterly)	Base of Cell 3	Apr., Sept., Dec. Note 10 *Not sampled in June*
Cell 4B Underdrain	Operational (quarterly)	Base of Cell 4	Dec. *No flow in April, June, Sept.*
Cell 5 Underdrain	Operational (quarterly)	Base of Cell 5	Apr., June, Sept., Dec.
Cell 6 Underdrain	Operational (quarterly)	Base of Cell 6	Apr., June, Sept., Dec.

Notes:

1. MW01-15A, B and C were installed as replacements to MW96-15A, B and C which were destroyed during the winter of 2000/2001. Results from MW01-15A/15B/C are assumed to reflect former testing conditions at MW96-15A/15B/15C. MW01-15A was found destroyed in November 2011.
2. MW01-26B and 27B were installed in 2001 to monitor conditions around the borrow pit.
3. C6, C7 and RD-16 to 22 were decommissioned in May 2001 as part of the Cell 3 construction.
4. The underdrains for Cell 1&2 and Cell 4A are consistently dry and therefore not sampled.

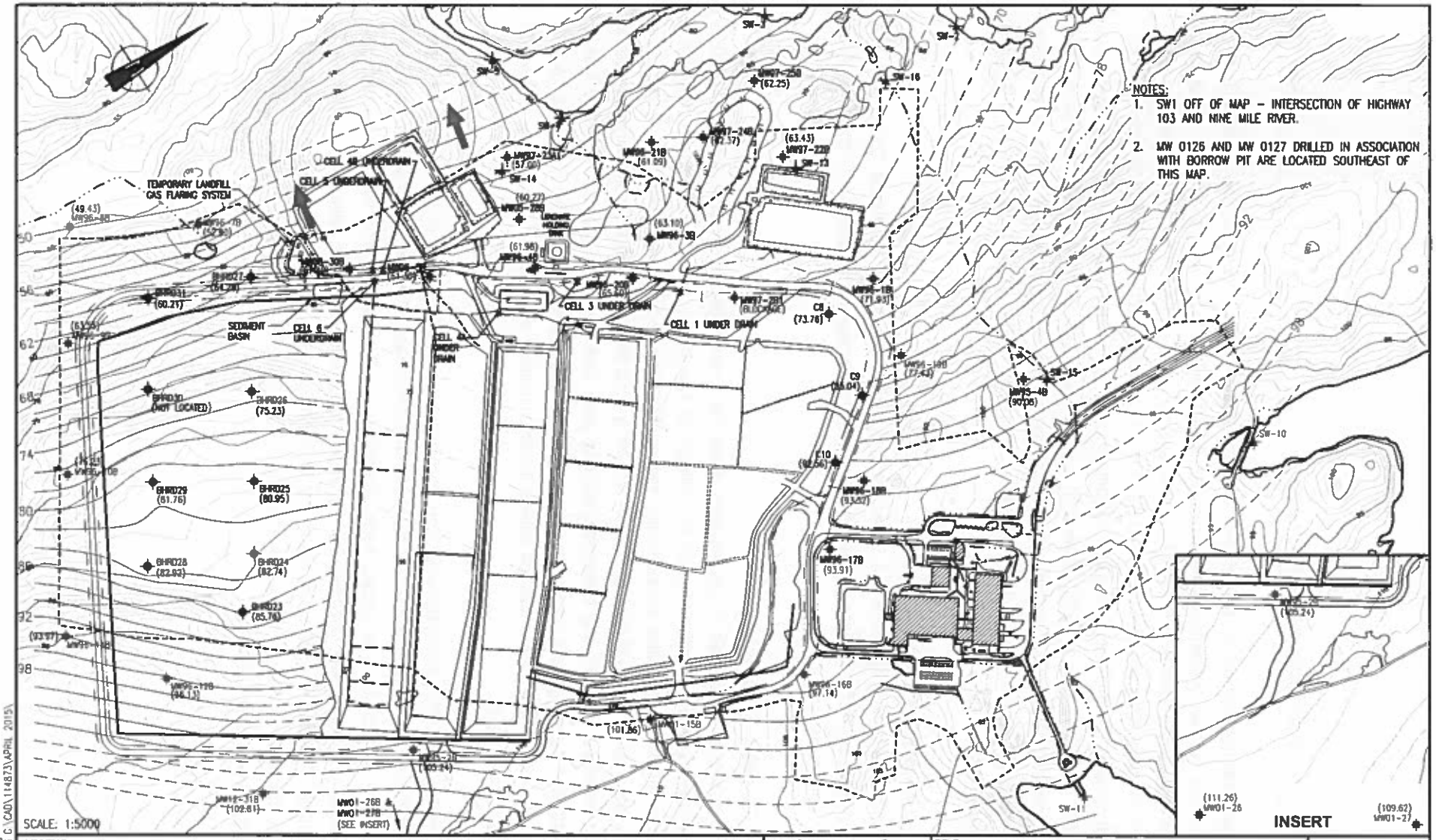
Monitor Well ID	Sampling Status	General Location	2014 Monitoring Events
5.	Additional wells MW05-28B and 29C were installed in June 2005.		
6.	Site 14 monitor wells decommissioned in 2005 in association with construction of Cell 4.		
7.	MW08-30B was installed in June 2008 to replace monitor wells MW95-1A and 1B that were decommissioned for the extension of the South Sedimentation Ponds.		
8.	MW12-31B and 31C were installed in April 2012 (up gradient of Cell 6) to replace monitor wells MW96-13B/13C that were decommissioned in relation to Cell 6 construction. Initial samples were collected in June 2012. Since September 2012, these wells have been tested annually.		
9.	Water levels were inadvertently not recorded from C8, C9 and C10 in June 2014; and, in September 2014, BHRD-30 was not located for water level measurement.		
10.	In June 2014, a sample was inadvertently not collected from the Cell 3 underdrain.		

3.1.1 Hydraulic Head Elevations

Groundwater elevation data collected since 1996 are presented in Appendix B-1. The 2014 program included water level measurements from the 51 monitor wells and 11 of the 12 piezometers during the annual (September) event (one piezometer, BHRD-30, was not located) and from a select number of wells during the other three quarterly sampling events (April, June and December). The September 2014 elevations and flow direction for the shallow bedrock aquifer are shown on Figure 3-3.

Fluctuations in groundwater elevations of one to two meters over a one year period are not uncommon throughout Nova Scotia due to seasonal influences. In 2014, excluding MW97-25B (which fluctuated by 2.3 meters), groundwater elevations fluctuated by less than two metres. Historically, in shallow wells, variation of up to 4 metres has been observed and, in intermediate to deep bedrock wells, variation of up to 6 or 7 metres has been observed. The majority of 2014 hydraulic head levels were comparable to previous results. Exceptions include marginally higher elevations recorded in three shallow bedrock wells (MW97-20B, MW96-25B and MW08-30B) in April 2014, which were attributed to significant rainfall preceding the event; and lower elevations recorded in seven wells in September 2014 (shallow till well MW95-4B; shallow bedrock wells MW96-5B, MW96-19B, MW97-24B, MW97-25B, MW05-28B and deep bedrock well MW96-10C), which were attributed to relatively dry conditions observed at the time of the field event. Differences between the prior low elevations and the September 2014 levels ranged between 0.003 metres in MW96-10C to 0.64 metres in MW96-5B.

As previously reported, lower hydraulic head levels observed since 2008 in the up gradient area of Cell 5 were attributed to installation of an underdrain as part of cell construction. In the Cell 5 area, 2014 groundwater elevations were comparable overall to levels observed since 2008, with the above-noted exception of MW96-5B in September 2014. For MW96-5B, to date (including September 2014), water levels have exhibited a difference of 3.0 metres in minimum and maximum hydraulic head elevations.



LEGEND:

- BOREHOLES/PIEZOMETERS (GENERALLY ONLY USED FOR WATER LEVELS)
- MONITOR WELL (DECOMMISSIONED)
- SURFACE WATER SAMPLING LOCATION
- MONITOR WELL
- GROUNDWATER CONTOURS
- GROUNDWATER CONTOURS INFERRED
- SAMPLE COLLECTION QUARTERLY
- SAMPLE COLLECTION ANNUALLY
- WATER LEVEL ONLY

DILLON CONSULTING

DATE: APRIL 2015

TITLE: **GROUNDWATER FLOW DIRECTION SHALLOW BEDROCK (SEPT. 2014)**

PROJECT: **RESIDUALS DISPOSAL FACILITY OPERATIONAL SURFACE & GROUNDWATER MONITORING 2014 QUARTERLY REPORT**

PROJECT No.: **11-4873**

FIGURE No.: **3-3**

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Consistent with historical observations, groundwater flow is westward, reflective of both topography and the bedrock surface. Horizontal hydraulic gradients at the site generally range from 0.01 to 0.1 in the south corner of the landfill (southwest of the existing cells) and from 0.01 to 0.04 generally down gradient of the existing cells, based on September 2014 data in shallow bedrock wells and piezometers (i.e., BHRD-23 through BHRD-31). It is noted that, for the south corner of the landfill, the calculated horizontal hydraulic gradients would be similar if piezometer data were excluded (i.e., about 0.03 to 0.09). Downward hydraulic gradients, indicative of groundwater recharge conditions, occur in the southern and eastern higher topographic areas of the site, as well as in a localized area at the base of the landfill footprint. Upward hydraulic gradients, indicative of discharge conditions, occur in the lower lying west and northwest regions.

3.1.2 Groundwater Analytical Results

Groundwater data are found in Appendix B-2. Exceedances to the DWQ Guidelines are shaded. Comments on the data in comparison to these guidelines, as well as commentary regarding the general overall character of the groundwater, are provided below.

3.1.2.1 Guideline Comparison

Iron and manganese have occurred in concentrations above the recommended guidelines of 0.3 mg/L and 0.05 mg/L, respectively, in samples collected since the initiation of sampling in 1996. Elevated levels of iron and manganese occurred in wells located across the site and installed within both the shallow till unit and the deeper bedrock. Elevated concentrations of these parameters commonly occur throughout Nova Scotia groundwater. Limits are in effect for aesthetic reasons only in that presence may cause staining of clothing and/or household fixtures. Specific comments regarding these parameters (in particular, occurrences at the site above 1 mg/L), as well as colour, turbidity and pH, which were reported outside the recommended guidelines in one or more of the 2014 samples, are provided below.

Samples from ten wells (noted below) contained iron concentrations of 1 mg/L or higher in 2014. Figure 3-4 depicts iron concentrations in these wells over time (it is noted that an additional well, MW96-5A, was maintained in the plots as this well had recently exhibited an increase in iron, as noted below). Consistent with previous results, iron in down gradient well samples, particularly in MW96-22A (below the North Sedimentation Ponds) remained high relative to up gradient samples. MW96-22A samples also continue to exhibit the greatest variation (with no apparent trending) in concentration from one sample to another. It is noted that concentrations in the bedrock well at this location have been significantly lower or non-detect.

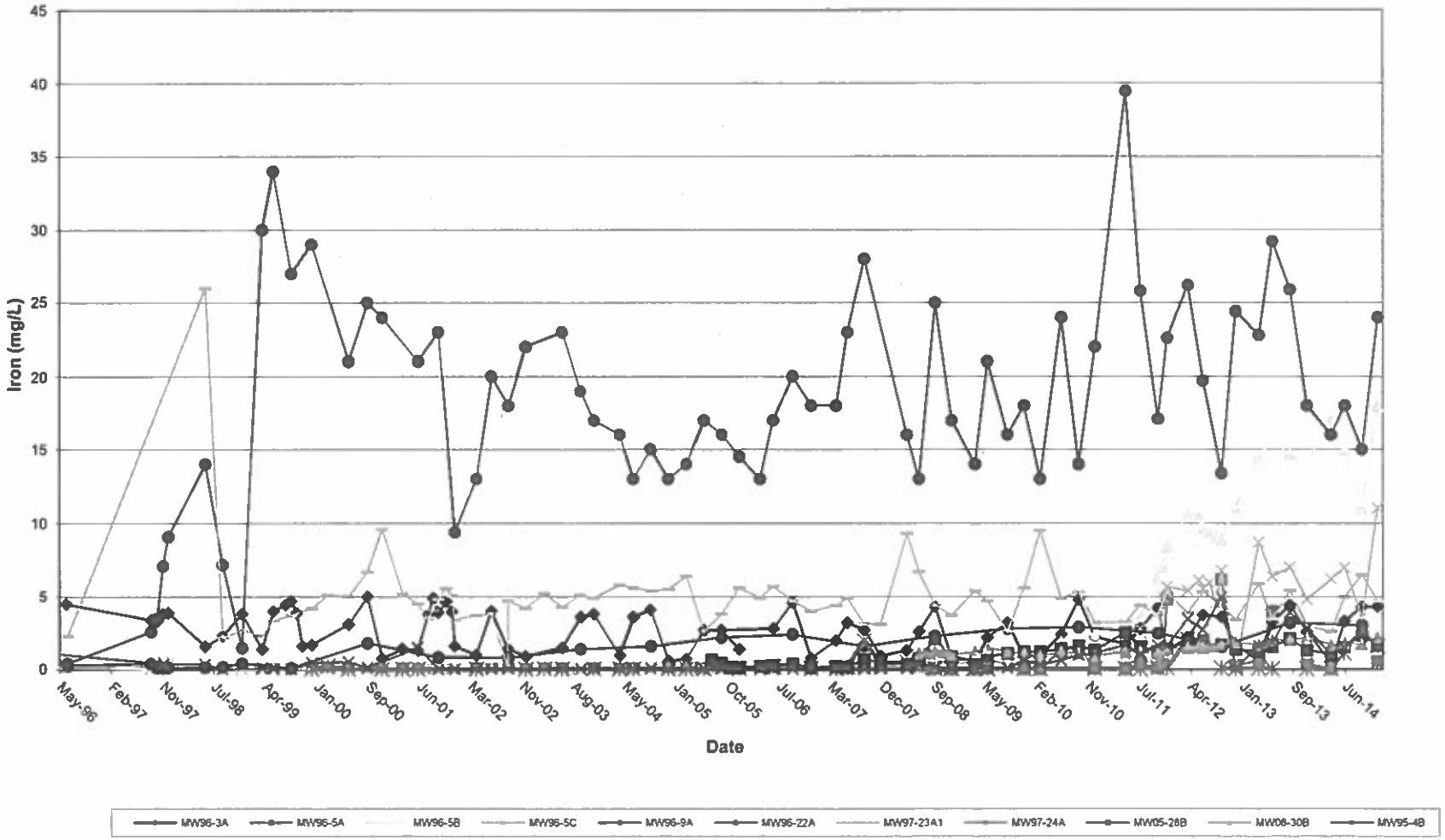
Well	2014 Exceedances above 1 mg/L	Prev. Range (mg/L)	General Location
MW96-3A	Jun. (3.3), Sept. (4.3), Dec (4.3)	0.52.-5.0	down gradient Cell 1
MW96-5B	Apr. (17), Jun (15), Sept. (11), Dec (18)	<0.02-16	down gradient Cell 5
MW96-5C	Apr. (6.2), Jun (7.0), Sept. (3.6), Dec (11)	<0.02-8.7	down gradient Cell 5
MW96-9A	Sept. (3.0)*	0.10-3.2	southwest of landfill
MW96-22A	Apr. (16), Jun. (18), Sept. (15), Dec (24)	0.42-40	down gradient of NS pond
MW97-23A1	Apr. (2.6), Jun. (5.0), Sept. (6.5), Dec (4.7)	<0.02-26	down gradient of SS pond
MW97-24A	Jun. (1.1), Dec. (1.6)	<0.02-2.1	west of NS pond
MW05-28B	Apr. (1.1), Jun. (1.5), Sept. (2.3), Dec (1.6)	0.13-2.5	near leachate holding tank
MW08-30B	Apr. (1.7), Jun. (1.8), Sept. (1.7), Dec (2.2)	0.92-2.2	down gradient of Cell 5
MW95-4B	Apr. (1.0), Jun. (1.5), Sept. (2.7), Dec (1.5)	<0.02-5.0	down gradient of FEP

**indicates that only one sample (as intended) was collected in 2014 (September)*

As indicated on Figure 3-4, MW96-22A has consistently exhibited iron levels >10 mg/L since 1999, with the exception of one sample. Concentrations in MW97-23A1 samples have frequently contained concentrations between 5 and 10 mg/L. MW96-5B and 5C have contained iron between 5 and 15 mg/L since late 2011. Samples in the remaining wells have varied but have generally been below 5 mg/L, including MW96-5A. Iron levels have exhibited a general increase at the MW96-5A/5B/5C location since 2008 (coincident with the construction of Cell 5), and earthwork activities adjacent to the monitor well nest, undertaken in late 2011 (in relation to Cell 6 construction), further contributed to higher levels of iron (as well as arsenic, manganese and colour). Iron exceedances were rarely observed in earlier samples. Of note, the April and December 2014 iron concentrations in MW96-5B (17 and 18 mg/L, respectively) and the December 2014 concentration in MW96-5C (11 mg/L) were above the prior ranges (noted above). For MW05-28B and MW08-30B, iron has been increasing generally/overall; however, the 2014 concentrations were within the prior ranges (i.e., 0.13 to 2.5 mg/L in May 2011 and 0.92 to 2.2 mg/L in December 2013, respectively), noting that the December 2014 concentration in MW08-30B was equivalent to the prior high.

Iron in MW96-9A has exhibited a general increase since 2000. The September 2014 level was below the high recorded in the preceding (i.e., September 2013) event (i.e., 3.2 mg/L); however, the concentration remains marginally above the range recorded prior to September 2013 (i.e., 0.10 to 2.9 mg/L). It is also noted that, for MW95-4B, iron was frequently above the guideline in earlier samples (i.e., up to 1.5 mg/L prior to September 2001) and then exceedances were not recorded until June 2008 (0.33 mg/L). Since December 2009, iron concentrations in MW95-4B have been above the guideline in most samples and exhibited a general increase ranging from 0.32 to a high of 5.0 mg/L in September 2012. The 2014 concentrations (1.0 to 2.7 mg/L) were above the recommended guideline but below the high recorded in September 2012. Iron concentrations in the remaining monitor well samples were comparable to previous results. Of note, although not indicated above, the September 2014 concentrations of iron in

Figure 3-4
Iron Concentrations Select Monitoring Wells
Otter Lake RDF

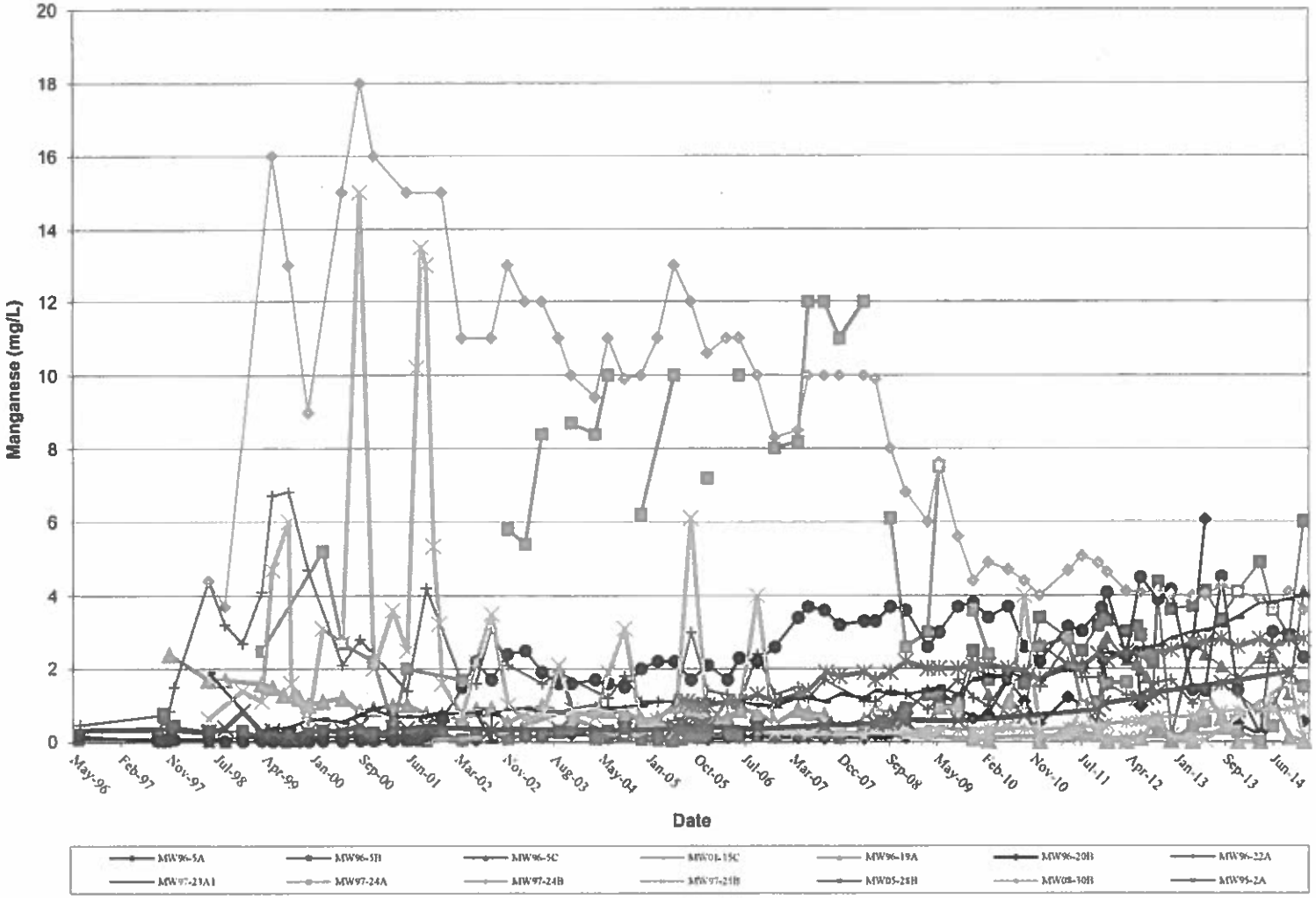


MW01-15B/15C (0.37 and 0.56 mg/L, respectively) were below the recent highs recorded in these wells (i.e., 1.3 mg/L in September 2013 and 1.5 mg/L in December 2013, respectively). Although typically sampled annually, these wells were resampled in December 2013 following generally higher concentrations observed in September 2013.

One or more samples from 12 wells (noted below) contained manganese at a concentration of 1 mg/L or higher in 2014. Consistent with previous information, the highest concentrations of manganese typically occurred in down gradient monitor wells (west of the North Sedimentation Ponds). Figure 3-5 depicts changes in concentrations in the 12 wells over time (it is noted that an additional well, MW96-5A, was maintained in the plots as this well had recently exhibited higher manganese concentrations, as noted below). Monitor wells MW97-24A/24B (west of North Sedimentation Ponds) and MW97-25B (northwest of North Sedimentation Ponds) initially exhibited an overall general increase; however, levels have decreased in recent years with 2014 levels comparable to or lower than initial data. Although manganese in monitor well MW96-20B had been relatively consistent up to 2002 (and similar to baseline levels), concentrations since that time have been notably higher. During 2014, concentrations were within the range recorded since 2002. Similar to iron, manganese has exhibited a general increase in wells MW96-5A/5B/5C since the construction of Cell 5 in 2008, and some of the 2014 concentrations were higher in MW96-5B (April and December) and MW96-5C (December). The prior highs for these wells were 4.4 mg/L and 4.0 mg/L (both recorded in September 2012), respectively, with the difference for MW96-5C marginal. Of note, 2014 concentrations in MW96-5A, although above the DWQ guideline, were below 1 mg/L in the samples collected (i.e., April and December). Historically, manganese in MW96-5A has been as high as 6.1 mg/L in June 2013. For MW01-15C, the September 2014 concentration was notably higher than previously recorded (the prior range was 0.032 to 0.78 mg/L), and trending is not apparent. Concentrations in MW97-23A1 (north of South Sedimentation Ponds), MW05-28B (down gradient of the landfill, near the leachate holding tank), MW08-30B (down gradient of Cell 5) and MW95-2A (up gradient of Cell 5) have been gradually increasing over time with the 2014 concentrations in MW97-23A1, MW03-30B and MW95-2A above the prior ranges. Although not shown below (i.e., <1.0 mg/L), the April and September 2014 concentrations in MW08-30B (0.86 and 0.87 mg/L, respectively) were also above the previous range, albeit marginally. As well, the majority of 2014 concentrations in MW05-28B were equivalent to the high (i.e., 2.8 mg/L in September 2013).

Well	2014 Exceedances above 1 mg/L	Previous Range	General Location
MW96-5B	Apr. (4.9), Jun. (3.6), Sept. (2.9), Dec. (6.0)	0.039-4.4	down gradient Cell 5
MW96-5C	Apr. (2.3), Jun. (2.3), Sept. (1.3), Dec. (4.1)	0.018-4.0	down gradient of Cell 5
MW01-15C	Sept. (1.5, 1.6-d)*	0.033-0.78	up gradient of Cell 2
MW96-19A	June (1.1)	0.0075-2.4	down gradient of FEP
MW96-20B	Jun. (3.0), Sept. (2.9), Dec (2.3)	0.015-4.5	down gradient of Cells
MW96-22A	Apr. (0.80), Jun. (0.92), Sept. (1.9), Dec (1.4)	0.46-6.8	down gradient of NS pond
MW97-23A1	Apr. (3.8), Jun. (3.8), Sept. (3.9), Dec (4.0)	0.026-3.4	down gradient of SS pond
MW97-24A	Dec. (1.5)	0.012-12	west of NS pond

Figure 3-5
Manganese Concentrations Select Monitoring Wells
Otter Lake RDF



MW97-24B	Apr. (3.9), Jun. (3.6), Sept. (4.1), Dec (3.6)	3.7-18	west of NS pond
MW97-25B	Sept. (1.6)	0.002-15	northwest of NS pond
MW05-28B	Apr. (2.8), Jun. (2.6), Sept. (2.8), Dec (2.8)	1.0-2.8	near leachate holding tank
MW08-30B	Dec. (1.0)	0.32-0.85	down gradient of Cell 5
MW95-2A	Sept. (1.9)*	0.10-1.6	up gradient of Cell 5

**indicates that only one sample (as intended) was collected in 2014 (September)*
"-d" denotes field duplicate sample result

Of note, manganese levels in MW05-29C (down gradient of future cells), although less than 1 mg/L, have been gradually trending upward. The highest concentration recorded to date was 0.51 mg/L in December 2014.

Colour and turbidity have also been elevated above the recommended guidelines of 15 TCU and 1 NTU, respectively, in samples collected from wells located across the site and installed within both the shallow till unit and the deeper bedrock since initiation of sampling. Although elevated concentrations of these parameters are not as common in Nova Scotia groundwater, their presence is a typical occurrence in monitor wells due to disturbance around the well screen during sporadic well development. A colour limit is in effect for aesthetic reasons only. Although a limit for turbidity is in effect for both aesthetic and health reasons, the latter is generally only applicable to chlorinated potable water supplies.

Overall, the 2014 levels of colour and turbidity were comparable to previous data. Exceptions included colour in MW96-5A/5B/5C, turbidity in MW96-5B/5C, and colour and turbidity in MW97-24A. Details are provided below along with relevant observations for other locations.

A general increase in colour has been observed in down gradient wells MW96-5A/5B/5C since the construction of Cell 5 in 2008, with the highest levels at this location recorded in shallow bedrock well MW96-5B. Overall, the 2014 levels of colour in these wells were comparable to levels recorded since 2008. An exception was colour in the December 2014 sample from MW96-5B (480 TCU), which was above the prior range (<5 to 390 in December 2013). For MW96-5B/5C, turbidity was recorded in earlier samples often at higher concentrations (i.e., up to 620 NTU in November 1997 and 490 NTU in November 1997, respectively) with only occasional exceedances exhibited since 1999. It is noted that the June 2014 level in MW96-5B (660 NTU) was higher than previously recorded; however, subsequent levels were below the guideline and comparable to results recorded before that time. The December 2014 level in MW96-5C (i.e., 16 NTU) was above a recent high (i.e., 10 NTU in April 2013) but within the prior range.

Colour in MW01-15C has consistently been above the guideline at concentrations ranging from 24 to 40 TCU since November 2011. Prior to this time, colour had been above the guideline on one occasion only (16 TCU in September 2005). The September 2014 concentration (30 TCU) was below the high recorded in a September 2012 laboratory

duplicate sample (40 TCU) but remained above results recorded prior to November 2011. Of note, colour and turbidity remained below the guidelines in the shallow bedrock well at this location (MW01-15B), following elevated levels recorded in September 2013 (59 TCU and 7.6 NTU, respectively) and similar to results for an additional sample collected in December 2013 (these wells are typically sampled annually).

For MW97-24A, colour was above the guideline in December 2014 (23 TCU) for the first time. Prior to December 2014, colour had been either non-detect or detected at generally low concentrations (i.e., less than 10 TCU). Turbidity was notably higher in June 2014 (i.e., 360 NTU); however, this higher level was attributed to a sample that had not been field filtered (this was due to poor well recovery) and not reflective of a change in chemical character.

Similar to iron and manganese, some wells down gradient of the landfill cells (MW96-3A, MW96-22A, MW97-23A1, MW05-28B and MW95-4B) exhibited higher concentrations of colour and/or turbidity in more recent years. It is noted that colour has generally been higher in samples from surficial well MW96-22A relative to other locations (typically above 100 TCU and as high as >1,000 TCU in November 1997). Of note, the September 2014 colour level for MW96-22A (26 TCU) was the lowest recorded since September 2001. Colour in remaining 2014 samples from this well (ranging from 360 to 540 TCU) was significantly higher but comparable to the majority of prior results. For MW05-28B, colour and turbidity have frequently been above the guideline in samples collected since December 2008 (up to 33 TCU recorded in both September 2010 and June 2014, and 4.3 NTU in April 2012, respectively).

pH has been below the recommended range of 6.5-8.5 units in samples collected across the site (primarily shallow till and shallow bedrock wells) since initiation of baseline sampling. Low pH or acidic waters are not uncommon especially in water table wells due to shallow water recharge. A limit for pH is in effect for aesthetic reasons only in that acidic waters may be corrosive and alkaline or high pH waters may cause encrustation to pipes and other household fixtures. In 2014, pH was below the recommended range in one or more samples from 25 wells.

Other parameter exceedances which have occurred less frequently and/or are not as commonly observed in Nova Scotia groundwater since initiation of sampling are: total dissolved solids (TDS), nitrate/nitrite, arsenic, barium, cadmium, chromium, lead, mercury, uranium and fluoride. Information pertaining to all of these parameters is summarized in the following paragraphs. As noted below, only arsenic and uranium guidelines were exceeded in the 2014 samples (consistent with previous results).

Total Dissolved Solids (TDS) - the term TDS pertains to the concentration of inorganic substances, such as, anions, cations and metals that are dissolved in water. At low concentrations, the presence of TDS contributes to the taste of potable waters. However, a recommended limit of 500 mg/L is in effect for aesthetic reasons only in that excessive levels could cause hardness, taste, corrosion and mineral deposition problems, depending on the levels of the individual components.

With the exception of a single exceedance in MW96-19B in 1996, TDS concentrations in all groundwater samples collected since the initiation of sampling have been below the recommended limit and most typically below 200 mg/L. It is assumed that the one occurrence was reflective of inadequate well development and not representative of true groundwater quality.

Nitrate/Nitrite - nitrate and nitrite occur naturally in groundwater at concentrations typically less than 5 mg/L. Potential sources of nitrate other than natural decay of plants and animals include fertilizers, ammonia (via release), manure and domestic sewage. The recommended limits of 10 mg/L for nitrate (as nitrogen) and 1.0 mg/L for nitrite (as nitrogen) are based on health considerations. There have been no exceedances observed during any sampling events since 1997.

Two prior exceedances observed in MW96-2B may have occurred due to blasting activities associated with the construction of the Cell 1 during 1997. The well was destroyed and subsequently replaced later that year. The concentrations in all samples collected from the replacement well (MW97-2B1) have been below the recommended limit. The other single exceedance occurred in MW96-17B during 1997 and was only slightly above the guideline, and may have reflected overland site drainage in the low-lying area down gradient of the site access road.

Arsenic - although elevated levels of arsenic may occur due to release of contaminants associated with both industrial processes and waste disposal, it is also a common natural occurring metal in groundwater through the dissolution of minerals. Elevated levels have been well documented in aquifers primarily associated with quartzite, slate and granite bedrock formations throughout Nova Scotia. Bedrock at the site is primarily granite. The recommended guideline of 0.010 mg/L (lowered from 0.025 mg/L in May 2006) is in effect for health reasons and assumes that the water will be consumed.

Table 3-2 summarizes arsenic exceedances recorded to date. Samples from five wells exhibited an exceedance in 2014. Prior to June 2010, arsenic had been detected in MW96-5C on four occasions (November 1997, June and September 1998, and September 2001) at low concentrations (i.e., 0.002 to 0.003 mg/L). Since June 2010 (when the detection limit was lowered to 0.001 mg/L), arsenic has consistently been detected and has shown an overall general increase in concentration (i.e., from 0.002 to a high of 0.017 mg/L in December 2014), noting that the April 2014 concentration was at the guideline. Similarly, arsenic detections have been more frequent in the other wells at this location since 2010, with concentrations in MW96-5B also increasing over time (up to 0.012 mg/L in both September 2013 and December 2014). Until September 2013, concentrations in MW96-5B had not exceeded the guideline. Similar to MW96-5C, the April 2014 concentration was at the guideline. The remaining data shown within the table were comparable to previous results. The presence of elevated levels is considered reflective of natural groundwater character.

Table 3-2 Summary of Arsenic Exceedances in Groundwater

Well ID	Status	Location	Previous Data		2014 Data	
			Occurrence Prior to 2014	Highest [mg/L]	No. Samples	[mg/L]
MW96-3C	Bedrock	Down gradient western area	since lowering of guideline in 2006, all subsequent samples have exceeded	0.022 (Nov. 2003)	4	0.014-0.016
MW96-5B	Bedrock	Down gradient of Cells 5 and 6	1 sample in 2013	0.012 (Sept. 2013)	3	0.011-0.012
MW96-5C	Bedrock		3 samples in 2013	0.015 (Dec. 2013)	3	0.013-0.017
MW96-7A*	Till	Down gradient cells & adjacent to borrow area	1 sample in 2010	0.014 (Sept. 2010)	None	-
MW96-10B*	Bedrock	South side of site	1 sample in 2000 and in 2012	0.026 (Sept. 2000)	None	-
MW96-10C*	Bedrock		all samples	0.059 (Sept. 2007)	1	0.055
MW96-11B*	Bedrock	South corner of landfill	1 sample in 1999	0.053 (Aug. 1999)	None	-
MW96-19B*	Bedrock	North corner of Cell 1	1 sample in 2000, 2006, 2007 and 2008	0.12 (Dec. 2000)	None	-
MW96-22A	Till	Down gradient western area below South Sedimentation Ponds	1 sample in 2006, 2007 and 2013, and 3 samples in 2008 through 2012	0.024 (May 1999)	1	0.016
MW97-23A1	Till	Down gradient of South Sedimentation Ponds	1 sample in 1998, 2 samples in 2006, 3 samples in 2008, 1 sample in 2009, 2 samples in 2010, 1 sample in 2013	2.1 (June 1998) - Baseline	None	-

Note:
* indicates that only one sample (as intended) was collected in 2014 (September)

Barium - Concentrations of barium are generally low in natural groundwater. The recommended limit of 1 mg/L is in effect for health reasons. Previous data indicated barium above the guideline in samples from three wells on a single occasion each (MW96-16A, MW96-22A and MW97-22B) and in samples from one well (MW97-23A1) on three occasions. The levels ranged from only slightly above the guideline to 1.4 mg/L. Sporadic occurrences of most metals, including barium above the recommended guideline, for the most part, is not considered to reflect an issue of concern.

Cadmium - Concentrations of cadmium are generally low in natural groundwater supplies. The recommended limit of 0.005 mg/L is in effect for health reasons. The December 2005 exceedance from MW96-1B (down gradient of Cell 1) was not repeated. Other historical exceedances included: MW96-3C, MW96-14B, MW96-16A, MW96-16B, MW96-

19B, and MW95-4B on single occasions only. The concentrations ranging from just slightly above the guideline to 0.009 mg/L were not considered to reflect issues of concern.

Chromium - Concentrations of chromium are generally low in natural groundwater supplies. The recommended limit of 0.05 mg/L is in effect for health reasons. With respect to previous data (i.e., pre-2014), exceedances were recorded in samples collected from MW96-5C, MW96-7A, MW96-8B, and MW96-10C on single occasions only. Concentrations ranged from 0.08 to 0.83 mg/L.

Lead - Lead is the most common of the heavy elements and occurs naturally throughout the environment. Unnatural sources include gasoline products, paints, batteries and lead compounds associated with pipe and plumbing fittings. The recommended guideline of 0.01 mg/L is in effect for health reasons.

With respect to previous data, exceedances of CDWQ guidelines for lead have been noted in six wells (MW96-3C, MW96-5A, MW96-6A, MW96-12B and MW01-27B) on one occasion each, in one well (MW96-19B) on two occasions and in another well (MW97-23A1) on four occasions. For the most part, these concentrations were only slightly above guidelines; the only exception was the observance of 0.24 mg/L in MW01-27B during December 2001. This well was incorporated into the monitoring program in 2001 and the sample containing the elevated lead was collected after an observance of vandalism. The subsequent April 2002 confirmatory sample, as well as all subsequent samples, indicated concentrations below the guideline.

Mercury – Although the concentration of mercury is generally low in natural groundwater, presence above guidelines occasionally occurs due to the adherence of metals to suspended matter not filtered during the sample collection process. The recommended limit of 0.001 mg/L is in effect for health reasons. There were no mercury exceedances during 2002 and, therefore, this parameter has not been included in the monitoring program since that time.

Historical guideline exceedances were observed on single occasions in five wells (MW96-2B, MW96-22A, MW97-23A1, MW95-4A and MW96-13B). Concentrations ranged from only marginally above the guideline to 0.07 mg/L.

Uranium - Although uranium may occur due to release of contaminants associated with mill tailings processes and phosphate fertilizers, it is also naturally present in groundwater through the dissolution of minerals. Elevated levels have been well documented in aquifers primarily associated with granite bedrock aquifers throughout Nova Scotia.

The recommended health-related guideline for uranium was lowered from 0.1 mg/L to 0.02 mg/L in October 1999. While only two wells (MW96-3C and MW96-19A) exhibited exceedances to the older less stringent guideline (0.1 mg/L), numerous well samples have historically and currently contain uranium above the 0.02 mg/L guideline. As summarized in Table 3-3 (consistent with previous results), the majority of exceedances are in bedrock wells located

in the topographically lower, down gradient area of the site. Concentrations in MW96-3C continue to be elevated; however, concentrations remain similar to baseline. Uranium levels in MW96-5C have exceeded the guideline in recent samples only (i.e., June 2010 and from December 2010 to present), and concentrations in 2014 remained below the high recorded in December 2012 (i.e., 0.16 mg/L). Concentrations up to 0.09 mg/L were recorded in the initial samples from MW96-5C prior to the establishment of the guideline in 1999. For four wells, one of the 2014 concentrations were higher than previously recorded (i.e., MW97-2B1 in June, and MW01-15C, MW96-19B and MW12-31C in September). Following the high recorded in MW97-2B1 in June, subsequent (September and December 2014) sample concentrations were lower and comparable to the range recorded prior to June 2014. For MW01-15C, the concentration was slightly above the guideline for the first time. Prior to 2013, concentrations had ranged from 0.0026 to 0.0081 mg/L in September 2003 (for comparison, uranium concentrations in historical MW96-15C samples ranged from 0.002 to 0.0024 mg/L), while concentrations in the two 2013 samples were higher (i.e., 0.010 and 0.011 mg/L in September and December 2013, respectively) but below the guideline. For MW96-19B, the September 2014 concentration was the highest recorded to date, and concentrations appear to have been increasing since 2009, ranging from 0.033 mg/L to 0.044 mg/L in the preceding (September 2013) event. For comparison, prior to 2009, concentrations had ranged from 0.0071 to 0.028 mg/L. The concentration in MW12-31C (which is sampled annually and has been sampled on only four occasions to date) was slightly above the guideline for the first time. The remaining 2014 concentrations were consistent with previous results. As referenced above, bedrock at the site is primarily granite, and the presence of uranium in groundwater at the site is presumed to be naturally occurring.

Table 3-3 Summary of Uranium Guideline Exceedances in Groundwater

Well ID	Status	Location	Previous Data		2014 Data	
			Occurrence Prior to 2014	Highest [mg/L]	No. Samples	[mg/L]
MW97-2B1	Bedrock	Down gradient western area	majority of samples	0.046 (Dec. 2012)	4	0.024-0.052
MW96-3B	Bedrock	Down gradient western area	majority of samples	0.086 (June 2004)	4	0.041-0.058
MW96-3C	Deep bedrock		all samples (see note 2)	0.20 (May 1996 & Dec. 1998) – Baseline	4	0.16-0.18
MW96-5C	Deep bedrock	Down gradient western area	1 sample in 1997, 3 in 1998, 2 in 2010, 5 in 2011, 7 in 2012 and 4 in 2013	0.16 (Dec. 2012)	4	0.051-0.11
MW96-7B	Bedrock	Down gradient of future cells, western area	all samples	0.068 (Nov. 2011)	1*	0.064
MW96-7C	Deep bedrock		all samples	0.10 (Nov. 2011)	1*	0.093
MW96-8B	Bedrock	Down gradient of future wells, west corner	majority of samples	0.062 (May 1996) – Baseline	1*	0.031
MW96-8C	Deep bedrock		majority of samples	0.071 (Sept. 2000)	1*	0.023
MW96-13C	Deep bedrock	Up gradient of future Cell 6	1 in 1996, 1 in 1998 and 1 in 2011	0.029 (Nov. 2011)	See note 3	-

Well ID	Status	Location	Previous Data		2014 Data	
			Occurrence Prior to 2014	Highest [mg/L]	No. Samples	[mg/L]
MW01-15C	Deep bedrock	Up gradient of Cell 2	None	0.011 (Dec. 2013)	1*	0.025
MW96-19A	Till	North corner of the site	7 samples	0.16 (June 1998) – Baseline	none	-
MW96-19B	Bedrock		15 samples	0.044 (Sept. 2013)	1*	0.053
MW96-20B	Bedrock	Down gradient of cells 1 and 3	1 sample in 1996, 1 in 1998, 2 in 2011, 3 in 2012 and 2 in 2013	0.056 (Dec. 1998) – Baseline	2	0.023-0.024
MW97-22B	Bedrock	Down gradient western area below North Sedimentation Ponds	all samples except one	0.067 (Dec. 1998) – Baseline	4	0.053-0.060
MW97-23A1	Till	Down gradient of South Sedimentation Ponds	2 samples in 1998, 1 in 2000 and 1 in 2002	0.1 (June 1998) – Baseline	none	-
MW05-29C	Bedrock	Down gradient of future cells	all samples except five	0.032 (Dec. 2013)	4	0.026-0.029
MW12-31C	Deep Bedrock	Up gradient of Cell 6 and future cells	none (see note 4)	0.020 (Sept. 2013)	1*	0.024
MW95-2B	Till	Up gradient of Cell 5	6 samples (all prior to Dec. 1999)	0.028 (Sept. & Dec. 1998) – Baseline	none	-

Notes:
1. "Occurrences" include all samples with uranium concentrations >0.02 mg/L even though the guideline only came into effect in October 1999.
2. All samples from this well contained uranium concentrations above the less stringent 0.1 mg/L guideline.
3. MW96-13C was decommissioned in 2012.
4. Replacement well for MW13-96C (only four samples collected to date).
* indicates that only one sample (as intended) was collected in 2014 (September)

Fluoride - Fluoride occurs naturally in some groundwater. The recommended limit of 1.5 mg/L is in effect for health reasons in that excessive concentrations may produce dental fluorosis, a condition characterized by mottling of tooth enamel. Elevated levels have been well documented in some aquifers within Nova Scotia. With the exception of only one sample from MW96-3A in 1999, there have been no fluoride concentrations above the recommended guideline. Testing for this parameter was, therefore, discontinued after 2001.

3.1.2.2 General Groundwater Character

With respect to the inorganic character of the groundwater, it is observed that some minor variation in the concentration of certain parameters, primarily the major anions and cations, occurs from one sampling event to another at all locations. For the most part, this variation is attributed to seasonal effects and is common throughout Nova Scotia especially in shallow aquifer wells. As indicated in the methodology section, select parameters were

evaluated in order to identify changes in concentration that could potentially be an early indication of impact. These parameters include the major anions and cations along with TDS and hardness.

With the exception of the shallow bedrock well MW96-17B (west corner of FEP) and till wells MW96-19B (down gradient of the FEP) and MW96-20A (down gradient of cells near leachate holding tank), chloride concentrations in all samples collected since initiation of site activities have been below 50 mg/L, with the majority of wells below 10 mg/L. The ten wells noted below exhibited concentrations above 10 mg/L in one or more 2014 samples. Chloride concentrations over time, for select wells installed in the till, shallow bedrock and deep bedrock unit, are graphically presented on Figures 3-6, 3-7 and 3-8, respectively.

Sample	Location	2014 Range	Baseline Range
MW97-2B1	Down gradient of Cell 1	8-11	5-16
MW96-5B	Down gradient of Cells 5 and 6	9-12	3.5-13.5
MW01-15B	Up gradient of Cell 2	14*	5.3-7.3
MW96-16A	Up gradient of FEP	32-34	6-17
MW96-16B	Up gradient of FEP	21-25	6-11
MW96-17B	Between Cell 1 & the FEP	8-12	5-9
MW96-20A	Down gradient of cells	11-32	3-15
MW96-20B	Down gradient of cells	5-17	4-6.2
MW97-24B	West of NS Pond	12-14	8-18
MW05-28B	Near leachate holding tank	7-11	9.8**

** Indicates that only one sample (as intended) was collected in 2014 (September)*
*** Represents initial sample collected in July 2005.*

TDS concentrations have shown higher variability than chloride, particularly in till well samples. With the exception of the initial 1996 sample from MW96-19B (north corner of Cell 1), concentrations have been below 400 mg/L, with the majority less than 200 mg/L. Concentrations of TDS over time in select wells installed in the till, shallow bedrock and deeper bedrock units are graphically presented on Figures 3-9, 3-10 and 3-11, respectively.

Table 3-4 presents a summary of indicator parameters (chloride, TDS, iron and manganese) in select wells for which specific comments have been made within this report and has been provided for context. Wells with chloride and/or TDS concentrations above the previously recorded ranges are highlighted in bold. Comments relating to iron and manganese concentrations above 1 mg/L were discussed above.

Figure 3-6
Chloride Concentration in Till Wells
Otter Lake RDF

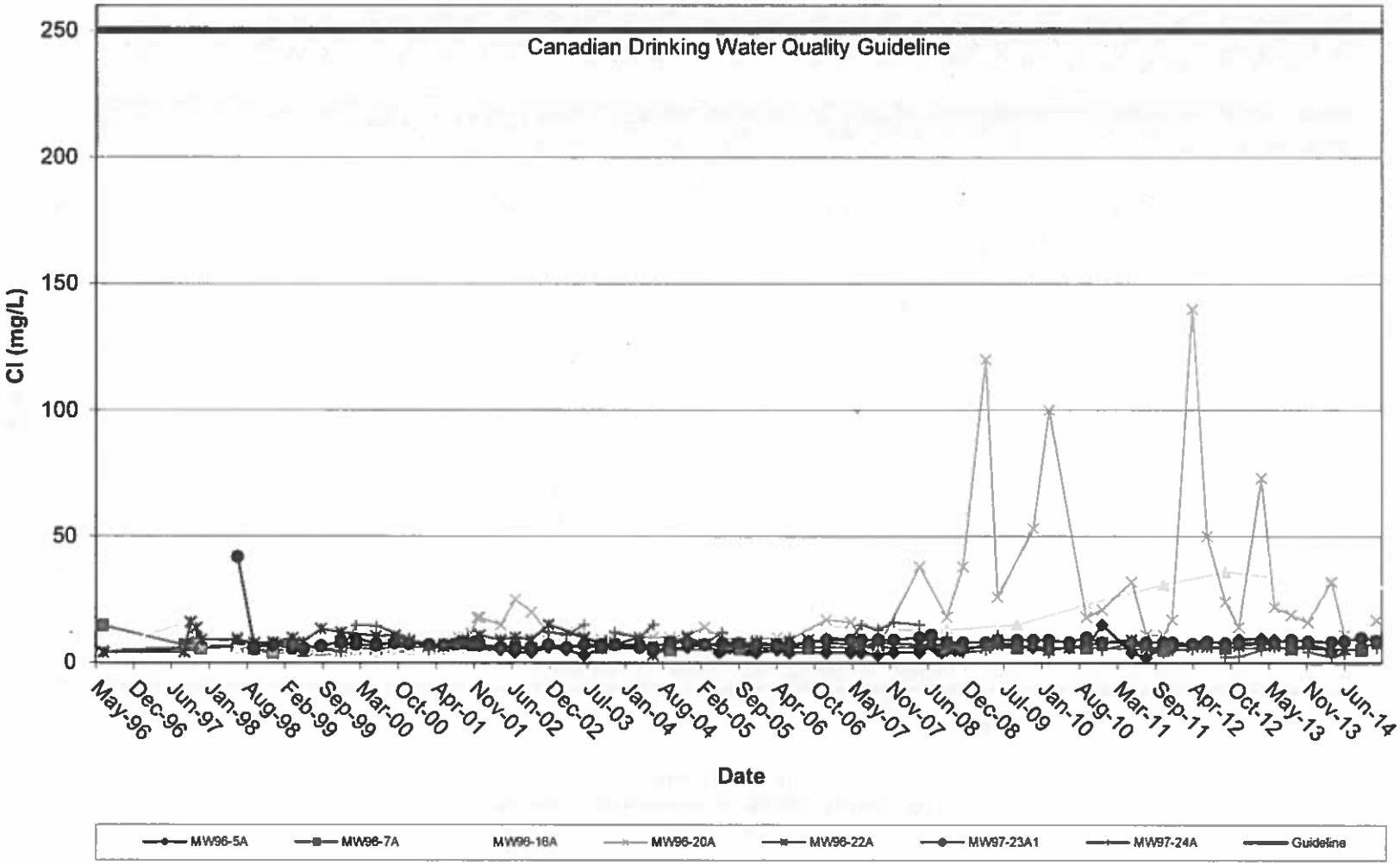


Figure 3-7
Chloride Concentration in Shallow Bedrock Wells
Otter Lake RDF

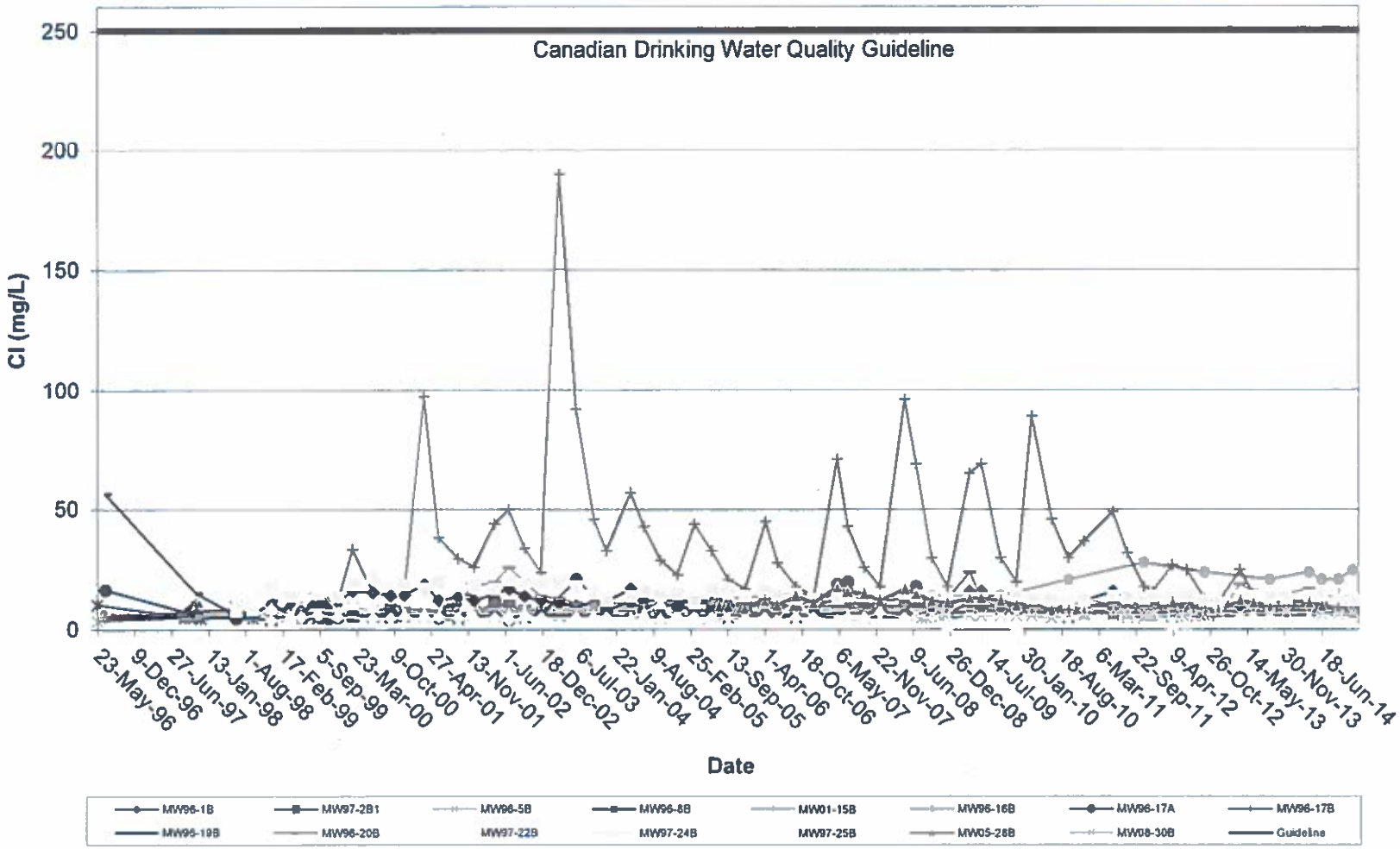


Figure 3-8
Chloride Concentration in Intermediate to Deep Bedrock Wells
Otter Lake RDF

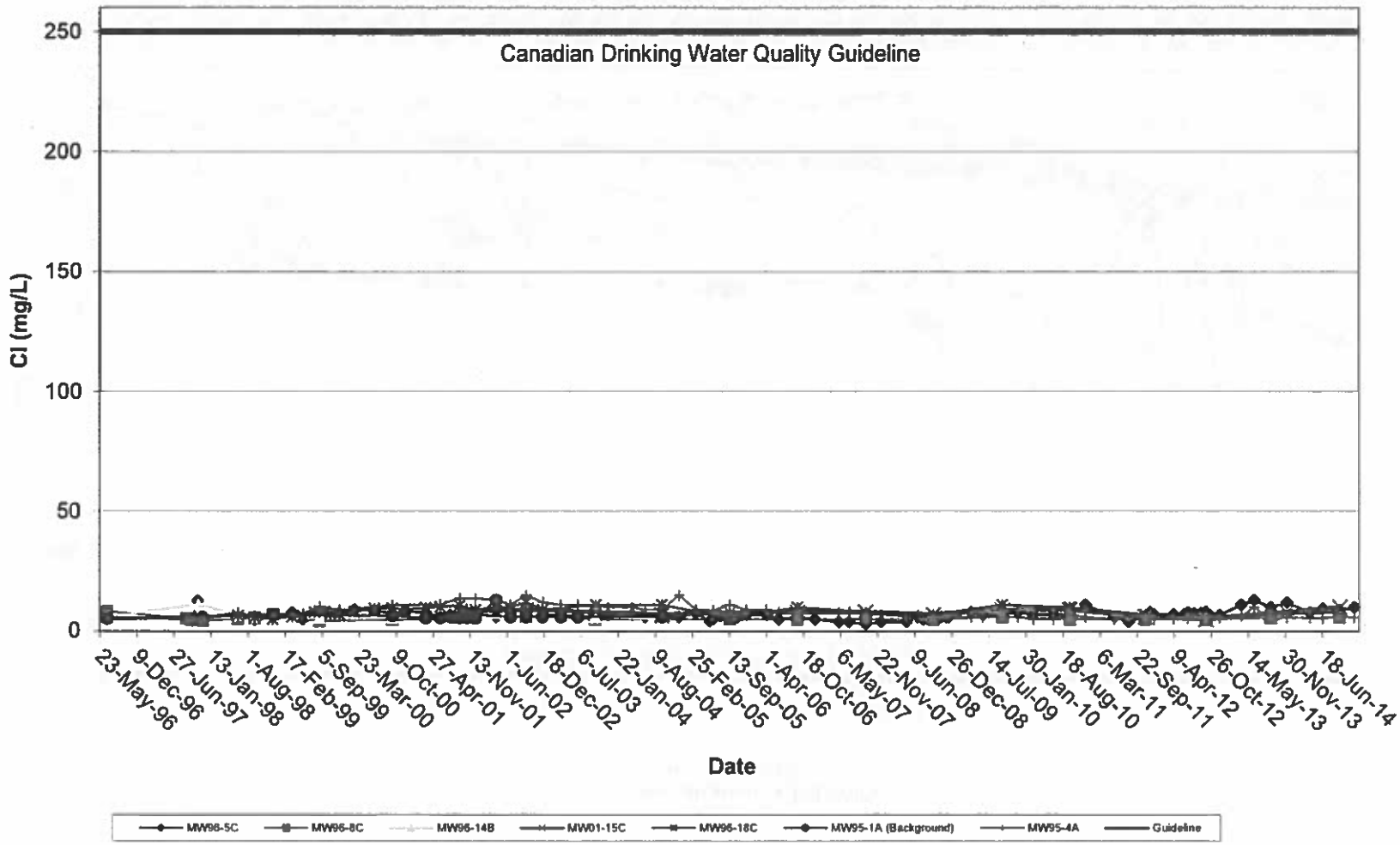


Figure 3-9
TDS Concentration in Till Wells
Otter Lake RDF

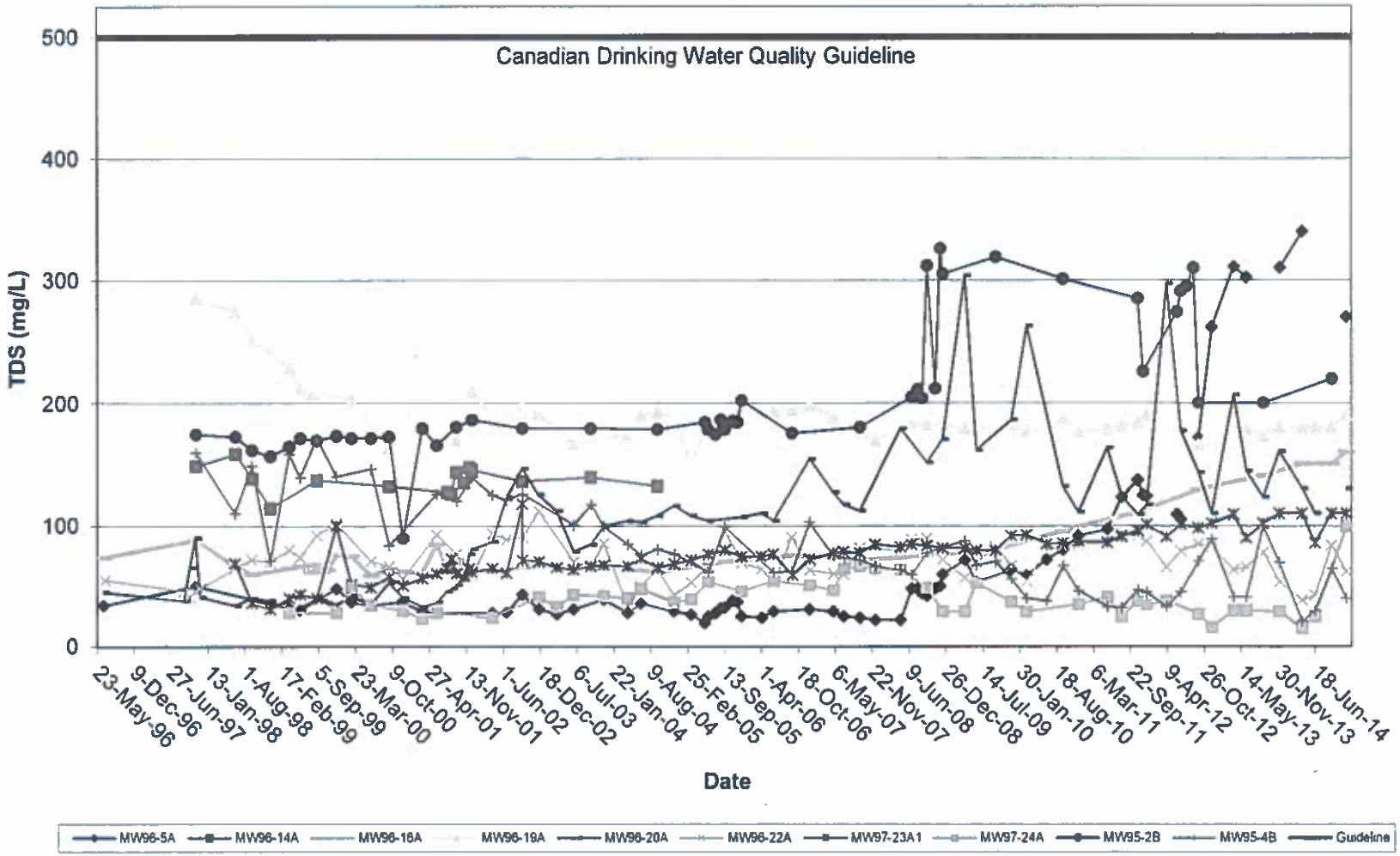


Figure 3-10
TDS Concentration in Shallow Bedrock Wells
Otter Lake RDF

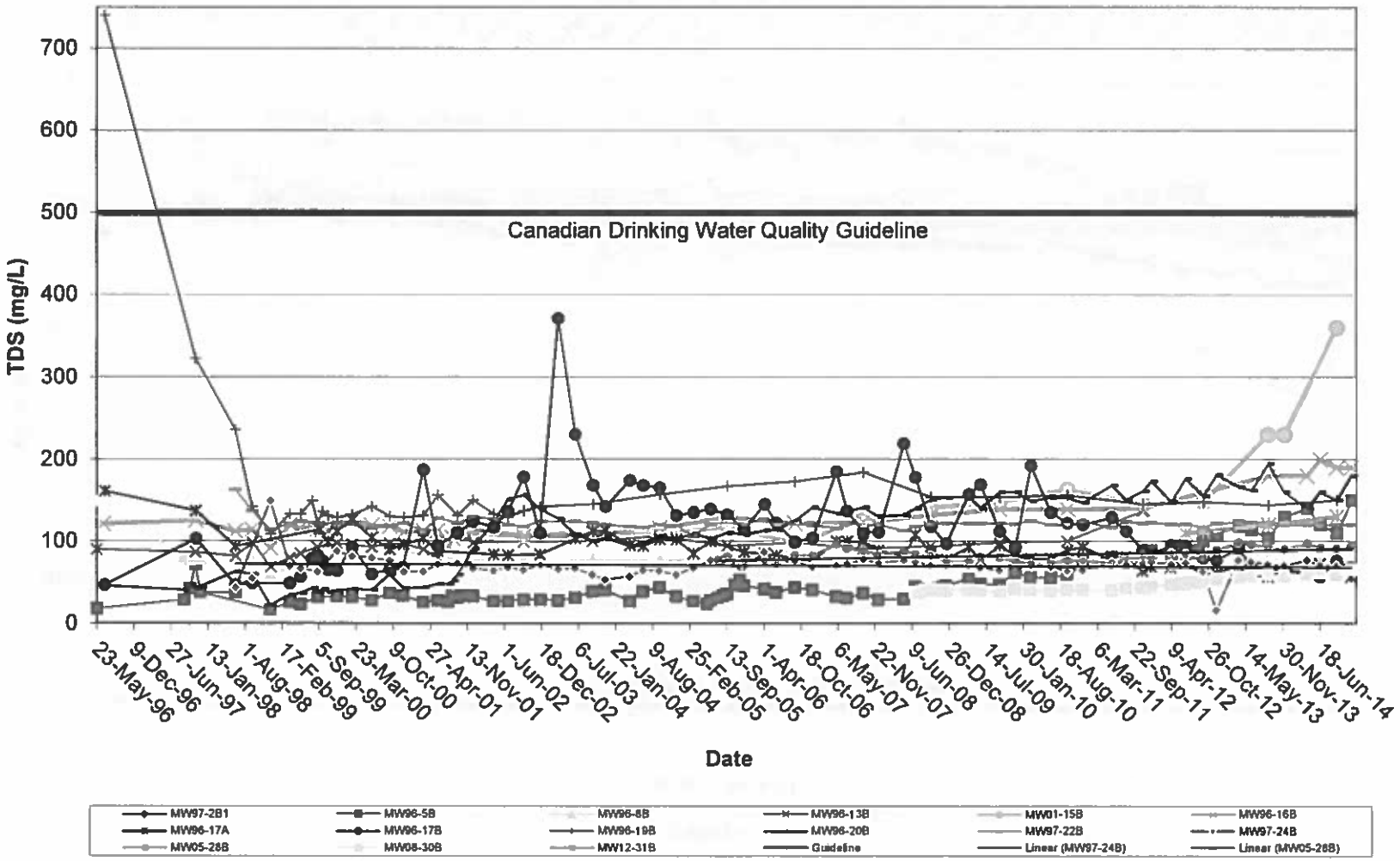


Figure 3-11
TDS Concentration in Intermediate to Deep Bedrock Wells
Otter Lake RDF

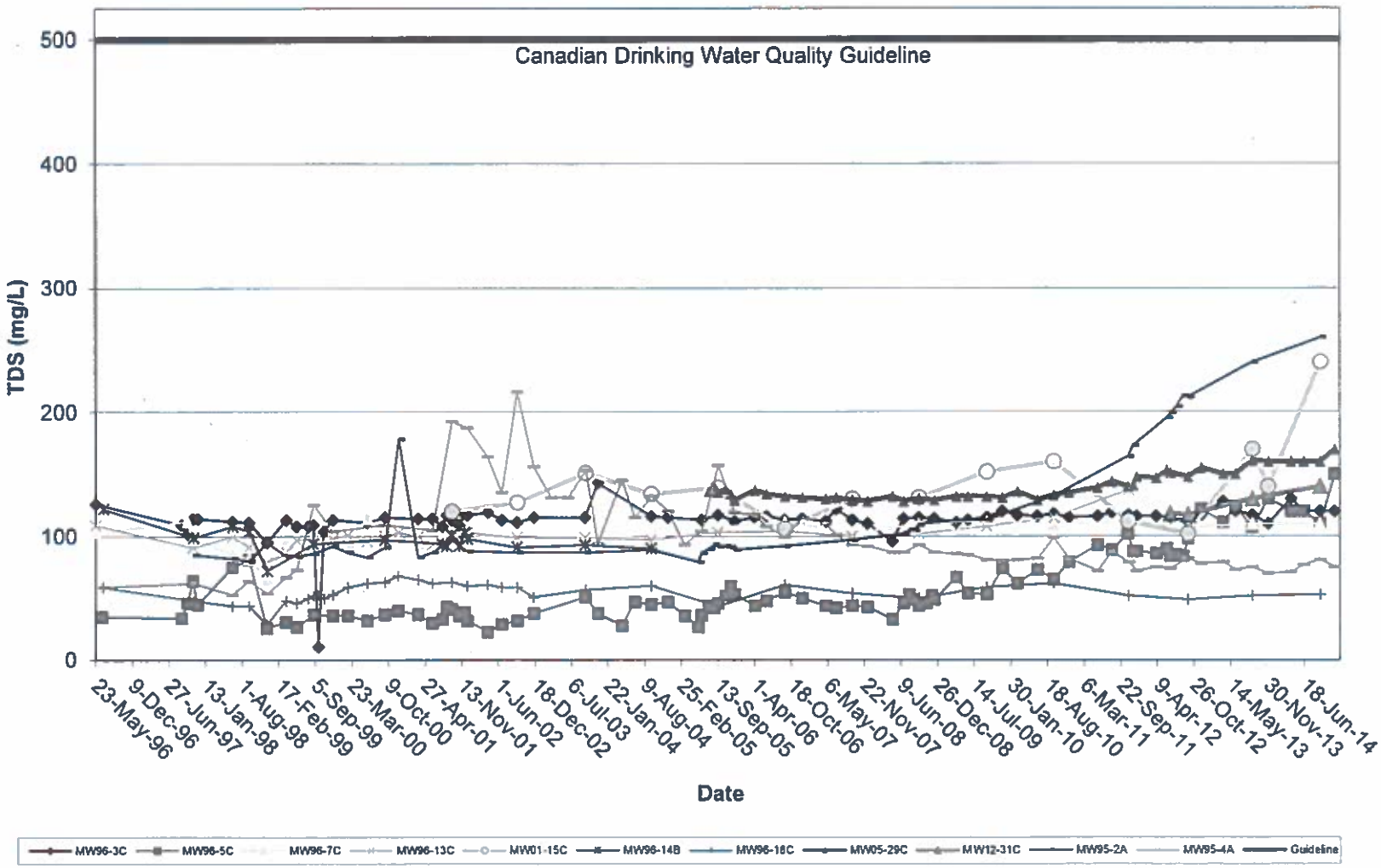


Table 3-4 Summary of Indicator Parameters in Select Groundwater Samples

Location	Chloride			TDS			Iron			Manganese		
	BL	Interim Range	2014 Range	BL	Interim Range	2014 Range	BL	Interim Range	2014 Range	BL	Interim Range	2014 Range
MW96-5A	4.5 - 5.8	2-15	5, 9**	34 - 50	20-311	270, 340**	0.2 - 0.27	<0.02-6.2	0.055, 0.52**	0.03 - 0.15	0.04-6.1	0.18, 0.54**
MW96-5B	3.5 - 13.5 [1]	3-15	9-12	17 - 72	23-130	110-150	ND - 0.58	<0.02-16	11-18	0.05 - 0.78	0.04-4.4	2.9-6.0
MW96-5C	4.5 - 12.7 [1]	3-13	8-10	26 - 81	23-130	110-150	0.025 - 0.57	<0.02-8.7	3.6-11	0.018 - 0.7	0.03-4.0	1.3-4.1
MW96-9A	4 - 7	5-7	6*	20 - 47	32-41	37*	0.11 - 0.42	0.10-3.2	3.0*	0.015 - 0.095	0.06-0.24	0.21*
MW96-9B	4 - 6.6	5-8	6*	22 - 65	33-49	42*	0.12 - 0.46	<0.05-0.26	<0.05*	0.029 - 0.13	0.003-0.06	0.029*
MW01-15B	5.3 - 7.3	7-11	14*	126 - 156	97-230	360*	ND - 0.85	<0.02-1.3	0.37*	0.01 - 0.084	<0.002-0.19	0.085*
MW01-15C	6 - 8.7	5-9	10*	95 - 121	102-170	240*	ND - 0.073	<0.02-1.5	0.56*	0.002 - 0.02	0.032-0.78	1.6-d*
MW96-16A	5.6 – 17 [1]	4-36	32-34***	60 - 88	59-140	150-160***	0.11 - 0.15	<0.02-3.4	<0.05 (all)***	0.009 - 0.075	<0.002-0.091	0.0034-0.024***
MW96-16B	6.3 - 11 [1]	6-28	21-25***	92 - 125	94-180	180-200***	ND - 0.22	<0.02-0.09	<0.05****	0.002 - 0.058	0.002-0.086	0.011-0.045***
MW96-17A	4.8 - 16.7 [1]	4-21	6-7	94 - 161	57-126	57-73	0.15 - 4.1	<0.02-0.08	<0.05 (all)	0.049 - 0.32	<0.002-0.35	<0.002 (all)
MW96-17B	5.2 - 8.7	10-190	8-12	47 - 103	48-371	57-76	0.039 - 0.35	<0.02-0.22	<0.05 (all)	ND - 0.1	0.0023-0.60	0.0022-0.010
MW96-19A	4.9 - 5.5	4-12	7-8	252 - 285	149-229	180-190	ND - 1.6	<0.02-1.4	<0.05-0.19	1.7 - 2.4	0.0078-1.6	0.0075-1.1
MW96-19B	5.5 - 56.6 [1]	5-8	9*	109 – 740 [1]	122-184	150-d*	0.082 - 9.2	<0.02-0.16	<0.05*	0.065 - 0.59	<0.002-0.31	<0.002*
MW96-20A	3 - 14.6	4-140	11-32**	34 - 90	30-304	110-130**	<0.01 - 2	<0.02-0.16	<0.05 (all)**	0.027 - 0.46	<0.002-1.8	<0.002-0.0057**
MW96-20B	4 - 6.2	4-26	5-17	22 - 63	35-195	140-180	ND - 0.94	<0.02-0.02	<0.05 (all)	0.019 - 0.17	0.015-4.5	0.19-3.0
MW96-22A	4 - 16	3-15	5-9	41 - 72	34-112	39-84	0.42 - 14	9.4-40	15-24	0.46 - 4.4	0.88-6.8	0.80-1.9
MW97-22B	4 - 12.9 [1]	4-7	5 (all)	114 – 163 [1]	106-130	120 (all)	<0.01 - 3.4	<0.02-1.5	<0.05 (all)	<0.005 - 0.48	<0.002-0.099	<0.002-0.010
MW97-23A1	5.9 - 41.9 [1]	5-11	8-10	31 - 69	40-118	86-110	2.2 – 26 [1]	<0.02-9.6	2.5-6.5	0.19 - 1.9	0.026-3.4	3.8-4.0
MW97-24A	7.2	2.5-16	2-6**	28	16-67	15-100**	<0.02	<0.02-2.1	<0.05-1.6**	2.5	0.012-12	0.065-1.5**
MW97-24B	8.4 - 18	11-22	12-14	44 – 149 [1]	53-88	67-77	0.65 - 4.7	<0.02-5.0	<0.05 (all)	3.6 - 4.4	4.0-18	3.6-4.1
MW05-28B	9.8	6-18	7-11	77	70-99	91-97	0.71	0.12-2.5	1.1-2.3	1.1	1.0-2.8	2.6-2.8
MW05-29C	9.5	8-11	9-10	136	128-161	160-170	<0.05	<0.05-0.13	0.11-0.13	0.19	0.15-0.44	0.44-0.51
MW08-30B	6	5-7.4	6-7	38	39-60	60-66	1.1	0.92-2.2	1.7-2.2	0.36	0.32-0.85	0.84-1.0
MW12-31B	6	7-8	8*	110	112-120	130*	<0.05	<0.05-0.07	<0.05*	0.042	0.024-0.041	0.020*
MW12-31C	7	7-8	8*	118	117-130	140*	<0.05	<0.05	<0.05*	0.016	0.016*	0.083*
MW95-2A	4.6 - 5.8	5-10	10*	80 - 95	79-240	260*	ND - 0.14	<0.02-3.0	0.053*	0.26 - 0.38	0.10-1.6	1.9*
MW95-2B	5.9 - 8.4	3-10	5*	156 - 174	90-326	220*	0.012 - 0.36	<0.05-1.2	<0.05*	0.022 - 0.96	<0.002-0.38	0.031*
MW95-4A	4.7 - 7.7	5-15	5-6	53 - 64	67-216	71-81	ND - 0.16	<0.02-0.72	<0.05 (all)	0.003 - 0.024	<0.002-1.6	<0.002 (all)
MW95-4B	5 - 7	3-14	5-10	71 - 159	32-171	21-65	ND - 1.2	<0.02-5.0	1.0-2.7	ND - 0.31	0.004-1.6	0.29-0.78

Notes:

All concentrations in mg/L.

[1] indicates anomalous concentration (not consistent with the majority of interim results), if anomalous concentration removed:

- BL chloride in MW96-5B: 3.5-7.1
- BL chloride in MW96-5C: 4.5-6.4
- BL chloride in MW96-16A: 5.6-7.2
- BL chloride in MW96-16B: 6.3-8
- BL chloride in MW96-17A: 4.8-6
- BL chloride in MW96-19B: 5.5-15.2

Location	Chloride			TDS			Iron			Manganese		
	BL	Interim Range	2014 Range	BL	Interim Range	2014 Range	BL	Interim Range	2014 Range	BL	Interim Range	2014 Range

- BL TDS in MW96-19B: 109-323
- BL chloride in MW97-22B: 4-9
- BL TDS in MW97-22B: 114-137
- BL chloride in MW97-23A1: 5.9-8.3
- BL iron in MW97-23A1: 2.2-2.7
- BL TDS in MW97-24B: 44-55

* indicates one sample collected, as scheduled

** The following wells were dry or contained insufficient water during 2014: MW96-5A in June and September, and MW96-20A and MW97-24A in September.

*** At the request of NSE, MW96-16A/16B, typically sampled annually, were sampled quarterly in 2014.

ND indicates "not detected"

d – denotes field duplicate value shown (when higher than primary sample concentration)

BL (Baseline) generally represents data collected during 1996 through 1998 with the following exceptions:

- For replacement wells MW01-15B/15C (sampled annually), BL refers to data collected from MW96-15B/15C.
- BL for MW97-24A represents initial sample collected from this well in March 1999.
- BL for MW05-28B and 29C represents initial samples collected in July 2005.
- BL for MW08-30B represents initial sample collected in June 2008.
- BL for MW12-31B and 31C represents initial samples collected in June 2012.

Bold indicates highest concentration recorded to date.

For MW01-15B and 15C, interim range refers to data collected from MW01-15B and 15C, noting that data from historical wells MW96-15B/15C was similar.

TDS, which (as noted above) has shown higher variability than chloride (particularly in the till well samples), concentrations were higher in several wells across the site during 2014, while chloride concentrations were either generally comparable to baseline data (1996 through 1998) or have remained relatively consistent since that time. Exceptions (as noted in Table 3-4) are noted in the following comments:

- During 2014, chloride concentrations in MW96-5B/5C (down gradient of Cells 5 and 6; Figures 3-7 and 3-8, respectively) remained below the highs recorded in June 2013 (15 and 13 mg/L, respectively). It is important to note that the prior highs for these wells (i.e., 13.5 mg/L and 12.7 mg/L, respectively, recorded in baseline samples) appear to be anomalous. If removed, the prior highs for MW96-5B/5C would be 10 and 11 mg/L, respectively (both recorded in December 2010). Therefore, the 2014 chloride concentrations (9 to 12 mg/L and 8 to 10 mg/L, respectively) were above the modified baseline ranges. Overall, chloride concentrations, which had generally been less than 10 mg/L in all three wells prior to 2010, indicate gradually increasing trends, most notably for the shallow and deep bedrock wells. TDS was higher than previously recorded in one or two samples each from MW96-5A/5B/5C during 2014 (generally in April and/or December), noting that MW96-5A was dry in both June and September. TDS in MW96-5A (Figure 3-9) has exhibited a general increase since 2008 coincident with the construction of Cell 5; however, TDS in MW96-5B/5C (Figures 3-10 and 3-11, respectively) remained relatively low (generally <80 mg/L) until 2011, when Cell 6 construction commenced. Although Cell 6 construction was completed in late 2012, this area continues to be influenced by site operations/runoff. As noted above and in Table 3-4, some of the 2014 iron and manganese levels were also higher in MW96-5B (April and December) and MW96-5C (December).
- TDS has been increasing in MW01-15B (up gradient of Cell 2; Figure 3-10) over time, with the September 2014 concentration (360 mg/L) above the previously recorded range. TDS had ranged from 97 to 167 mg/L in September 2010 (field duplicate sample), and the September and December 2013 concentrations were both 230 mg/L. Chloride (14 mg/L) was also above the prior range (see Table 3-4 and Figure 3-7), which had been relatively consistent prior to 2013 (ranging from 7.0 to 8.6 mg/L in September 2005). Then, in September 2013 (and the follow up December 2013 sample), chloride concentrations were 11 mg/L. This well is typically sampled once per year. Concentrations of other inorganic parameters (including sodium, calcium, magnesium, alkalinity, conductivity and hardness) also generally increased in September 2013 (leading to the follow up sample). The September 2014 concentrations were higher once again. Metals (including arsenic, cobalt, iron, manganese, strontium and uranium) were higher in September 2013; however, subsequent concentrations (with the exception of manganese, strontium and uranium in December 2013 and strontium and uranium in September 2014) were lower and generally comparable to results recorded prior to September 2013. Of note, manganese in September 2014 (0.085 mg/L) was below the high recorded in both September and December 2013 (0.19 mg/L) but slightly above the range recorded prior to 2013 (i.e., <0.002 to 0.073 mg/L in November 2001). However, it is noted that in historical MW96-15B samples, manganese had been as high as 0.084 mg/L (November 1997).

For the most part, similar observations were made for MW01-15C in relation to major cation and anion concentrations in September 2013 (although the differences were less significant compared to MW01-15B, with generally lower concentrations observed in December 2013). In September 2014, TDS, as well as manganese (discussed above), were notably higher (the prior range for TDS was 102 to 170 mg/L in September 2013), and conductivity (390 uS/cm) and hardness (190 mg/L) were also above the previously recorded ranges (170 to 280 mg/L in September 2013 and 64 to 130 mg/L in September 2013, respectively). Chloride, at 10 mg/L, was marginally higher (i.e., the prior range was 5 to 9 mg/L in September 2002).

Overall, chloride and manganese at both locations remain variable; future results will determine if an increasing trend is occurring (similar to TDS). It is noted that these wells are located adjacent to a roadway, which had been subject to increased traffic during Cell 6 construction in 2011/2012. In addition, these wells are also immediately adjacent to an operational white goods area. For comparison, chloride in the originally installed MW96-15B and 15C ranged from 5.3 to 7.3 mg/L and 6 to 8.7 mg/L, respectively; and TDS ranged from 126 to 167 mg/L and 95 to 121 mg/L, respectively.

- For MW96-16A/16B (northeast corner of landfill, south corner of the FEP), chloride and TDS have been gradually increasing over time in both wells (most notably since 2010 and 2008, respectively). It is noted that, prior to the 2014 monitoring program, these wells were sampled on an annual basis (i.e., fall). In 2014, these wells were sampled quarterly to further assess the observed changes in chloride and TDS and to assess seasonal correlation. During 2014, concentrations of chloride in MW96-16A/16B (Figures 3-6 and 3-7, respectively) remained below the highs recorded in September 2012 and November 2011, respectively, but were above the concentrations recorded prior to 2010. The majority of 2014 TDS concentrations (Figures 3-9 and 3-10, respectively) were higher, the exception being MW96-16B in April 2014, where TDS was equivalent to the high (i.e., 180 mg/L in September 2013). Conductivity, hardness and sulphate, which have also been generally increasing, were also higher in 2014. It is noted that seasonal correlation was not apparent in 2014. These wells, which are located adjacent to the road used to access the operational areas of the landfill (currently Cell 6) and within a ditch that receives drainage from the area up gradient of the landfill, are likely influenced by operations activities in the up gradient area of the site, roadway run-off and/or the FEP/WSF compound which, based on groundwater contouring (Figure 3-3), is cross gradient.
- Chloride has been variable in MW96-20A/20B (down gradient of Cells 1&2 and 3; Figures 3-6 and 3-7) since the initiation of sampling. As previously reported, chloride in MW96-20A has exhibited occasional concentrations above 100 mg/L since April 2009 (with the high of 140 mg/L recorded in April 2012) and appears to be seasonally influenced (by roadway runoff), with the highest concentrations since 2009 occurring during spring events (i.e., March or April), including 2014. Levels in MW96-20B have been much lower (for the most part 20 mg/L or less). TDS concentrations in both wells have exhibited a notable increase since 2002 (Figures 3-9 and 3-10); however, the 2014 concentrations were within the previously recorded ranges.

- TDS concentrations in MW08-30B (down gradient of Cell 6 and future cells; Figure 3-10) have been gradually increasing over time (albeit slightly), with the majority of 2014 levels above the previously recorded range. As shown in Table 3-4 manganese concentrations were also higher during 2014. In addition, other major cations and anions (including conductivity and hardness) appear to be generally increasing. This well has been sampled since June 2008.
- For MW12-31B/31C (up gradient of Cell 6 and future cells), where only four samples have been collected to date, chloride, TDS and/or manganese were above initial sample concentrations. TDS in both wells (Figures 3-10 and 3-11, respectively) was slightly higher than the prior ranges. Hardness and conductivity were also higher in both wells. Iron was not detected in both samples (comparable to previous results). Manganese was lower than previously recorded in MW12-31B (the prior range was 0.024 to 0.042 mg/L, with the high reported for the initial sample) and higher than previously recorded in MW12-31C (prior to 2014, the concentration had consistently been recorded at 0.016 mg/L). Chloride was equivalent to the concentrations recorded during the preceding (i.e., September 2013) event and only slightly higher than initial concentrations. Some seasonal variation is expected and, due to the limited data set, it is not possible to ascertain trending at this time for this location. It is noted that a grubbing area (active during Cell 5 and Cell 6 construction from 2008 to 2012) is located immediately adjacent to these monitor wells.
- TDS concentrations in shallow well MW95-2B (up gradient side of Cells 5 and 6; Figure 3-9) had generally increased from levels generally below 200 mg/L (prior to 2008) to over 300 mg/L. However, recent concentrations have been lower (i.e., 200 to 220 mg/L since September 2012), including 2014. The deeper well MW95-2A (Figure 3-11) has exhibited a general increase in TDS and the September 2014 concentration (260 mg/L) was above the previously recorded range (79 to 240 mg/L in September 2013). It is noted that several other parameters have increased at this location in recent years, such as, chloride (equivalent to the high of 10 mg/L recorded in September 2013), hardness, conductivity, manganese (higher than previously recorded in 2014, as noted above) and uranium (although below the DWQ Guideline), which appeared to coincide with cell construction. This well is located along the up gradient site access road, and heavy traffic was experienced during the construction periods (i.e., both Cell 5 in 2008 and Cell 6 in 2011/2012). In addition, this area may still be showing affects from routine site operations, noting that a grubbing area (active during Cell 5 and Cell 6 construction from 2008 to 2012) is located immediately up gradient.
- Samples from the shallow bedrock well MW96-17B (between Cell 1 and the FEP), the till and shallow bedrock wells MW96-19A and MW96-19B (down gradient of the FEP, off the north corner of Cell 1), and the shallow till well MW95-4B (down gradient of the FEP) exhibit the greatest variation in TDS and generally contained higher levels compared to their respective baseline concentrations and/or concentrations in samples from other wells (see Table 3-4). For MW95-4B (Figure 3-9), TDS was frequently above 100 mg/L prior to 2009 with no obvious increasing or decreasing trend. However, since that time levels have decreased with 2014 concentrations similar to or lower than baseline. Baseline concentrations for MW96-19A (Figure 3-9) were between 250 and 300 mg/L. More recent levels are typically <200 mg/L, but still elevated in comparison to most of the other well samples in

this area of the site. Similar observations were made for the shallow bedrock well (MW96-19B) at the same location (Figure 3-10). TDS was high in the initial sample from this well (i.e., 740 mg/L in July 1996) and relatively high in the two subsequent samples (323 and 236 mg/L in November 1997 and June 1998, respectively); however, samples collected since this time contained significantly lower concentrations (i.e., <200 mg/L, including 2014). For MW96-17B, 2014 levels of TDS were comparable to baseline.

- For MW05-29C (down gradient of cells; Figure 3-11), TDS has exhibited a general (albeit slight) increase, with the December 2014 concentrations (170 mg/L) slightly higher than previously recorded. Other parameters at this location have been gradually increasing (including alkalinity, hardness, conductivity, iron and manganese), and manganese concentrations were also slightly higher in the majority of 2014 samples. TDS in MW97-23A1 (down gradient near the South Sedimentation Pond; Figure 3-9) has exhibited an overall increase from baseline levels. Manganese concentrations, which were initially high during baseline then lowered, have gradually increased over time, with 2014 levels higher than previously recorded (as noted above). For MW05-28B (down gradient of leachate holding tank) and MW97-24A/24B (west of North Sedimentation Ponds), TDS has exhibited variation with no apparent trending (Figures 3-9 and 3-10, respectively). MW94-24A exhibited TDS significantly higher than previously recorded in December 2014 (i.e., 100 mg/L; Figure 3-9). Of note, during the December 2014 sampling event, this well contained organics (ants) and a stagnant odour.

3.1.2.3 Organic Chemistry

Since 1999, approximately 35 monitor wells have been sampled for organic compounds, specifically TPH/BTEX components and VOC and PAH compounds, on at least one occasion. The 2014 monitoring program included samples from 15 wells in September: MW96-1B, MW97-2B1, MW96-3A, MW96-5B, MW96-9A, MW01-15B, MW96-16B, MW96-17B, MW96-22A, MW97-23A1, MW97-24B, MW05-28B, MW08-30B and MW95-4A, as scheduled, and MW96-20B in lieu of MW96-20A, which contained insufficient water to sample. With the exception of one well, TPH/BTEX and VOCs were not detected in the September 2014 samples. For MW97-23A1, toluene analyzed in the TPH/BTEX package was detected at a concentration of 0.011 mg/L, below the DWQ Guidelines (i.e., the recently released health based limit is 0.06 mg/L, while the aesthetic objective remains as 0.024 mg/L). Toluene was also analyzed in the VOC package and reported to be 0.064 mg/L, slightly above the health-based DWQ Guideline as well as the aesthetic guideline. Remaining VOC parameters were below the detection limits in this sample. Petroleum hydrocarbons in the fuel (C_{10}-C_{21}) and lube oil (C_{21}-C_{32}) ranges were detected (the total modified TPH concentration was 2.9 mg/L). This concentration was above the prior high recorded in September 2013 (i.e., 2.5 mg/L). Laboratory resemblance comments indicated "unidentified compounds in the fuel/lube oil range". Modified TPH has frequently been detected in prior samples from this location, and there are no CDWQ Guidelines for these compounds. Toluene was detected on one prior occasion in September 2013 (0.0021 mg/L in the TPH/BTEX package and 0.0036 mg/L in the VOC package) and, following the September 2013 results, this well was resampled for TPH/BTEX in December 2013 and, prior to analysis, the laboratory performed a silica gel clean-up in an effort to reduce/remove naturally occurring or non-petrogenic compounds. Petroleum hydrocarbon concentrations in the December 2013 sample were

not detected (i.e., below the detection limits) and, therefore, the concentrations were attributed to organics and sediment associated with background organic matter, noting that this well has frequently contained ants and stagnant odour (including the September 2014 event). Therefore, similar to 2013 observations, the September 2014 results are assumed to be non-petrogenic and not of concern.

PAHs were not detected in groundwater samples, with the exception of one parameter. Phenanthrene was detected at low concentrations (ranging from 0.011 to 0.024 ug/L) in samples from nine wells (MW96-3A, MW96-9A, MW01-15B, MW96-16B, MW96-20B, MW96-22A, MW97-24B, MW05-28B and MW08-30B), noting that the detection limit is 0.010 ug/L. There is no DWQ Guideline for this parameter. Some of these wells (MW96-3A, MW96-9A, MW96-20B, MW96-22A and MW97-24B) have exhibited detections of phenanthrene in one or two prior samples at similar concentrations; however, it is noted that the sample frequency for each monitor well has varied over the years and, therefore, there are limited data sets for some wells (e.g., MW96-16B has only been analyzed for organics since 2012). The laboratory quality assurance report indicated the presence of sediment in these samples, which can contribute to concentrations of some organic parameters (including phenanthrene).

3.2 Surface Water Monitoring Network

The surface water monitoring network consists of 15 sampling stations. Locations are shown on Figure 3-1 and Figure 3-2. A summary of the network, including station identifications, general location, number of samples collected prior to 2014 and the sampling events undertaken during this program, is found in Table 3-5.

Table 3-5 2014 Surface Water Sampling Program

Station ID	Sampling Status	General Location	No. Prior Events	2014 Event(s)
SW-1	Operational (annually)	Nine Mile River; furthest up gradient station, near Highway 103	23	September
SW-2	Operational (quarterly)	Nine Mile River; up gradient of site; down gradient of SW-1	64	Apr., Jun., Sept., Dec.
SW-3	Operational (quarterly)	Nine Mile River; down gradient of North Sedimentation Ponds	64	Apr., Jun., Sept., Dec.
SW-4	Operational (quarterly)	Site receiving waters below South Sedimentation Ponds	62	Jun., Sept., Dec. *Station flooded/inaccessible in April*
SW-5	Operational (quarterly)	Nine Mile River; down gradient of SW-4	65	Apr., Jun., Sept., Dec.
SW-6A[1]	Operational (annually)	Nine Mile River; down gradient of SW-5	17 *(13 SW-6)*	September
SW-7	Operational (quarterly)	Nine Mile River; furthest down gradient sampling station	65	Apr., Jun., Sept., Dec.

Station ID	Sampling Status	General Location	No. Prior Events	2014 Event(s)
SW-8A[2]	Operational (quarterly)	Tributary into Duck Pond; down gradient	50 *(16 SW-8)*	Apr., Jun., Sept., Dec.
SW-9	Operational (annually)	Duck Pond Outlet; down gradient of site activities	29	September
SW-10	Operational (annually)	Otter Lake; outside RDF watershed area but down gradient of other activities	22	September
SW-11	Operational (annually)	Otter Lake; outside RDF watershed area but down gradient of other activities	23	September
SW-13	Operational (quarterly)	On-site; North Sedimentation Ponds outlet	49	Apr., Jun., Sept., Dec.
SW-14[4]	Operational (quarterly)	On-site; South Sedimentation Ponds outlet	55	Apr., Jun., Sept., Dec.
SW-15	Operational (quarterly)	On-site; ditch near FEP down gradient of the site access road	58 *(6 SW-15A)*	Apr., Jun., Sept., Dec.
SW-16	Operational (quarterly)	Tributary to Nine Mile River down gradient of SW-15 near Nine Mile River	41	Apr., Jun., Dec. *SW16 was dry in Sept.*

Notes:
1. Location of SW-6 sample collection slightly modified for better access. The more recent data from new SW-6A station are considered to be representative of SW-6 which has been discontinued.
2. Station SW-8A added to monitor more direct flow from landfill, SW-8 deleted from program after 2001.
3. SW-12 (Otter Lake Outlet) discontinued in 1998.
4. Due to mechanical issues with the discharge pipe (i.e., the outlet to the pond could not be opened), samples have been collected from (or immediately prior to) the final pond overflow location since June 2012.
5. Temporary SW-15A (ditch, up gradient of SW-15) removed from program after 2001.

3.2.1 Surface Water Analytical Results

Surface water analytical data are found in Appendix B-3. Based on field observations, surface water flow conditions during 2014 were, in general, high in April, moderate in both June and December, and low in September. Although the data collected during June 2014 were representative of moderate flow at most locations sampled, a significant rainfall event commenced immediately prior to completion of the sampling event (heavy rainfall was noted by field staff), which increased flow at two surface water stations (i.e., SW-15 and SW-16) before a sample could be collected. Environment Canada reported 36 millimetres of rainfall at Halifax Stanfield International Airport weather station the day of surface water sampling. As indicated in Table 3-5, SW-4 was not sampled in April 2014 (the area was flooded and the station inaccessible), and SW-16 was dry in September 2014.

3.2.1.1 Guideline Comparison

Exceedances to the FWAL Guidelines or the NSE discharge limit for TSS are shaded in the Appendix B-3 tables and discussed below. A value in brackets denoted by "-d" denotes the field duplicate value, which has been shown where the concentration is higher than the primary sample concentration.

It is important to note that elevated concentrations of aluminum, arsenic, cadmium, chromium, copper, iron, lead and/or zinc above the FWAL guidelines, as well as relatively high turbidity and TSS, recorded in the June 2014 samples from SW-15 (the on-site drainage ditch downstream from the FEP compound and SW-16 (downstream of SW-15) were attributed to the above-noted rainfall event. The increased flow conditions resulted in the presence of sediment in the sample, which contributed to the higher TSS and metals concentrations. Subsequent concentrations were significantly lower and, in the majority of instances, below the guidelines.

TSS exceeded the NSE's Pit and Quarry Guidelines discharge limit for a grab sample (i.e., 50 mg/L) at two locations (noted below). TSS was above the guideline in SW-15 and SW-16 on two prior occasions each (ranging from 61 to 100 mg/L and 73 to 99 mg/L, respectively).

Station	2014 Concentration(s) in mg/L	General Location
SW-15	June (69)	FEP drainage ditch
SW-16	June (52)	Tributary to Nine Mile River

pH was below the FWAL recommended range (6.5-9.0 units) in at least one of the 2014 samples collected from the following stations: SW-2, SW-3, SW-5, SW-7, SW-8A and SW-9 (all downstream samples); and SW-10 and SW-11 (both Otter Lake, outside of site watershed). Most surface water stations have exhibited low pH at least occasionally. The level in SW-9 in September 2014 (6.21 units) was above the previously recorded range for this location (i.e., 4.4 to 5.79 units). This station is sampled annually. Remaining 2014 surface water pH concentrations were comparable to previous years.

Consistent with previous results, aluminum was above the guideline (0.005 mg/L to 0.1 mg/L, pH dependant) in the majority of samples (including background), as shown below. In June 2014, aluminum in SW-16 was slightly higher than previously recorded (the prior range was 0.030 to 1.0 mg/L in June 2012), and aluminum in SW-15, while within the previously recorded range, was the second highest concentration recorded to date (i.e., aluminum was recorded at a concentration of 3.2 mg/L in December 2011). Remaining concentrations were comparable to previous results. Aluminum levels tend to be variable in both sedimentation ponds.

Station	2014 Concentration(s) in mg/L	General Location
SW-1	Sept. (0.14)*	Nine Mile River upstream
SW-2	Apr. (0.32), June (0.31), Dec. (0.33)	Nine Mile River upstream
SW-3	Apr. (0.41), June (0.31-d), Sept. (0.10), Dec. (0.12)	Downstream of North Sed. Pond
SW-4	June (1.4), Sept. (0.53), Dec. (0.32)	Below South Sed. Pond
SW-5	Apr. (0.37), June (0.33), Sept. (0.11), Dec. (0.35)	Nine Mile River downstream
SW-6A	Sept. (0.12)*	Nine Mile River downstream
SW-7	Apr. (0.42), June (0.29), Sept. (0.14), Dec. (0.36)	Nine Mile River downstream
SW-8A	Apr. (1.2), June (0.61), Sept. (0.20), Dec. (0.39)	Tributary into Duck Pond

SW-9	Sept. (0.44)*	Duck Pond Outlet, down gradient
SW-10	Sept. (0.036)*	Otter Lake, outside the RDF watershed
SW-11	Sept. (0.033-d)*	Otter Lake, outside the RDF watershed
SW-13	Apr. (2.2), June (0.78), Sept. (0.89), Dec. (0.85)	North Sedimentation Pond (discharge)
SW-14	Apr. (1.5), June (0.75), Sept. (0.74), Dec. (0.19)	South Sedimentation Pond
SW-15	Apr. (0.29), June (3.0), Dec. (0.22)	FEP drainage ditch
SW-16	Apr. (0.32), June (1.3), Dec. (0.19)	Tributary to Nine Mile River

* *Indicates that only one sample (as intended) was collected in 2014 (September)*

As previously reported, aluminum in SW-4 (below the south sedimentation pond) has been recorded up to 8.7 mg/L (in December 2011), also coincident with higher turbidity (170 NTU). The higher levels in the samples were attributed to increased runoff during Cell 6 construction (2011/2012) and/or precipitation events (i.e., June 2013), which contributed in general to higher turbidity levels (and consequently higher concentrations of metals) at this location. The area of SW-4 is prone to flooding on occasion (as occurred in April 2014). Concentrations at SW-14 (South Sedimentation Pond) were also generally higher during Cell 6 construction in 2011/2012 and, since that time, have been comparable to data recorded prior to Cell 6 construction (including 2014 concentrations). It is noted that the new sediment basin at the foot of future Cell 7, which was constructed prior to the second quarter (i.e., June) event, now collects run-off from the Cell 6 area of the site.

Arsenic was above the guideline (5 ug/L) in June 2014 sample from SW-15. Arsenic has been above the guideline in occasional samples from SW-15 at similar or higher concentrations. It is noted that the concentration of arsenic in the June 2014 sample from downstream SW-16 was lower and below the guideline (i.e., 2.9 ug/L).

Station	2014 Concentration(s) in ug/L	General Location
SW-15	June (11)	FEP drainage ditch

Cadmium was above the guideline (hardness dependent) in 2014 in one sample from the four stations noted below. It is noted that laboratory detection limits (LDL) had lowered from 0.3 ug/L to 0.017 ug/L in 2005 (therefore, cadmium was not detected in the majority of historical samples) and from 0.017 ug/L to 0.010 ug/L in 2013. Also of note, the guideline for cadmium (which is dependent on hardness) changed in January 2014. The new guideline, which incorporates hardness into the long term guideline calculation, is less stringent. Therefore, during 2014, fewer exceedances to the guideline were observed relative to 2005 through 2013 samples. For the April 2014 exceedances noted below, the concentrations were comparable to previous results. Prior to 2005 (when the detection limit was higher), cadmium was detected in SW-15 on three occasions (0.4 ug/L in February 2000 and 0.3 ug/L in March and December 2001) and non-detect in SW-16 samples. As noted above, for SW-15 and SW-16, the June 2014

concentrations were above the ranges recorded since 2005 at both stations (i.e., 0.018 to 0.19 mg/L in SW-15 and 0.018 to 0.20 mg/L in SW-16). Concentrations in the subsequent samples were below the guidelines.

Station	2014 Concentration(s) in ug/L	General Location
SW-3	Apr. (0.044)	Downstream of North Sed. Pond
SW-5	Apr. (0.048)	Nine Mile River downstream
SW-15	June (0.25)	FEP drainage ditch
SW-16	June (0.12)	Tributary to Nine Mile River

Chromium (total) was above the most conservative guideline of 1 ug/L (i.e., more stringent guideline associated with the hexavalent species) in samples from three stations (noted below). It is noted that the LDL was lowered from 2 ug/L to 1 ug/L in 2009. Chromium has been detected occasionally in prior samples from both sedimentation ponds (up to 5.0 and 4.4 ug/L in SW-13 and SW-14, respectively), and levels in SW-13 have exceeded on occasion at similar or higher concentrations. Of note, chromium was not detected in the downstream station (SW-3) in April 2014. Chromium levels in SW-15 and SW-16 have exceeded on two or three prior occasions at similar or higher concentrations, and chromium was non-detect in subsequent samples from these stations.

Station	2014 Concentration(s) in ug/L	General Location
SW-13	Apr. (1.5)	North Sedimentation Pond
SW-15	June (4.6)	FEP drainage ditch
SW-16	June (1.8)	Tributary to Nine Mile River

Copper exceeded the guideline (2-4 ug/L; hardness dependant) in samples from three stations (noted below). The June 2014 concentrations in SW-15 and SW-16 were above the previously recorded ranges, albeit marginally for SW-15 (i.e., <0.002 to 18 ug/L) and slightly for SW-16 (non-detect to 5.6 ug/L). Copper has been above the guideline in the majority of prior samples from both stations. Remaining 2014 concentrations were comparable to previous results, including SW-13.

Station	2014 Concentration(s) in ug/L	General Location
SW-13	Apr. (2.5)	North Sedimentation Pond
SW-15	Apr. (2.8), June (19), Dec. (3.5)	FEP drainage ditch
SW-16	Apr. (2.9), June (6.4), Dec. (3.3)	Tributary to Nine Mile River

It is noted that copper in SW-7 was once again non-detect (i.e., <2 ug/L) in 2014 samples and, therefore, significantly below the concentration recorded in the December 2013 sample (i.e., 61 ug/L). Prior to December 2013, copper had been non-detect in the majority of SW-7 samples with only three concentrations above the guideline (7.0 ug/L in September 2000, 6.2 ug/L in September 2005 and 20 ug/L in September 2009). The December 2013 concentration, therefore, appears to be anomalous.

Iron was above the guideline (0.3 mg/L) in samples from 11 stations (noted below). Iron has exceeded at least occasionally in samples from the majority of stations. Of note, the concentrations denoted below in SW-2, SW-3, SW5 and SW-7, as well as the April and/or December concentrations in SW-4, SW-15 and SW-16, were marginally above the guideline. The June 2014 concentrations in SW-15 and SW-16 were above the previously recorded ranges (<0.05 to 5.4 mg/L and 0.087 to 1.7 mg/L, respectively). Remaining concentrations were consistent with previous data (including baseline). Iron levels in SW-13, SW-14 and SW-15 tend to be variable.

Station	2014 Concentration(s) in mg/L	General Location
SW-2	June (0.31), Dec (0.31)	Nine Mile River upstream
SW-3	Apr. (0.31), June (0.31-d)**	Downstream of North Sed. Pond
SW-4	June (1.0), Sept. (0.90), Dec (0.32)**	Below South Sed. Pond
SW-5	June (0.32), Dec (0.32)	Nine Mile River downstream
SW-7	Apr. (0.32), Dec (0.34)	Nine Mile River
SW-8A	Apr. (0.90), June (0.86), Sept. (0.68), Dec (0.61)	Tributary into Duck Pond
SW-9	Sept. (0.75)*	Duck Pond outlet, down gradient
SW-13	Apr. (1.3)	North Sedimentation Pond
SW-14	Apr. (0.46)	South Sedimentation Pond
SW-15	Apr. (0.36), June (6.5), Sept. (0.42), Dec (0.63)	FEP drainage ditch
SW-16	Apr. (0.33)**, June (2.2), Dec (0.33)	Tributary to Nine Mile River

* *Indicates that only one sample (as intended) was collected in 2014 (September)*

** *The primary sample result for SW-3 in June (0.30 mg/L) and the field duplicate results for SW-4 in December and SW-16 in April (0.27 mg/L and 0.26 mg/L, respectively) did not exceed the FWAL guideline*

Similar to observations made for aluminum, iron in SW-4 has been recorded up to 8.0 mg/L (in December 2011) with generally higher concentrations recorded during Cell 6 construction in 2011/2012. Concentrations in 2014 (i.e., June, September and December) were comparable to pre-2011/2012 levels.

Lead was above the guideline (1 to 7 ug/L, hardness dependent) in samples from three stations (shown below). Lead has occasionally been detected in SW-13 samples at similar or higher concentrations. It is noted that lead was lower and below the guideline in the April 2014 sample downstream of SW-13 (i.e., 0.64 ug/L in SW-3). For SW-15, lead has been detected at higher concentrations on two prior occasions (19 ug/L in December 2011 and 66 ug/L in April 2007). For SW-16, the June 2014 concentration was above the previously recorded range (<0.5 to 3.8 ug/L).

Station	2014 Concentration(s) in ug/L	General Location
SW-13	Apr. (1.4)	North Sedimentation Pond
SW-15	June (13)	FEP drainage ditch
SW-16	June (4.7)	Tributary to Nine Mile River

Zinc was above the guideline (30 ug/L) in the June 2014 samples from SW-15 and SW-16 (shown below). Zinc has occasionally been above the guideline in previous SW-16 samples at similar or higher concentrations. For SW-15, although occasional exceedances of zinc have been recorded, the June 2014 concentration was the second highest to date (zinc was recorded at a concentration of 96 ug/L in December 2011).

Station	2014 Concentration(s) in ug/L	General Location
SW-15	June (80)	FEP drainage ditch
SW-16	June (39)	Tributary to Nine Mile River

Table 3-6 provides a summary of parameter exceedances to date, for all surface water stations. Some parameters (including pH, aluminum, cadmium and iron) are excluded from the table, as concentrations commonly occur (or, for cadmium, have frequently occurred in historical samples) outside the recommended range limit. As noted above, cadmium exceedances occurred less frequently in 2014 since the guideline became less stringent in January 2014. The 2014 occurrences have been underlined, and it is noted that selenium, silver, nitrite and ammonia exceedances were not observed during 2014 (and mercury has not been analyzed since 2004). Elevated TSS occurrences have been included within the table, even though these are based on provincial discharge criteria (not FWAL Guidelines).

Table 3-6 Summary of Exceedances to FWAL Guideline for Selected Parameters

Parameter	FWAL Guideline (mg/L)	Station ID	Occurrence(s)	Concentration (mg/L)
Arsenic	0.005	SW-4	Sep 98	0.009
		SW-15	Jun 00; Sep 02; Nov 03; Sep 05; Jun & Sep 08; Jun & Sep 09; Jun 10; Jun 14	0.006-0.016
Chromium (Total)	0.001 (more stringent guideline based on hexavalent species)	SW-1	Sep 01	0.005
		SW-2	Dec 99	0.019
		SW-3	Sep 04	0.011
		SW-4	Sep 98; Mar 99; Sep 02; Nov & Dec 11; Apr & Sep 12; Jun & Sep 13	0.0013-0.030
		SW-6	Dec 00	0.008
		SW-7	Nov 97, Mar 00	0.002-0.005
		SW-8	Sep 98; Mar 99; Mar, Jul & Dec 00	0.002-0.076
		SW-8A	May, Aug, Nov & Dec 11	0.0024-0.0048
		SW-9	Mar 99, Nov 11	0.002-0.014
		SW-10	Nov 97, Sep 98	0.002-0.019
		SW-11	Sep 01, Sep 02	0.003-0.008
		SW-12	Sep 98	0.003
		SW-13	Mar 99; Mar 05; Apr & Dec 09; Mar 10; Dec 11; Sep 12; Apr, Jun & Dec 13; Apr 14	0.0011-0.005
		SW-14	Apr 06; Sep & Dec 08; Apr 09; May, Nov & Dec 11; Sep & Dec 12 [3]; Sep & Dec 13	0.0011-0.0044
		SW-15	Sep 02, Dec 11, Jun 14	0.0046-0.0061
		SW-16	Jun & Sep 12; Jun 13; Jun 14	0.0011-0.002

Parameter	FWAL Guideline (mg/L)	Station ID	Occurrence(s)	Concentration (mg/L)
Copper	dependent on hardness (minimum 0.002)	SW-1	Sep 09	0.0030
		SW-2	Jul 96; Mar & Jun 06; Jun 08	0.0027-0.0085
		SW-3	Sep 01, Sep 05, Jun 06, Dec 09	0.0025-0.01
		SW-4	Nov 97; Feb 00; Sep 03; Sep 05; Nov & Dec 11; Apr & Sep 12; Jun 13	0.0026-0.0081
		SW-5	May & Dec 99; Dec 00; Sep & Dec 06; Dec 09	0.003-0.0181
		SW-6	Dec. 98, Dec 00	0.003
		SW-7	Sep 00, Sep 05, Sep 09; Dec 13	0.0062-0.061
		SW-8A	Dec 01; May, Aug, Nov & Dec 11	0.005
		SW-9	Sep 05, Sep 09	0.0035-0.0068
		SW-11	Jul 96, Sep 07, Sep 09	0.0026-0.003
		SW-12	Jul 96	0.005
		SW-13	Mar 99; Dec 00; Dec 02; Jun & Sep 03; Mar 05; Jun 06; Sep & Dec 08; Apr, Sep & Dec 09; Mar 10; Dec 11; Jun, Sep & Dec 12; all 2013 events; Apr 14	0.0021-0.0117
		SW-14	Sep 01; Dec 05; Apr & Jun 06; Jun, Sep & Dec 08; Apr & Sep 09; Dec 10; Nov & Dec 11; Sep 12; Sep & Dec 13	0.0021-0.0096
		SW-15	All 99, 00 & 01 events; Apr, Jun & Dec 02; Mar, Jun & Sep 03; Apr & Dec 04; Mar, Jun & Dec 05; Mar, Jun & Dec 06; Apr & Jun 07; May, Sep & Dec 08; Apr & Dec 09; all 2010, 2011, 2012 & 2013 events; Apr, Jun & Dec 14	0.0021-0.019
		SW-15A	All 00 & 01 events	0.003-0.006
		SW-16	all 02 events; Mar & Jun 03; Dec 04; Dec 05; Mar, Jun & Dec 06; Jun & Sep 07; Jun & Dec 08; all 09 events; Dec 10; all 2011 & 2012 events; Jun, Sep & Dec 13; Apr, Jun & Dec 14	0.0021-0.0064

Parameter	FWAL Guideline (mg/L)	Station ID	Occurrence(s)	Concentration (mg/L)
Lead	dependent on hardness (minimum 0.001)	SW-1	Nov 97, Dec 98, Dec 99	0.0011-0.0046
		SW-2	Jul 96, Nov 97, Jun 98, Jun 06	0.0011 -0. 00404
		SW-3	Mar 00, Jun 06	0.0017-0.0021
		SW-4	Nov 97; Jun 98; Mar & Aug 99; Feb 00; Mar 01; Dec 05; Nov & Dec 11; Apr & Sep 12; Jun 13	0.0011 - 0.00502
		SW-5	Dec 07, Dec 09	0.00121-0.0052
		SW-6	Jul 96, Nov 97, Dec 98	0.0014 - 0.007
		SW-7	Nov 97	0.0014
		SW-8	Jul 96; Jul & Dec 00; Jun 01	0.0012 - 0.0036
		SW-8A	Dec 10; all 2011 events	0.00168-0.00306
		SW-9	Jul 96, Jul 00, Sep 07, Sep 08, Sep 09, Nov 11, Sep 12	0.00119 - 0.0018
		SW-12	Dec 98	0.0051
		SW-13	Mar 99, Dec 00, Dec 02, Mar 05, Apr 09, Dec 11, Dec 13; Apr 14	0.00121 - 0.0052
		SW-14	Mar 01, Dec 05, Sep & Dec 08, Apr 09, Dec 11, Sep 12, Dec 13	0.00156-0.00295
		SW-15	Mar 99, Feb & Sep 00, Mar & Jun 01, Dec 11, Dec 12, Jun 13; Jun 14	0.0012-0.066
		SW-15A	Sep & Dec 00, Mar & Jun 01	0.0017 - 0.0031
		SW-16	Jun 01, Jun & Sep 07, May & Dec 11; all 2012 events; Jun & Dec 13 [4]; Jun 14	0.00102-0.0047
Mercury	0.000026 (prior to 2003, 0.0001)	SW-2	Mar 01	0.00012
		SW-8	Jul 96	0.00012
Zinc	0.002	SW-1	Jun 98	0.076
		SW-5	Mar 99, Dec 00	0.033 - 0.039
		SW-6	Dec 98	0.3
		SW-9	Dec 98	0.044
		SW-11	Jul 96	0.032
		SW-15	Dec 99; Feb 00; Mar 01; Apr 04; Sep 05; Mar & Dec 10; Dec 11; Jun 14	0.032-0.096
		SW-15A	Dec 00, Mar 01	0.035 - 0.038
		SW-16	Jun & Sep 07; Jun & Sep 12; Jun 14	0.0047-0.0415
Selenium	0.001	SW-3	Dec 98	0.003
Silver	0.0001	SW-8	Nov 97	0.014
		SW-11	Jul 96	0.003
		SW-12	Jul 96	0.0014
		SW-14	Dec 13	0.00013
		SW-15	Dec 11	0.00014

Parameter	FWAL Guideline (mg/L)	Station ID	Occurrence(s)	Concentration (mg/L)
TSS [5]	50	SW-4 SW-8 SW-13 SW-14 SW-15 SW-16	Mar 10, Nov 11, Apr & Sep 12 Dec 00 Mar 05, Apr 09 Dec 05, Apr 06, Apr 09, Dec 11, Sep 12, Dec 13 Sep 05, Dec 11, Jun 14 Sep 04, May 11, Jun 14	60-160 86 60-66 58-180 61-100 52-99
Nitrite	0.06	SW-15 SW-15A	May & Dec 99; Feb, Jun & Sep 00 Jun & Sep 00	0.1-0.86 0.25-0.63
Ammonia	pH dependant	SW-13 SW-15 SW-15A	Mar 01, Dec 02 Dec 99; Feb, Jun & Sep 00 Jun & Sep 00	1.5-2.7 4.55-10.6 4.95-12.4

Notes:
1. Information pertaining to pH, aluminum, cadmium and iron is intentionally not included in this table.
2. Underline denotes 2014 samples.
3. In December 2012, chromium was detected in the field duplicate sample from SW-14 only, at a concentration only slightly above the guideline (which is the same as the LDL).
4. Lead was above the guideline in the December 2013 primary sample only and was not detected in the field duplicate sample from SW-16.
5. The criteria for TSS is based on the Provincial Pit and Quarry Guidelines.

3.2.1.2 General Surface Water Character

As expected, and typical of surface water quality in general, the chemistry at all stations exhibits some variation. For instance, pH in the Nine Mile River appears to fluctuate considerably both upstream and downstream of the landfill site. The pH in the Duck Pond waters is low, reflective of bog water character.

Concentrations of chloride and TDS in surface water stations over time are graphically shown on Figures 3-12 through 3-17. Table 3-7 provides a summary of 2014 concentration ranges in comparison to baseline (i.e., 1996 to 1998) and interim (i.e., as early as 1999 to 2013) concentrations. It is noted that baseline samples were not collected for some of the surface water stations, as indicated in the table. As shown in Table 3-7, some of the 2014 concentrations were above baseline (when available); however, concentrations in all samples were within the previously recorded ranges.

Figure 3-12 Chloride Concentration in Surface Waters
Otter Lake and FEP Stations

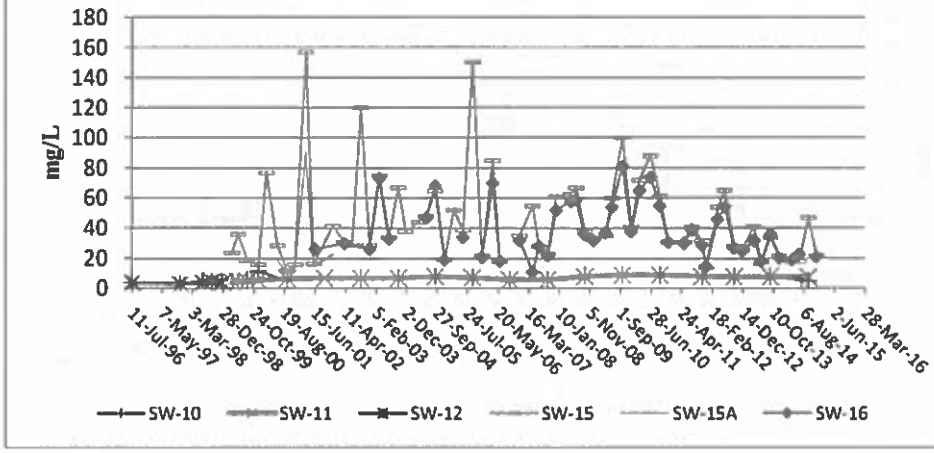


Figure 3-13 Chloride Concentration in Surface Waters
Nine Mile River and Sedimentation Ponds/Receiving Waters

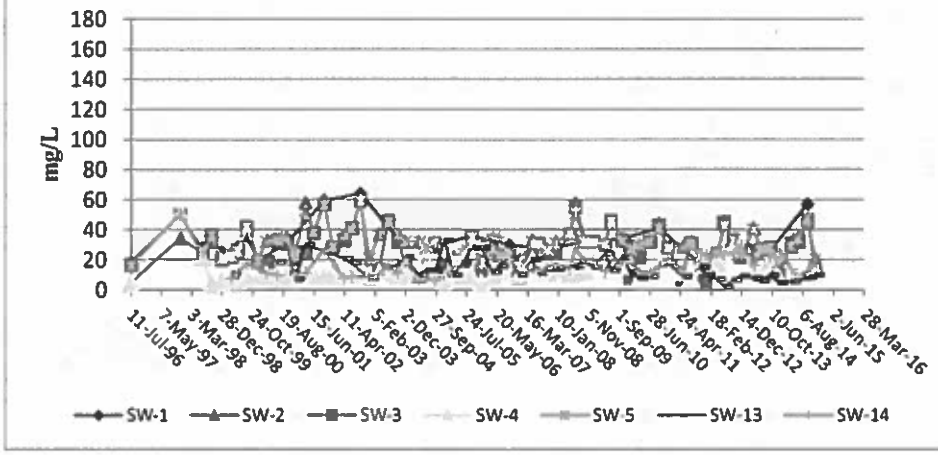


Figure 3-14 Chloride Concentration in Surface Waters
Duck Pond/Furthest Downstream Nine Mile River Stations

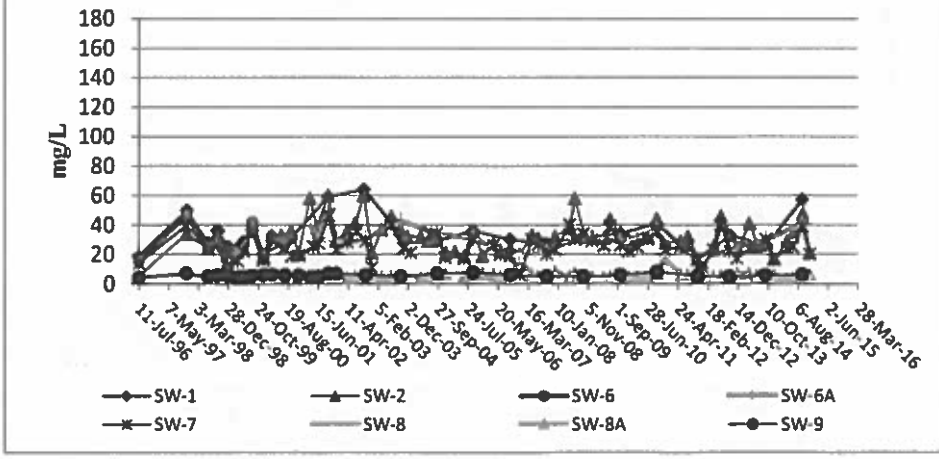


Figure 3-15 TDS Concentration in Surface Waters
Otter Lake and FEP Stations

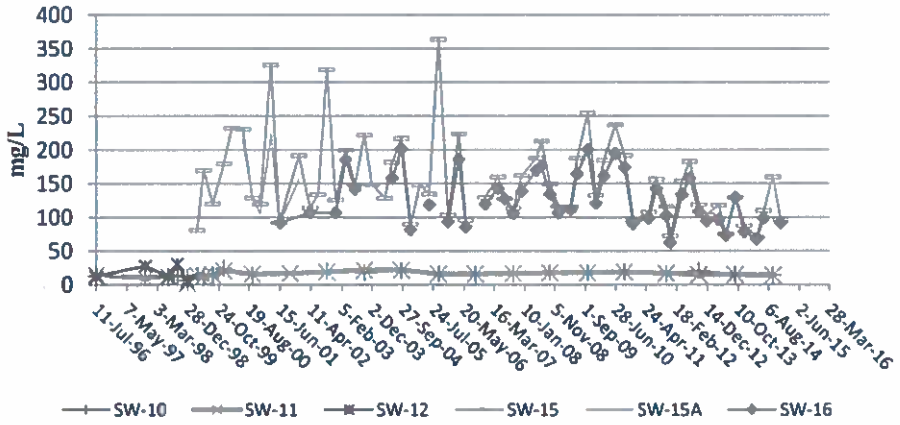


Figure 3-16 TDS Concentration in Surface Waters
Nine Mile River and Sedimentation Ponds/Receiving Waters

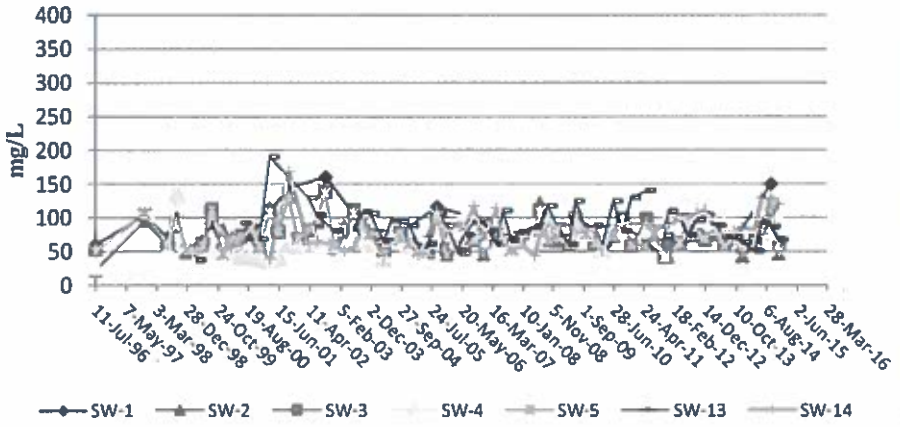


Figure 3-17 TDS Concentration in Surface Waters
Duck Pond/Furthest Downstream Nine Mile River Stations

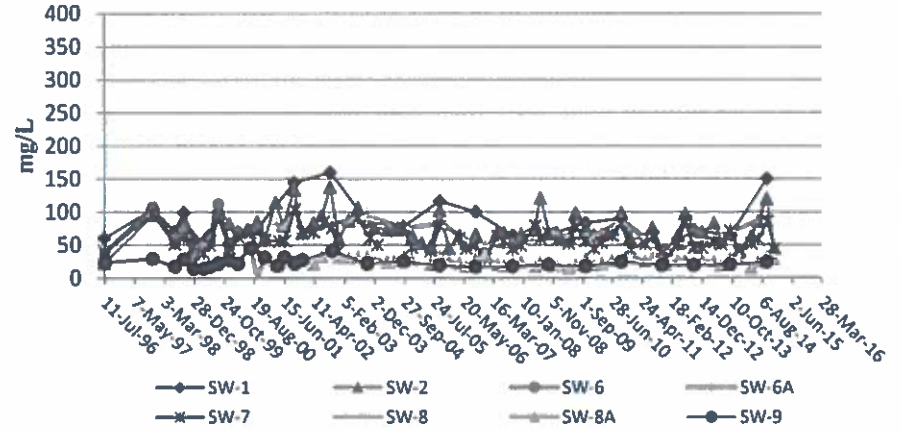


Table 3-7 Summary of Surface Water Indicator Parameters

Surface Water Station	Chloride Concentrations			TDS Concentrations		
	BL	Interim	2014	BL	Interim	2014
Otter Lake (outside of RDF watershed)						
SW-10	3.2-5.2	4.5-11.6	7*	11-13	12-24	14*
SW-11	2.6-4.7	4.6-9	7*	3-15	13-22	14*
Nine Mile River						
SW-1 (U/S)	18.3-50	17-64	57*	56-104	42-160	150*
SW-2 (U/S)	4.6-34.1	14-60	21-48	22-95	42-137	46-120
SW-5	16-50.5	14-59	20-48	50-107	40-136	49-120
SW-6	10-46.4	17.7-42	n/a	32-107	47-111	n/a
SW-6A	n/a	16-51.1	41*	n/a	39-107	92*
SW-7	13.7-39.5	6-45.9	20-39	38-97	28-104	44-86
Duck Pond						
SW-8	4.3-6.3	4-7.1	n/a	16-28	14-49	n/a
SW-8A	n/a	4-17	3-6	n/a	14-39	15-33
SW-9	4-7	4.1-8	6*	14-29	14-45	24*
North Sedimentation Ponds						
SW-3	16.7-50	6-59	11-46	48-104	41-137	62-110
SW-13	n/a	2-33	5-10	n/a	37-190	50-93
South Sedimentation Ponds						
SW-4**	3.6-51.5	5-28	8-12	28-136	31-109	79-120
SW-14	n/a	6-37	9-19	n/a	39-168	82-130
FEP Ditch and Tributary Below FEP						
SW-15	n/a	11.8-157	18-47	n/a	73-364	71-160
SW-16**	n/a	11-81	19-23	n/a	63-202	67-99

Notes:
All concentrations in mg/L.
n/a – no data (i.e., no sample(s) collected)
U/S – indicates sample is upstream
"-d" – denotes field duplicate result (shown where higher than primary sample result)
Underline – one or more 2014 concentrations above baseline.
* Only one sample (as scheduled) was collected in 2014 (September)
**In 2014, SW-4 was flooded and the sample station inaccessible in April, and SW-16 was dry in September.
BL (Baseline) generally represents data collected during 1996 through 1998 with the following comments or exceptions:

- Baseline for SW-6 is considered representative of SW-6A. The station location was modified in April 2001 for better access.
- Station SW-8A added to monitor more direct flow from landfill, SW-8 deleted from program after 2001. Historical SW-8 is presented for information purposes only.
- Stations SW-13, SW-14 and SW-15 were established in March 1999, and SW-16 was established in June 2001; therefore, there is no baseline data for these locations.

With the exception of historical samples from SW-15 (on-site drainage ditch below the FEP), chloride concentrations in the surface water samples collected to date have been below 100 mg/L and, in the majority of instances, have been below 50 mg/L. For SW-15, 2014 concentrations ranged up to 47 mg/L during the spring (September) event. As shown above and on Figure 3-12, chloride levels in SW-15 have been as high as 157 mg/L (in March 2001); however, levels have been consistently below 100 mg/L since December 2009. Downstream SW-16 concentrations during this time (since December 2009) have been generally similar and lower than the high recorded for this location (81 mg/L in September 2009). Concentrations at both of these stations have been above the other stations located in

this general area of the site (i.e., SW-10 and SW-11). Levels of TDS (as well as hardness and metals) remain higher relative to the majority of other locations, as shown in Table 3-6 and on Figure 3-15.

In general, Nine Mile River samples have historically contained higher or similar chloride concentrations not only compared to background chemistry (i.e., Nine Mile River stations SW-1 and SW-2), as shown in Table 3-6 and on Figures 3-13 and 3-14, but as compared to SW-13 and SW-14 (sedimentation ponds discharge water) and SW-3 and SW-4 (receiving waters). A similar trend has been observed for TDS, as shown on Figures 3-16 and 3-17.

Concentrations of inorganic parameters in the on-site drainage ditch below the FEP and in the tributary below the FEP have exhibited variation in chemistry from one sample event to another, and, as noted above, the 2014 chloride and TDS levels were comparable to previous results. As shown on Figures 3-12 through 3-17, chloride and TDS were generally lowest in the samples from Otter Lake and the Duck Pond (both the inlet and outlet stations) compared to the other surface water stations.

3.2.1.3 Organic Chemistry

Since 1999, eight stations (SW-1, SW-2, SW-3, SW-4, SW-5, SW-14, SW-15 and SW-16) have been tested for TPH/BTEX, VOCs, and PAHs on at least one occasion. In 2003, organics sampling was reduced to surface water stations that directly monitor site discharge, that is, SW-3 (Nine Mile River, down gradient of North Sediment Pond), SW-4 (site receiving waters) and SW-16 (down gradient of SW-15 and FEP drainage). The September 2014 event included samples from two of these three stations, as scheduled (SW-16 was dry). The results are included in Appendix B-3. Consistent with previous results, TPH/BTEX and VOCs were not detected in the two surface water samples. One PAH compound, phenanthrene, was detected in both SW-3 and SW-4 (0.024 and 0.019 ug/L, respectively) at low concentrations (i.e., within three times of the detection limit of 0.010 ug/L) and well below the FWAL Guideline of 0.4 ug/L. Dillon reviewed the laboratory quality assurance report and contacted Maxxam to confirm the results.

Phenanthrene is naturally occurring in surface water and has been found to be present in background soil concentrations in Nova Scotia. The laboratory indicated the presence of sediment in these samples, which can contribute to concentrations of some organic parameters (including phenanthrene).

3.3 Sediment Sampling Results

The 2014 monitoring program included the collection of sediment samples (Sed-3, Sed-4 and Sed-15) at the three corresponding surface water stations: SW-3 (Nine Mile River downstream of the North Sedimentation Ponds), SW-4 (receiving water) and SW-15 (FEP drainage ditch), as scheduled. Sediment analytical data collected since 1996 are found in Appendix B-4.

Table 3-8 summarizes metals exceedances in all samples collected from initiation (including baseline) of testing through 2014. Comments pertaining to the 2014 results are as follows:

- Arsenic (6.2 mg/kg) in SED-3 was above the 5.9 mg/kg guideline, while cadmium (0.7 mg/kg) and mercury (0.18 mg/kg) were marginally above the guidelines (0.6 mg/kg and 0.17 mg/kg, respectively). Arsenic and cadmium have exceeded on occasion at similar or higher concentrations. Mercury has been detected in historical samples (including the initial 1997 sample) at concentrations below the guideline; however, the September 2014 concentration was only slightly higher than previous results (i.e., the prior range was <0.1 to 0.15 mg/kg). Historical exceedances at this location have also included lead and zinc.

- Arsenic (24 mg/kg), chromium (39 mg/kg) and copper (44 mg/kg) were above the guidelines (5.9 mg/kg, 37.3 mg/kg and 35.7 mg/kg, respectively) in SED-4. Arsenic has exceeded the guideline in the majority of samples collected since 1996, and copper has exceeded the guideline on three prior occasions (i.e., September 2000, September 2001 and September 2013) at similar concentrations. Chromium was above the guideline on one prior occasion (i.e., September 2013). In comparison, the September 2014 concentration was lower and only slightly above the guideline. Other parameters that have exceeded guidelines on one or more prior occasions include: cadmium, lead, mercury and zinc. It is noted that, in September 2014, mercury was non-detect (i.e., <0.1 mg/kg) and zinc, which, similar to chromium, had been above the guideline on one prior occasion (i.e., September 2013), was below the guideline.

- Arsenic (53 mg/kg), cadmium (2.5 mg/kg), copper (93 mg/kg), lead (95 mg/kg), mercury (0.62 mg/kg) and zinc (520 mg/kg) were above the guidelines (5.9 mg/kg, 0.6 mg/kg, 35.7 mg/kg, 35 mg/kg, 0.17 mg/kg and 123 mg/kg, respectively) in SED-15 at concentrations comparable to previous results. Arsenic has been above the guideline in the majority of prior samples and remaining parameters have been above the guidelines on four prior occasions (i.e., September 2006, September 2007, September 2010 and November 2011), noting that samples have only been collected at this location since 2003.

Table 3-8 Summary of Metals Exceedances in Sediment

Sample ID	Parameters (Concentrations)						
	Arsenic (5.9)	Cadmium (0.6)	Chromium (37.3)	Copper (35.7)	Lead (35)	Mercury (0.17)	Zinc (123)
Sed-2	-	-	-	-	Jul 96 (39) Nov 97 (46)	Jul 96 (0.21) Nov 97 (0.26)	-
Sed-3	Sep 00 (8) Sep 04 (8) Sep 08 (6) Sep 14 (6.2)	Nov 97 (0.7) Aug 99 (1.1) Sep 04 (1.1) Sep 14 (0.7)	-	-	Nov 97 (52)	Sep 14 (0.18)	Sep 04 (130)
Sed-4	Jul 96 (7.5) Aug 99 (21) Sep 00 (14)	Jul 96 (0.7)	Sep 13 (46) Sep 14 (39)	Sep 00 (36) Sep 01 (36) Sep 13 (50)	Jul 96 (36) Nov 97 (59) Aug 99 (36)	Jul 96 (0.21) Nov 97 (0.21) Sep 08 (0.3)	Sep 13 (150)

Sample ID	Parameters (Concentrations)						
	Arsenic (5.9)	Cadmium (0.6)	Chromium (37.3)	Copper (35.7)	Lead (35)	Mercury (0.17)	Zinc (123)
	Sep 01 (14) Sep 02 (24) Sep 03 (13) Sep 04 (12) Sep 05 (14) Sep 06 (10) Sep 07 (18) Sep 08 (12) Sep 09 (6) Nov 11 (13) Sep 12 (15) Sep 13 (26) Sep 14 (24)			Sep 14 (44)			
Sed-5	Nov 97 (26) Aug 99 (8) Sep 02 (40)	Aug 99 (1.0) - -	-	- - -	Aug 99 (73) Sep 02 (44) -	- - -	- - -
Sed-8	- -	- -	-	- -	Jul 96 (36) Nov 97 (49)	Jul 96 (0.28) Nov 97 (0.19)	- -
Sed-9	-	-	-	-	Jul 96 (44)	Jul 16 (0.38)	-
Sed-12	Nov 97 (7.7)	-	-	-	-	-	-
Sed-15	Sep 03 (7) Sep 04 (9) Sep 05 (12) Sep 06 (180) Sep 07 (190) Sep 08 (7) Sep 09 (21) Sep 10 (150) Nov 11 (30) Sep 13 (9.3) Sep 14 (53)	Sep 06 (7.1) Sep 07 (4.6) Sep 10 (6.8) Nov 11 (1.8) Sep 14 (2.5)	-	Sep 06 (72) Sep 07 (93) Sep 10 (150) Nov 11 (54) Sep 14 (93)	Sep 06 (52) Sep 07 (58) Sep 10 (110) Nov 11 (59) Sep 14 (95)	Sep 06 (0.29) Sep 07 (0.28) Sep 10 (0.8) Nov 11 (0.3) Sep 14 (0.62)	Sep 06 (730) Sep 07 (1500) Sep 10 (1500) Nov 11 (420) Sep 14 (520)

Notes:
All concentrations in mg/kg.
Bold denotes sampled during 2014 monitoring program (September only).
Underline denotes 2014 samples

3.4 Other Monitoring Results

Other monitoring includes sample collection from the underdrains below the cells, the leak detection sumps and the leachate holding tank. The results are found in Appendix B-5, B-6 and B-7, respectively, and discussed in the following sections.

3.4.1 Underdrain Samples

The five underdrains (Cell 1&2, Cell 3, Cell 4, Cell 5 and Cell 6) daylight at the base of the landfill cells. The Cell1&2 Underdrain has consistently been dry. Cell 3 Underdrain has been sampled on a quarterly basis since March 2003,

with the exception of June 2014 (inadvertently not sampled). Sampling of Cell 4 Underdrain was incorporated into the program in September 2008. It is noted that, of the two Cell 4 Underdrain locations (4A and 4B; see Figure 3-2), there has never been flow at the 4A location. The Cell 4B Underdrain has historically exhibited very little or no flow and, during the April, June and September 2014 events, this location was dry. Sampling of the Cell 5 Underdrain commenced in April 2009, and sampling of the Cell 6 Underdrain commenced in December 2012.

Of note, concentrations from the three samples collected from Cell 3 Underdrain in 2014 were below the DWQ guidelines. Historically, uranium has frequently been above the guideline, and turbidity, iron and manganese have exceeded on one or two occasions each. Organic compounds (TPH/BTEX, PAHs and VOCs) were not detected, consistent with previous data. Table 3-9 provides a summary of select parameter concentrations in 2003 through 2014 samples for Cell 3 Underdrain. The 2014 concentrations were comparable overall to previous results, with marginally lower concentrations of TDS and sulphate recorded in April 2014 and December 2014, respectively. As indicated, there has been some variation but, overall, no significant change in chemistry. A possible exception is TDS, which exhibited relatively higher levels (i.e., >300 mg/L) between 2009 and 2012, with the high of 436 mg/L recorded in June 2012. Since December 2012, TDS has been below 300 mg/L and, of note, 2014 levels were below initial concentrations recorded in 2003. Chloride levels have generally been less than 10 mg/L. It is noted that, since September 2010, iron, as well as the majority of manganese concentrations, have been non-detect. Zinc has frequently been non-detect since the initiation of sampling (March 2003).

Table 3-9 Cell 3 Underdrain Samples - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2003	8-9	20-24	223-251	0.8-1.3	<0.05-1.2	<0.002-0.064	<0.005-0.013
2004	7-8	16-20	208-233	0.8-1.3	<0.05	<0.002-0.01	<0.005
2005	7.3-9	14-25	191-254	0.8-1.8	<0.05	0.0028-0.0041	<0.005-0.062
2006	8-9	27-33	161-269	1.1-2.2	<0.05	<0.002-0.026	<0.005
2007	8-11	29-34	239-260	1.4-2.1	<0.05-0.052	<0.002-0.033	<0.005-0.007
2008	8-9	22-33	271-288	1.8-2.5	<0.05	<0.002-0.01	<0.005-0.006
2009	7-9	18-34	256-313	1.5-3.0	<0.05-0.095	<0.002-0.022	<0.005-0.007
2010	8-14	17-37	233-367	1.6-2.3	<0.05-1.07	<0.002-0.13	<0.005-0.0101
2011	3-7	11-30	212-346	1.6-2.0	<0.05	<0.002-0.0056	<0.005
2012	7-9	20-39	194-436	1.9-2.3	<0.05	<0.002	<0.005-0.0055
2013	4-9	11-36	191-290	1.4-1.7	<0.05	<0.002-0.002	<0.005
2014*	4-9	9-31	160-220	0.7-1.9	<0.05	<0.002	<0.005

*Note: Cell 3 Underdrain was not sampled in June 2014

As indicated above, only one sample was collected from the Cell 4B Underdrain in 2014. Although sampling of this location was added to the monitoring program in September 2008, the December 2014 sample represents only the sixteenth sample (as the location was also dry in November 2011; April, June and September 2012; and April, September and December 2013). Turbidity (2.2 NTU) and manganese (0.077 mg/L) were above the DWQ Guidelines (i.e., 1 NTU and 0.05 mg/L, respectively) in December 2014. Both parameters have exceeded in all or most of the

samples collected to date from this location. A generally increasing trend for manganese had been observed since initiation of sampling in 2008; however, concentrations appear to be lowering since the high recorded in May 2011, with manganese in the December 2014 sample comparable to initial concentrations. Organic compounds (TPH/BTEX, PAHs and VOCs) could not be sampled as scheduled as there was no flow at the sample location during the annual event in September. Table 3-10 provides a summary of select parameter concentrations in 2008 through 2014 samples. Indicator parameter concentrations were generally comparable to previous results. TDS (as well as hardness and conductivity) appear to be generally increasing (based on the limited data sets); however, concentrations in December 2014 were within the previously recorded ranges. Chloride levels have been relatively low (11 mg/L or less). Iron remained significantly lower than the high recorded in August 2011 (14 mg/L).

Table 3-10 Cell 4B Underdrain Samples - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2008	4-7	12-24	118-152	<0.5-3	1.52-1.6	0.065-0.081	0.015-0.0194
2009	6-7	6-18	138-194	<0.5-3	<0.05-0.34	0.16-0.53	0.008-0.017
2010	4-8	7-16	139-184	0.8-1.4	<0.05-1.34	0.49-0.56	0.0055-0.0082
2011	5-7	11-24	161-227	1.9-10	0.19-14	0.26-0.66	<0.005-0.043
2012	11	43	281	6.8	1.9	0.21	0.015
2013	10	63	397	5.6	0.099	0.10	0.0068
2014	10	37	350	4.0	0.14	0.077	<0.005

For the Cell 5 Underdrain, manganese was above the guideline and pH below the DWQ recommended range of 6.5-8.5 units in the four samples collected in 2014. Manganese has consistently been above the DWQ Guideline of 0.05 mg/L in Cell 5 Underdrain samples. Since June 2012, pH has been below the recommended range (6.5-8.5 units) in the majority of samples from the Cell 5 Underdrain (i.e., ranging from 6.11 units in June 2012 to 6.89 units in September 2012). Prior to this time, pH had been within the recommended range. Organic compounds (TPH/BTEX, PAHs and VOCs) were not detected. As shown in Table 3-11, the 2014 concentrations were comparable to previous results with the exception of marginally higher chloride in the September sample and slightly higher TDS in the December sample. Chloride has exhibited little variation since initiation of sampling in April 2009 (with concentrations 10 mg/L or less), whereas TDS, iron and the majority of manganese concentrations remain higher than the initial samples.

Table 3-11 Cell 5 Underdrain Samples - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2009	6-7	5-8	135-141	0.6-1.3	<0.05-0.065	0.16-0.83	0.008-0.013
2010	6-7	5	138-151	0.6-0.7	0.055-0.080	0.72-0.76	<0.005-0.007
2011	7	4-6	149-154	0.7-1.3	0.087-0.31	0.76-0.81	<0.005
2012	7-8	5-8	152-164	0.6-1.1	0.10-0.19	0.82-1.0	<0.005-0.0064
2013	8-9	4-5	155-160	0.8-1.0	0.11-0.18	0.82-0.89	<0.005-0.0073
2014	8-10	4	160-170	0.6-0.9	0.11-0.16	0.87-0.93	<0.005-0.0072

The initial Cell 6 Underdrain sample was collected in December 2012, following the completion of Cell 6 in October 2012. To date, nine samples have been collected from this location. During 2014 (and similar to 2013), parameter concentrations were below the DWQ Guidelines. Organic compounds (TPH/BTEX, PAHs and VOCs) were not detected. As shown in Table 3-12, sulphate and TDS exhibited higher concentrations during 2014 (in April 2014 and June 2014, respectively), although the differences were minor. Remaining parameter concentrations were within the previously recorded ranges. With a limited data set, it is not practical to ascertain trending at this time.

Table 3-12 Cell 6 Underdrain Sample - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2012	8	11	162	2.0	<0.05	0.003	0.0058
2013	8-9*	3-13	174-200*	1.0-1.6	<0.05	0.004-0.040	<0.005-0.0057
2014	8-9	8-16	180-210	0.8-1.1	<0.05	0.0021-0.022	<0.005

*Note: The anomalous chloride and TDS results recorded in the September 2013 field duplicate sample (160 mg/L and 330 mg/L, respectively) have been excluded from this table.

3.4.2 Leak Detection Sump Samples

The leak detection layer sumps for Cell 1&2, Cell 3, Cell 4, Cell 5 and Cell 6 were sampled on four occasions (April, June, September and December) in 2014, as scheduled.

3.4.2.1 Inorganic Chemistry Results

Water in the five sumps exhibits a high dissolved ion load. Elevated TDS primarily reflects high concentrations of sodium and bicarbonate (alkalinity) due to water contact with bentonite within the liner system.

Table 3-13 provides a summary of concentrations for select parameters in the Cell 1&2 sump since initiation of monitoring in 1998. As indicated, there has been significant variation in parameter concentrations. TDS and sulphate were high initially but have decreased over time, for sulphate most notably in 2011. The 2014 concentrations were within the previously recorded ranges, and 2014 TDS levels were toward the lower end of the previously recorded range. Iron and manganese were not detected in the 2014 samples. Of note, TOC, which has been as high as 64 mg/L (in December 2000), has been below 10 mg/L since December 2009. Chloride is highest (overall) in the Cell 1&2 sump relative to the other sumps.

It is noted that chloride levels in Cell 1&2 were generally consistent up to June 2008 and, with the exception of some early samples and the September 2004 (44 mg/L) sample, concentrations were less than 20 mg/L. Since that time, chloride concentrations have shown significant variation, ranging from 16 to 83 mg/L (in December 2008). Calcium and hardness show gradually increasing trends, while nitrates were significantly higher in late 2008 and early 2009 (i.e., up to 13 mg/L in December 2008). No potential sources of nitrate have been identified and concentrations have lowered since that time. The 2014 concentrations ranged from 0.11 mg/L in June to 3.8 mg/L in September and remained significantly below the high.

Table 3-13 Leak Detection Cell 1&2 Sump - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
1998	28-29	960	1950-1960	7.5-7.7	0.6	8.1-8.3	0.041-0.042
1999	16-26	518-1100	1320-2330	7.4-17.1	<0.2-0.23	<0.02-0.21	0.003-0.06
2000	14-28	596-1190	1610-2660	18.9-64	0.4-2.3	0.16-0.84	<0.005-0.05
2001	11-18	741-844	1840-2260	5.2-62.4	0.24-3.5	0.052-0.32	0.017-0.042
2002	11-16	140-640	817-2090	5.7-51.2	<0.2-2	<0.02-0.04	0.005-0.027
2003	7-19	180-490	698-1580	18.8-28.7	0.24-1.4	0.01-4.2	<0.05-0.018
2004	15-44	260-400	973-1820	15.9-17.5	<0.05-1.3	0.1-0.9	<0.05-0.012
2005	15-17	270-400	1040-1440	12-24	<0.05-2.0	0.005-0.16	0.006-0.015
2006	14-16	290-370	1100-1510	14-24	<0.05-0.35	<0.02-0.023	<0.05-0.016
2007	10-13	160-250	576-999	6.4-13	0.69-2.24	0.69-2.24	0.08-0.19
2008	14-83	84-280	590-1200	9.9-18	<0.05-3.9	0.006-0.18	0.007-0.022
2009	29-53	69-150	556-948	6.8-17	0.068-8.0	0.005-0.43	0.008-0.058
2010	16-48	70-180	599-722	6.1-7.8	<0.05	0.004-0.007	<0.005-0.019
2011	19-29	34-48	466-579	3.6-7.5	<0.05-1.64	<0.002-0.066	<0.005-0.021
2012	35-50	47-58	537-626	6.1-6.4	<0.05-0.18	<0.002-0.015	0.010-0.037
2013	22-56	35-55	460-665	4.3-6.3	<0.05	<0.002-0.005	<0.005-0.014
2014	22-38	36-59	490-560	3.8-6.9	<0.05	<0.002	<0.005-0.11

Table 3-14 provides a summary of concentrations for select parameters in the Cell 3 sump since the initiation of monitoring in 2003. Similar to the comments made for the Cell 1&2 sump, sulphate and TDS levels have decreased over time and, in 2014, sulphate and TDS concentrations were within the previously recorded ranges. Chloride concentrations increased from 2009 to 2012 (with the high of 28 mg/L recorded in March 2010); however, concentrations since that time have been within the previously recorded range, including 2014. Of note, some of the 2014 concentrations of iron in Cell 3 were the highest since June 2006 (i.e., 9.7 mg/L) noting that, since December 2007, concentrations had been below 1 mg/L until June 2014 (4.8 mg/L) and September 2014 (6.8 mg/L). However, the December 2014 concentration was significantly lower (0.18 mg/L). Relative to Cell 1&2, concentrations of sulphate were not as high in initial samples collected from this sump; however, concentrations have decreased over time at this location.

Upon comparison, calcium and hardness levels in Cell 3 have also been increasing over time, although chloride (for the most part) and nitrate levels have been generally consistent. In particular, the 2014 concentrations of nitrate (non-detect to 1.6 mg/L in June) were within the previously recorded range (i.e., non-detect to 3.0 mg/L in June 2007).

Table 3-14 Leak Detection Sump 3 - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2003	8-13	200-440	799-1730	30.3-52.6	<0.05-0.78	0.037-0.69	<0.005-0.068
2004	8-11	63-220	434-955	10-44	0.88-4.3	0.2-1.1	0.012-0.056
2005	7-10	140-360	559-1030	35-65	1.3-19	0.17-0.66	0.013-0.11

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2006	10-17	380-470	743-999	32-150	0.38-9.7	0.016-0.11	<0.05-0.01
2007	9-16	130-160	571-674	23-32	0.23-2.4	0.007-0.039	0.008-0.01
2008	14-17	110-170	594-690	25-35	<0.05-0.62	0.041-0.47	<0.005-0.012
2009	23-27	98-150	541-747	20-38	0.23-0.43	0.11-0.86	0.008-0.010
2010	25-28	100-140	644-811	20-40	0.09-0.49	0.383-0.828	0.006-0.018
2011	18-27	74-110	619-680	16-24	0.10-0.18	0.14-0.50	<0.005-0.011
2012	14-25	52-83	572-683	12-27	0.17-0.35	0.080-0.91	0.006-0.016
2013	10-14	29-46	480-540	7.1-11	0.064-0.15	0.67-1.5	<0.005-0.0096
2014	18-26	45-75	540-610	12-15	0.13-6.8	0.085-0.57	0.0077-0.031

Table 3-15 provides a summary of concentrations for select parameters in Cell 4 sump water since June 2006. Cell 4 data has been fairly consistent; however, TDS and sulphate have decreased over time. The December 2014 concentration of iron was marginally above the high recorded in the initial June 2006 sample. Remaining 2014 concentrations were generally similar to or lower than levels recorded in 2006. The Cell 4 sump contains higher TDS levels relative to other cells.

Table 3-15 Leak Detection Sump 4 - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2006	11-23	430-1200	1190-2450	15-26	<5-1.1	<0.02-0.057	<0.05-0.015
2007	8-14	240-730	1040-1740	12-19	0.27-0.46	0.009-0.2	0.007-0.016
2008	8-15	220-690	999-1740	14-32	0.086-0.65	0.003-0.013	0.011-0.081
2009	13-15	160-430	1220-1610	25-35	<0.05-0.076	0.002-0.004	<0.05-0.014
2010	13-18	230-300	1250-1320	21-26	<0.05-<0.5	<0.002-<0.02	<0.05-0.0110
2011	18-20	310-390	1330-1400	23-25	<0.05-0.055	<0.002-0.003	0.012-0.017
2012	9-19	96-330	508-1230	18-26	0.23-0.89	0.005-1.8	0.021-0.035
2013	17-20	310-390	1070-1300	16-21	0.74-0.89	0.019	0.0083-0.071
2014	17-23	230-420	990-1300	16-23	0.060-1.2	0.0022-0.037	0.010-0.021

Note: Some 2009 iron and manganese levels had non-detect concentrations at elevated detection limits. Since elevated detection limits were greater than the detected concentrations, these were not included in the table.

The 2014 data represents the seventh year of monitoring Cell 5 sump water, noting that the single 2008 result represents a sample collected following an observance by site personnel of abnormally coloured/turbid water during pumping. Table 3-16 provides a summary of concentrations for select parameters since that time. Concentrations of most parameters (including sulphate and TDS) had decreased from 2008/2009 levels. A possible exception is chloride. Chloride concentrations had lowered from initial levels and were 8 mg/L or less between September 2009 and December 2011. However, since April 2012, concentrations have ranged from 11 mg/L to 16 mg/L in April 2013. The 2014 chloride concentrations were comparable to levels recorded since 2012. Manganese concentrations remained below the high recorded in April 2013. Similar to the other sump waters, variability in parameter concentrations has been observed over time.

Table 3-16 Leak Detection Sump 5 - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2008	15	890	2560	35	21	0.62	0.24
2009	7-17	140-920	890-2340	6.3-22	<0.05-<0.5	0.011-0.036	0.010-0.039
2010	5-7	76-93	698-785	4.2-5.9	<0.05	0.033-0.095	0.008-0.012
2011	6-8	45-64	499-641	3.2-4.3	<0.05-0.078	0.018-0.13	0.008-0.019
2012	11-12	95-140	714-816	7.1-17	<0.05-0.71	0.15-2.0	<0.005-0.17
2013	14-16	83-140	718-840	10-11	<0.05-2.4	0.10-2.4	<0.005-0.18
2014	13-14	64-83	780-820	9.8-12	<0.05-0.18	0.041-0.12	<0.005-0.0081

Note: Some 2009 manganese and zinc levels had non-detect concentrations at elevated detection limits. Since elevated detection limits were greater than the detected concentrations, these were not included in the table.

The 2014 data represents the second year of monitoring Cell 6 sump water noting that, although the sump was in operation during the December 2012 monitoring event, the sump contained insufficient water to collect a sample. A summary of indicator parameters is presented in Table 3-17. The 2014 concentrations of chloride, sulphate and TDS were below the concentrations recorded in 2013; whereas, concentrations of TOC, iron, manganese and zinc were generally similar. With a limited data set, it is not practical to ascertain trending at this time.

Table 3-17 Leak Detection Sump 6 - Summary of Indicator Parameters

Year	Concentrations in mg/L						
	Chloride	Sulphate	TDS	TOC	Iron	Manganese	Zinc
2013	9-12	150*-320	780-1040	4.7-5.8	<0.05-0.54	<0.002-0.025	<0.005-0.0067
2014	7-8	98-110	720-750	4.1-5.6	<0.05-0.26	<0.002-0.015	<0.005-0.0077

*Note: The sulphate concentration of 150 mg/L represents a laboratory duplicate sample.

3.4.2.2 Organic Chemistry Data

Leak detection sumps were sampled for organic compounds (TPH/BTEX, PAHs and VOCs) in September 2014. Two PAH compounds were detected in the Cell 5 sample (acenaphthene and phenanthrene at 0.011 ug/L and 0.080 ug/L, respectively), and one PAH compound (phenanthrene) was detected in samples from Cell 3 and Cell 6 at 0.01 ug/L (the laboratory detection limit) and 0.023 ug/L, respectively. Cell 6 contained a trace concentration of petroleum hydrocarbons in the fuel oil range (C_{10} to C_{21}). Modified TPH, however, was non-detect with resemblance comments indicating unidentified compounds. VOCs were not detected in the September 2014 samples. Previous leak detection samples from Cell 3, as well as Cell 1&2 and Cell 4, have contained traces of petroleum hydrocarbons and PAHs; and Cell 5 contained a trace concentration of one PAH parameter on one prior occasion (i.e., September 2009). It is noted that the September 2014 results for Cell 6 represents only the second data set for organic parameters.

3.4.3 Leachate Sample Results

Leachate samples from the holding tank were collected four times in 2014, as scheduled. The character of leachate reflects the decomposition of waste and, as expected, there is significant variation in the inorganic chemistry from one sampling event to another. Overall, 2014 data were generally comparable to previous results. In April 2014,

significantly lower concentrations of sodium, potassium, calcium, magnesium, chloride and hardness, as well as several metals parameters (including antimony, boron, chromium, molybdenum, nickel, strontium, tin, uranium and vanadium) were observed in comparison to previous results; however, subsequent concentrations were higher than April 2014 and within the previously recorded ranges. The April 2014 nitrate concentration was the highest recorded to date (i.e., 290 mg/L), and remaining 2014 concentrations (15 to 52 mg/L) were lower and comparable to concentrations recorded prior to April 2014 (i.e., <0.05 to 270 mg/L).

In September 2014, VOCs were not detected with the exception of one compound (1,2-Dichloroethane) detected at a concentration equivalent to the detection limit (i.e., 0.001 mg/L). Petroleum hydrocarbons were detected in the gas ($C_{6\text{-}10}$), fuel oil (C_{10}-C_{21}) and lube oil (C_{21}-C_{32}) ranges. Modified TPH was 0.48 mg/L (fuel and lube oil resemblances). For PAHs, nine compounds were detected ranging from 0.000010 mg/L (at the laboratory detection limit) to 0.00011 mg/L (for a total PAH concentration of 0.00040 mg/L). These occurrences were comparable to previous results.

4.0 Summary and Conclusions

Monitor wells and surface water sampling stations were established in 1996 as part of the hydrogeological and hydrological assessment of the Otter Lake Solid Waste Management Facility. Sampling was continued through to the end of 1998 in association with site construction. These data provide the baseline for which subsequent data are compared.

The 2014 sampling program represented the sixteenth year of operational monitoring at the facility. The program, conducted in approval with NSE, involved quarterly sampling events undertaken in April, June, September (annual event) and December. Monitoring includes the collection of groundwater, surface water, leak detection sump and leachate samples. Consistent with previous monitoring events, the 2014 program focused on general inorganic chemistry and metal parameters with inclusion of TPH/BTEX, VOCs and PAHs for select samples during the September (annual) monitoring event. Surface waters were also sampled for TSS and, in some instances, COD/BOD. In addition, sediment samples for metals analysis were collected at three locations during the September monitoring event.

Groundwater analytical data were compared to the Health Canada Drinking Water Quality (DWQ) Guidelines and surface water analytical results to the Canadian Council of Ministers of the Environment (CCME) Freshwater Aquatic Life (FWAL) Guidelines and the provincial "Pit and Quarry Guidelines" discharge limit. Data were also compared to baseline data collected between 1996 and 1998 and operational monitoring results collected from 1999 through to present. Sediment data were compared to the CCME Sediment Quality Guidelines for Protection of Aquatic Life, as well as historical data. In absence of relevant guidelines, leak detection sump and leachate sample results were compared to previously collected data only.

Elevated levels of indicator parameters in waters down gradient of the landfill and in the immediate vicinity of the FEP likely reflect site operations (i.e., roadway drainage and earthworks) rather than actual landfill impacts. As outlined below, it was anticipated that the elevated levels of indicator parameters immediately down gradient of Cell 5 and Cell 6 (observed since construction of Cell 5 in 2008 and Cell 6 in 2011/12) would eventually stabilize; however, this has not occurred to date and the area is still showing influence from routine site operations. Sediment control measures undertaken at the site in 2014, including construction of a sediment basin at the foot of future Cell 7, as well as sodding and hydro-seeding the slopes of Cells 4 and 5 on the down gradient side of the landfill, should help to stabilize indicator parameter concentrations in this area.

As discussed below, in addition to the increases noted for the down gradient wells (i.e., below Cell 5 or Cell 6), there appears to be a general increase in indicator parameter concentrations at some locations immediately up gradient of the landfill (i.e., two wells up gradient of Cell 2 and one well up gradient of Cell 5) as well as in the northeast corner of

the landfill/topographically up gradient of the FEP compound (two wells). These locations appear to be influenced by local site operations and roadway runoff. However, this influence is not apparent in further up gradient locations (i.e., MW01-26B and MW01-27B). It is important to note the following:

- These wells are adjacent to the site access road, which was subject to increased truck traffic during Cell 5 and Cell 6 construction and is still heavily used by trucks to access the current disposal cell;
- There is a grubbing area located immediately up gradient of Cells 5 and 6, which was active during construction of these cells generally between 2008 and 2012;
- The wells up gradient of Cell 2 are adjacent to an operational white goods area; and
- The wells at the northeast corner of the landfill are located within a ditch that receives drainage from roadway runoff.

As previously reported, runoff from Cell 6 (under construction between October 2011 and October 2012) had been directed to the South Sedimentation Ponds, which had presumably contributed to the higher metals concentrations recorded at these sampling locations during 2012. Since completion of Cell 6 construction activity (late 2012), concentrations of metals, as well as turbidity, in the South Sedimentation Pond samples have been lower and comparable to levels recorded prior to Cell 6 construction. The receiving waters below the South Sedimentation Ponds had also exhibited generally higher levels during Cell 6 construction and/or during precipitation events; however, levels recorded in 2014 were also comparable to earlier results (i.e., prior to Cell 6 construction). This area is prone to flooding on occasion (as occurred in April 2014). A new sediment basin constructed at the base of future Cell 7 in early to mid-2014 (prior to the second quarter sampling event in June) now collects run-off from the Cell 6 area.

Overall, there is no significant indication of off-site environmental impacts to either the surface or groundwater as a result of either site operations or recent construction activities. Parameter exceedances to applicable guidelines have been recorded since the initiation of baseline sampling and have been observed at both background and downstream/down gradient surface and groundwater sampling locations.

Specific comments pertaining to groundwater and surface water, as well as sediments, the leak detection sumps and leachate, are provided in the following paragraphs.

Groundwater

The 2014 hydraulic head elevations were generally comparable to previously recorded elevations. Higher elevations observed in the spring and lower elevations observed in the fall in some wells were reflective of seasonal influences. Lower hydraulic head levels observed since 2008 in the up gradient area of Cell 5 have been attributed to installation of an underdrain as part of cell construction, and the 2014 groundwater elevations in this area were comparable

(overall) to levels observed since 2008. Overall, there has been no change in groundwater flow patterns related to landfill activities. Groundwater flow has consistently been generally westward with downward hydraulic gradients (indicative of groundwater recharge conditions) occurring in the southern and eastern higher topographic areas of the site and localized areas at the base of the landfill footprint.

Parameters above (or, in the case of pH, below) the CDWQ Guidelines in 2014 are summarized in Table 4-1. These parameters were similar to previous events, with iron and manganese being the most commonly observed and pH below the recommended range in several samples at both up gradient and down gradient locations. With the exception of uranium, parameters were elevated in both the till (surficial) and bedrock wells. Uranium exceedances were observed in bedrock wells at primarily down gradient locations and, with the exception of four wells (down gradient of Cell 1, down gradient of FEP and two up gradient wells), the concentrations were consistent with previous results (baseline and operational). Of note, the highest concentrations of arsenic were associated with the cross gradient locations. The presence of uranium, as well as arsenic, in groundwater at the site is presumed to be naturally occurring. Elevated concentrations of iron, manganese, colour, turbidity, as well as low pH, are typical in Nova Scotia groundwater and presence is, therefore, not normally considered to be an issue of concern.

Table 4-1 Summary of 2014 Groundwater Exceedances

Month (No. Samples)	Sampling Area (No. of Wells)			
	Up Gradient (10)	Cross Gradient (4)	Down Gradient (27)	Down Gradient of FEP and/or Cross Gradient of Landfill** (10)
April (29)	n/a	n/a	low pH (12) colour (5) turbidity (4) arsenic (1) iron (7) manganese (11) uranium (6)	low pH (5) colour (1) turbidity (1) iron (1) manganese (1)
June (28)*	n/a	n/a	low pH (13) colour (5) turbidity (5) arsenic (3) iron (8) manganese (12) uranium (7)	low pH (5) colour (1) iron (1) manganese (2)
September (48*)	low pH (3) colour (1) iron (3) manganese (6) uranium (2)	low pH (3) colour (1) arsenic (1) iron (3) manganese (2)	low pH (11) colour (6) turbidity (4) arsenic (4) iron (7) manganese (13) uranium (11)	low pH (4) colour (1) iron (1) manganese (2) uranium (1)
December (29)	n/a	n/a	low pH (13) colour (8) turbidity (5**) arsenic (3)	low pH (5) colour (1) turbidity (1)

Month (No. Samples)	Sampling Area (No. of Wells)			
	Up Gradient (10)	Cross Gradient (4)	Down Gradient (27)	Down Gradient of FEP and/or Cross Gradient of Landfill** (10)
			iron (9) manganese (14) uranium (6)	iron (1) manganese (1)

Notes:
(1) – represents number of samples.
n/a – not applicable (samples not collected)
April, June, September and December represent operational monitoring events.
In 2014, FEP wells MW96-16A/16B, typically sampled annually, were sampled quarterly to assess observed changes in water quality.
*In June 2014, MW96-5A (down gradient area) was dry; and in September 2014, MW96-5A, MW96-20A and MW97-24A (down gradient area) were either dry or contained insufficient water to collect a sample.
**In December 2014, turbidity was above the guideline in the primary duplicate sample from MW05-29C but below the guideline in the field duplicate sample.

A general increase in TDS, colour, iron and manganese has been noted in down gradient wells MW96-5A/5B/5C (below Cells 5 and 6). Chloride in the shallow and deep bedrock wells remained below the highs recorded in June 2013 but above the modified baseline range (i.e., excluding the anomalous November 1997 results). Overall, chloride concentrations, which had generally been less than 10 mg/L in all three wells prior to 2010, indicate gradually increasing trends, most notably for the shallow and deep bedrock wells. Concentrations of one or more indicator parameters have been gradually increasing at some down gradient locations, including till well MW97-23A1 (near the South Sedimentation Pond), interface well MW08-30B (which has been sampled since 2008) and deep bedrock well MW05-29C (which has been sampled since 2005), with concentrations of one or more parameters higher during 2014.

Levels of chloride, TDS, iron and manganese in the vicinity of the FEP have been variable, with TDS (as well as hardness, conductivity and sulphate) generally increasing at one location (MW96-16A/16B) topographically up gradient of the FEP and near the northeast corner of the landfill. It is noted that MW96-16A/16B are located within a ditch along a site road that is heavily used by trucks to access the current disposal cell. Water quality in this area is likely influenced by operations activities in the up gradient area of the site, roadway runoff and/or the FEP/WSF compound.

Indicator parameter concentrations are also increasing at locations up gradient of the landfill. For MW95-2A/2B (up gradient of Cell 5), TDS levels have generally increased since 2008. For the deeper well (MW95-2A), other parameters have increased in recent years, such as, chloride (the 2014 concentration was equivalent to the prior high of 10 mg/L), hardness, conductivity, manganese (higher than previously recorded in 2014) and uranium. These wells are located along the up gradient site access road and experienced heavy traffic during the construction periods (i.e., both Cell 5 in 2008 and Cell 6 in 2011/2012), and a grubbing area using during cell construction (2008

to 2012) is immediately up gradient. In addition, this area may still be showing affects from routine site operations. Levels of chloride and/or TDS (as well as other major cations and anions, including hardness and conductivity) have generally increased in MW01-15B/15C, up gradient of Cell 2, since September 2013. These wells are located adjacent to a roadway, which had been subject to increased traffic during Cell 6 construction in 2011/2012 and are immediately adjacent to a white goods area. The area may be subject to periodic traffic and site operations activity (noting that the original wells installed at this location, MW96-15A/15B/15C, were destroyed and subsequently replaced by MW01-15A/15B/15C; and, in 2011, MW01-15A was found destroyed). Therefore, as recommended, the wells have been barricaded/secured to protect the wells from equipment and traffic operating in close proximity. Although concentrations of TDS were higher up gradient of future Cell 7, these wells have been sampled since 2012 and only four data sets have been collected to date. It is not possible to assess trending at this time.

Overall, the highest levels of colour and iron, as well as turbidity (historically), have been observed in the till (surficial) well MW96-22A (down gradient of the North Sedimentation Pond); while concentrations in the bedrock well at this location are significantly lower or non-detect. It is noted that these wells are located adjacent to the sedimentation pond discharge point. If, over time, the integrity of the surficial well has been compromised, then, based on future monitoring results and any observed increasing trend in chloride concentrations, consideration may need to be given to rehabilitating and/or replacing this well.

Variation in general inorganic chemistry is attributed to seasonal influences and is typical; particularly of shallow groundwater character (due to more frequent recharge). With the above-noted exceptions, there were very few instances overall where 2014 parameter concentrations in samples from a particular well represented the highest concentrations recorded to date; and, in all instances, the difference between the highest and lowest parameter levels recorded over time was not considered significant. Samples from a few down gradient (till and/or shallow bedrock) wells and in the vicinity of the FEP exhibit the greatest variation in TDS and have generally contained higher levels compared to their respective baseline concentrations and/or concentrations in samples from other wells.

Of the 15 samples submitted for organics analysis in September 2014, one down gradient well (near the South Sedimentation Pond) contained detectable concentrations of petroleum hydrocarbons in the fuel (C_{10}-C_{21}) and lube oil (C_{21}-C_{32}) ranges (there are no CDWQ Guidelines established for these compounds). Toluene was detected at a concentration that exceeded the CDWQ Guidelines (health limit and aesthetic objective) in the VOC sample but was below the guidelines in the TPH/BTEX sample. TPH compounds have occasionally been detected in prior samples from this location (which contains an ant nest that could contribute organic compounds to the well water). In December 2013, this well was resampled for TPH/BTEX (following the September 2013 event) and analyzed after performing a silica gel cleanup. The results were non-detect, indicating that the presence of these compounds at this location are naturally occurring and not petrogenic in nature. Organic compounds were not detected in the remaining 14 TPH/BTEX and VOC samples submitted for analysis. One PAH compound, phenanthrene, was detected at low

concentrations in samples from nine wells, some of which have exhibited detections of this compound in one or two prior samples. The laboratory indicated the presence of sediment in these samples, which can contribute to concentrations of some organic parameters (including phenanthrene).

Surface Water and Sediments

Samples were collected from 14 of the 15 surface water stations in September 2014 (SW-16 was dry) and, with the exception of one station in April 2014 (SW-4, which was inaccessible due to flooding), from the 10 scheduled stations during April, June and December. Based on field observations, surface water flow conditions were (generally) high in April, moderate in both June and December, and low in September. However, two stations in the vicinity of the FEP (SW-15 and SW-16) were sampled in June under high flow conditions, as a precipitation event commenced immediately prior to sample collection at these stations.

Parameter occurrences above (or, in the case of pH, below) the FWAL Guidelines are summarized in Table 4-2. The parameters exceeded (including aluminum and iron at most of the stations) were generally similar to previous events. Aluminum and iron have exceeded the recommended FWAL Guidelines, and pH has been below the recommended range, in samples collected from surface water upstream and downstream of site activities since the initiation of sampling in 1996, including pre-construction sampling. Other parameters, specifically arsenic, cadmium, chromium, copper, lead, mercury, selenium, silver, zinc, and TSS, have exceeded the recommended limits at one or more stations on one or more occasions. Exceedances observed during 2014 included arsenic, cadmium, chromium, copper, lead, zinc and/or TSS in one or more samples, the majority occurring during June 2014 in samples from the FEP stations. It is noted that the June 2014 FEP samples were collected during a precipitation event, which had commenced immediately prior to sample collection at these stations. This increased flow conditions increased and, as a result, metals concentrations at these stations. However, in general, elevated concentrations of all these parameters are typical occurrences in surface water and their presence, for the most part, is not considered to be an issue of concern at the Otter Lake facility.

Overall, the greatest number of exceedances was associated with the North Sedimentation Pond and FEP sample stations, and metals concentrations (excluding June 2014 in the FEP samples) were generally consistent with previous results.

Table 4-2 Summary of 2014 Surface Water Exceedances

Month (No. Stations Sampled)	Otter Lake (2)	Nine Mile River (5)	Duck Pond (2)	North Sed. Pond (2)	South Sed. Pond (2)	FEP (2)
Location	outside WS	2 US, 3 DS	DS	DS	DS	DS
April (9)[1]	n/a	low pH (1 US, 2 DS) aluminum (1 US, 2 DS) cadmium (1 DS) iron (1 DS)	low pH (1) aluminum (1) iron (1)	low pH (1) aluminum (2) cadmium (1) chromium (1)	aluminum (1) iron (1)	aluminum (2) copper (2) iron (2**)

Month (No. Stations Sampled)	Otter Lake (2)	Nine Mile River (5)	Duck Pond (2)	North Sed. Pond (2)	South Sed. Pond (2)	FEP (2)
Location	outside WS	2 US, 3 DS	DS	DS	DS	DS
				copper (1) iron (2) lead (1)		
June (10)	n/a	low pH (1 DS) aluminum (1 US, 2 DS) iron (1 US, 1 DS)	low pH (1) aluminum (1) iron (1)	aluminum (2) iron (1*)	aluminum (2) iron (1)	TSS (2) aluminum (2) arsenic (1) cadmium (2) chromium (2) copper (2) iron (2) lead (2) zinc (2)
September (14)[2]	low pH (2) aluminum (2)	aluminum (1 US, 3 DS)	low pH (1) aluminum (2) iron (2)	aluminum (2)	aluminum (2) iron (1)	iron (1)
December (10)	n/a	low pH (1 US, 1 DS) aluminum (1 US, 2 DS) iron (1 US, 2 DS)	low pH (1) aluminum (1) iron (1)	aluminum (2)	aluminum (2) iron (1**)	aluminum (2) copper (2) iron (2)

Notes:
(1) – represents number of samples.
US – upstream
DS – downstream
1. SW-4 (South Sedimentation Pond area) was inaccessible for sampling due to flooding in April 2014.
2. SW-16 (FEP area) was dry in September 2014.
*Iron was above the guideline in the field duplicate sample from SW-3. Primary sample concentration was equivalent to (but did not exceed) the guideline.
**Field duplicate concentrations for iron in SW-4 in December and SW-16 in April were below the guideline.

Variation in inorganic chemistry has been observed at all stations since the initiation of the sampling. For the most part, this variation is attributed to seasonal influences and is typical of surface water character. The downstream monitoring results from Nine Mile River are comparable to upstream suggesting little to no influence from landfill activities. It is noted that the North and South Sedimentation Ponds water, and particularly the FEP drainage ditch (and downstream) samples, have historically contained higher concentrations of inorganic chemistry and metals parameters compared to both baseline and other Otter Lake stations. One exception is chloride, which is generally lower in pond and associated downstream samples compared to Nine Mile River levels. Once cell construction activities were completed (late 2012), concentrations of metals, as well as turbidity, in this area of the site decreased, although increased runoff as a result of precipitation events may contribute to higher turbidity and metals in general in the vicinity of the receiving waters for the South Sedimentation Ponds, which tends to flood on occasion (as occurred in April 2014). A new sediment basin constructed in 2014 and located at the foot of future Cell 7 now collects run-off from the Cell 6 area. The water discharging from the FEP area continues to have higher levels of indicator parameters (with the exception of chloride) relative to other stations.

With the exception of one PAH compound (phenanthrene) detected at a low concentration, organic compounds were not detected in the two samples submitted for organics analysis (one station also scheduled for organics analysis, SW-16, was dry). Phenanthrene is naturally occurring in surface water is present at low concentrations in background soils in Nova Scotia. The low concentrations detected in the samples are presumably attributed to the presence of sediment in the samples.

Sediment samples were collected in September 2014 for metals and mercury at three surface water stations: downstream of North Sedimentation Pond, downstream of South Sedimentation Pond and within the FEP drainage ditch. Exceedances included arsenic (at the three stations), cadmium, chromium, copper, lead, mercury, and/or zinc (noting that cadmium and mercury concentrations downstream of the North Sedimentation Pond were marginally above the guidelines). Concentrations were comparable to previous results, with the exception of slightly higher mercury at the station downstream of the North Sedimentation Pond. For the station downstream of the South Sedimentation Pond, it is noted that chromium and zinc, which had been above the guidelines on one prior occasion (September 2013), were lower, with chromium slightly above the guideline and zinc below the guideline in September 2014.

Underdrain

The Cell 1&2 and Cell 4A Underdrains have consistently been dry. In addition, Cell 4B has historically exhibited very little flow relative to the other underdrains, and there was no flow in April, June and September 2014. Consistent with previous results, parameters above the DWQ Guidelines in 2014 included turbidity and manganese in the Cell 4B Underdrain sample and manganese and low pH in the Cell 5 Underdrain samples. Organic compounds (analyzed in September) were not detected in the Cell 3, Cell 5 and Cell 6 Underdrain samples (organics were not sampled for the Cell 4B Underdrain since there was no flow during the annual event in September). Cell 3 Underdrain has exhibited some variation in inorganic chemistry parameters. Overall, there has been no significant change in chemistry. TDS levels have generally lowered from the higher concentrations recorded between 2009 and 2012 and, of note, the 2014 concentrations were below initial (i.e., 2003) levels. Manganese had been generally increasing in the Cell 4B Underdrain; however, the December 2014 concentration was comparable to initial concentrations. TDS (and hardness and conductivity) also appear to be generally increasing; however, concentrations were within the prior ranges. Other parameters remain comparable to previous results. For the Cell 5 Underdrain, indicator parameter concentrations were comparable overall to previous results, with marginally higher chloride and TDS observed on one occasion each during 2014. Chloride has exhibited little variation since initiation of sampling in April 2009 (with levels, including 2014, at 10 mg/L or less). TDS, iron and manganese remain higher than the initial samples. The Cell 6 Underdrain was added to the monitoring program in December 2012, and to date there are only nine data sets. The 2014 results were generally similar to previous results; however, sulphate and TDS concentrations were higher than recorded on one occasion each (the differences were minor). Trending cannot be ascertained at this time given the limited data set.

Leak Detection Sumps

The sump waters from Cell 1&2, Cell 3, Cell 4 and Cell 5 sampling ports exhibit a high dissolved ion load, likely due to water contact with the bentonite layers in the liner system. TDS and sulphate concentrations in each cell have decreased over time. Chloride has exhibited an overall increase in Cell 1&2 (with the highest concentration recorded in late 2008), as well as other parameters (including calcium and hardness). High nitrate concentrations were recorded in late 2008/early 2009; however, no potential sources of nitrate have been identified, and concentrations (including 2014 samples) have lowered since that time. Chloride in Cell 3 generally increased in 2009, and the majority of levels recorded since that time have been comparable to 2009 concentrations (including 2014). Similar to observations made for Cell 1&2, calcium and hardness have increased over time at this location, whereas nitrate has remained relatively consistent. Cell 4 data has been relatively consistent (including 2014 results) with overall decreases in TDS and sulphate; however, iron in the December 2014 sample was marginally higher than previously recorded. Samples from this sump contain the highest levels of TDS relative to other sumps. Overall, inorganic parameter concentrations in Cell 5 remain below concentrations in the initial Cell 5 samples (2008/2009). Chloride concentrations have been variable in general, and the 2014 concentrations were within the previously recorded ranges. The 2014 data represents the second year of monitoring for the Cell 6 sump. The 2014 indicator parameter concentrations were lower than 2013 concentrations. The presence of low concentrations of organics, including one or two PAH compounds detected in three sumps, hydrocarbons in the fuel oil range in one sump, was comparable to historical observations made for other sumps and is not considered to reflect an issue of concern.

Leachate

Leachate samples from the holding tank were collected four times in 2014, as scheduled. The character of leachate reflects the decomposition of waste and, as expected, there is significant variation in the inorganic chemistry from one sampling event to another. Overall, the 2014 data (both organic and inorganic chemistry) were comparable to previous results. Minor exceptions included lower concentrations of some inorganic chemistry and metals parameters, as well as slightly higher nitrate, in the April 2014 sample. Subsequent concentrations were within the ranges recorded prior to April 2014.

5.0 Recommendations

The purpose of a surface and groundwater monitoring network is to provide a means of assessing changes in hydrogeological and hydrological characteristics/quality over time. These changes are then evaluated to determine whether they are indicative of impact associated with site operations.

A monitoring program must be structured such that changes in sample frequency and/or parameters analyzed (incorporation of additional analysis) can be made in accordance to site conditions encountered. The intent is to establish a solid baseline for which on-going data can be compared to determine variation in quality opposed to trends. Variation in both surface and groundwater quality is common and typically represents natural seasonal influences. Trends could potentially indicate impact from site activities or, on the other hand, they could reflect stabilization in quality.

There are essentially three objectives to monitoring. First, it is necessary to identify parameters of potential concern above appropriate guidelines and/or background as well as changes in general character over time. Second, it is necessary to evaluate presence of exceedances and/or change in character in terms of quality deterioration or environmental impact. The third objective is to recommend an appropriate level of action to address confirmed issues of concern. Based on these objectives, it is prudent that the 2015 program be designed to focus on down gradient and/or cross-gradient areas of the site which have either exhibited some indication of change and/or have a higher potential for change. In particular, for groundwater, this is the down gradient discharge area in the western low-lying region of the site. The primary issue regarding surface water quality relates to the on-site ditch below the FEP and drainage immediately down gradient of the sedimentation ponds.

Aside from the potential issues mentioned in the preceding information, there is no indication that activities associated with the Otter Lake Solid Waste Management Facility have caused offsite environmental impacts. Based on this conclusion, it is recommended that there be no changes to the monitoring program, with the exceptions of some minor revisions (similar to previous years) in regard to the wells selected for organic analysis following the protocol noted below and the continuation of sampling MW96-16A/16B quarterly in 2015 (similar to 2014, which was at NSE's request).

Groundwater

In this regard, it is recommended that the level of effort for monitoring be consistent with the 2014 program and include four sampling events (April, June, September and December). The April, June and December events should include testing for general inorganic chemistry and metal parameters on a select number of wells. The September event should include these parameters for all of the monitor wells. Organic compounds (i.e., petroleum hydrocarbons, VOCs and PAHs) should continue to be tested in monitor wells which exhibit iron levels >1 mg/L, contain elevated

levels of chloride (in comparison to other samples) and/or have previously shown presence of organic compounds. Details pertaining to the groundwater monitoring program are provided in Table 5-1.

Surface Water and Sediments

The surface water and sediment sampling program for 2015 is the same as recommended for 2014 (refer to Table 5-2). Surface water includes annual monitoring of five stations and quarterly sampling at the remaining 12 stations. Sediment monitoring includes annual collection of samples for metals at three stations.

Other Monitoring

The underdrains at the base of the cells should be tested for general inorganic chemistry and metals during all four sampling events. Organics (VOCs, PAHs and TPH/BTEX) should be included in the September event. Similar recommendations are made for Cells 1&2, 3, 4, 5 and 6 leak detection sump waters and leachate. Details are provided on Table 5-3.

Table 5-1 Groundwater Sampling Recommendations

Well ID #	Aquifer	2015 Sampling Frequency	Analysis	Location
MW96-1B	Bedrock (Granite)	Quarterly	GC, M for each event	Perimeter well, down gradient of Cells 1&2
MW97-2B1	Bedrock (Granite)	Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX on one event (Sept.)	Perimeter well, down gradient of Cells 1&2
MW96-3A MW96-3B MW96-3C	Till Bedrock (Granite) Bedrock (Granite)	Quarterly Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 3A on one event (Sept.)	Nested perimeter wells, down gradient of Cells 1&2 and Cell 3
MW96-4B	Bedrock (Granite)	Quarterly	GC, M for each event	Perimeter well, down gradient of Cell 4 and adjacent to leachate holding tank
MW96-5A MW96-5B MW96-5C	Till Bedrock (Granite) Bedrock (Granite)	Quarterly Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 5B on one event (Sept.)	Nested perimeter wells, down gradient of Cell 5 and up gradient of South Sedimentation Ponds
MW96-7A MW96-7B MW96-7C	Till Bedrock (Granite) Bedrock (Granite)	Annually Annually Annually	GC, M for each event	Nested perimeter wells, down gradient of future cells and south of borrow area
MW96-8A MW96-8B MW96-8C	Till Bedrock (Granite) Bedrock (Granite)	Annually Annually Annually	GC, M for each event	Nested perimeter wells, down gradient of future cells
MW96-9A MW96-9B	Till Bedrock (Granite)	Annually Annually	GC, M for each event VOCs, PAHs, TPH/BTEX for 9A on one event (Sept.)	Nested perimeter wells, southwest of Cells 1&2, cross gradient of future cells

Table 5-1 Groundwater Sampling Recommendations (cont.)

Well ID #	Aquifer	2015 Sampling Frequency	Analysis	Location
MW96-10B MW96-10C	Bedrock (Granite) Bedrock (Granite)	Annually Annually	GC, M for each event	Nested perimeter wells, southwest of Cells 1&2, cross gradient of future cells
MW96-11B	Bedrock (Granite)	Annually	GC, M for each event	Perimeter well, south corner of landfill and up gradient of future cells
MW96-12B	Bedrock (Granite)	Annually	GC, M for each event	Perimeter well, southeast corner of landfill and up gradient of future cells
MW01-15B MW01-15C	Bedrock (Granite) Bedrock (Granite)	Annually Annually	GC, M for each event VOCs, PAHs, TPH/BTEX for 15B on one event (Sept.)	Nested perimeter wells, east of Cell 2 and up gradient of landfill
MW96-16A MW96-16B	Till Bedrock (Granite)	Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 16B on one event (Sept.)	Nested perimeter wells, northeast corner of the landfill, topographically up gradient of the FEP compound
MW96-17A MW96-17B	Bedrock (Granite) Bedrock (Granite)	Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 17B on one event (Sept.)	Nested perimeter wells, cross gradient between Cells 1&2 and the FEP compound
MW96-18B MW96-18C	Bedrock (Granite) Bedrock (Granite)	Quarterly Annually	GC, M for each event	Nested perimeter wells, cross gradient between Cells 1&2 and the FEP compound
MW96-19A MW96-19B	Bedrock (Till) Bedrock (Granite)	Quarterly Annually	GC, M for each event	Nested perimeter wells, north corner of the landfill (Cells 1&2) and down gradient of the FEP compound
MW96-20A MW96-20B	Bedrock (Till) Bedrock (Granite)	Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 20A on one event (Sept.)	Nested perimeter wells, down gradient of Cells 1&2 and Cell 3

Table 5-1 Groundwater Sampling Recommendations (cont.)

Well ID #	Aquifer	2015 Sampling Frequency	Analysis	Location
MW96-21B	Bedrock (Granite)	Quarterly	GC, M for each event	Down gradient between North Sedimentation Ponds and Nine Mile River
MW96-22A MW97-22B	Till Bedrock (Granite)	Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 22A on one event (Sept.)	Nested wells, down gradient between North Sedimentation Ponds and Nine Mile River
MW97-23A1	Till	Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX on one event (Sept.)	Down gradient between South Sedimentation Ponds and borrow pit area
MW97-24A MW97-24B	Till Bedrock (Granite)	Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 24B on one event (Sept.)	Nested wells west of the North Sedimentation Ponds and grubbing area
MW97-25B	Bedrock (Granite)	Quarterly	GC, M for each event	Well northwest of the North Sedimentation Ponds and grubbing area
MW01-26B	Bedrock (Granite)	Annually	GC, M for each event	Along Greenhead Road and up gradient of borrow pit area
MW01-27B	Bedrock (Granite)	Annually	GC, M for each event	Along Greenhead Road and up gradient of borrow pit area
MW05-28B	Bedrock (Granite)	Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX on one event (Sept.)	Perimeter well, down gradient of landfill and adjacent to leachate holding tank
MW05-29C	Bedrock (Granite)	Quarterly	GC, M for each event)	Perimeter well, down gradient of future cells and south of borrow area

Table 5-1 Groundwater Sampling Recommendations (cont.)

Well ID #	Aquifer	2015 Sampling Frequency	Analysis	Location
MW08-30B	Till/Shallow Bedrock (Granite)	Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX on one event (Sept.)	Down gradient of Cell 6 and up gradient of South Sedimentation Ponds
MW12-31B MW12-31C	Bedrock (Granite) Bedrock (Granite)	Annually Annually	GC, M for each event	Nested perimeter wells, up gradient of Cell 6 and future cells
MW95-2A MW95-2B	Bedrock (Granite) Till	Annually Annually	GC, M for each event	Nested wells up gradient of Cell 5
MW95-4A MW95-4B	Bedrock (Granite) Till	Quarterly Quarterly	GC, M for each event VOCs, PAHs, TPH/BTEX for 4B on one event (Sept.)	Nested perimeter wells north/cross gradient of Cells 1&2 and down gradient of the FEP compound

Notes:

GC	General Inorganic Chemistry Scan
M	Metals
VOCs	Volatile Organic Compounds (modified EPA 624 Scan)
PAHs	Polycyclic Aromatic Hydrocarbons (priority pollutants, part of an EPA 625 Scan)
TPH/BTEX	Petroleum Hydrocarbon Components (Atlantic RBCA Analysis)
*	Wells MW96-16A and -16B will be sampled quarterly in 2015 (similar to 2014, which was at NSE's request)

Table 5-2 Surface Water Sampling Recommendations

Station ID #	Status	2015 Sampling Frequency	Analysis	Location
SW-1	Up-gradient	Annually	GC, M, TSS for each event	Nine Mile River
SW-2	Up-gradient	Quarterly	GC, M, TSS, COD/BOD for each event	Nine Mile River
SW-3	Down-gradient	Quarterly	GC, M, TSS for each event VOCs, PAHs, TPH/BTEX on one event only Collection of a sediment sample for metals on one event only (Sept.)	Nine Mile River downstream of drainage from North Sedimentation Pond
SW-4	Facility Discharge Water	Quarterly	GC, M, TSS, COD/BOD for each event VOCs, PAHs, TPH/BTEX on one event only Collection of a sediment sample for metals on one event only (Sept.)	Drainage from South Sedimentation Pond
SW-5	Down-gradient	Quarterly	GC, M, TSS for each event	Nine Mile River
SW-6A	Down-gradient	Annually	GC, M, TSS for each event	Nine Mile River
SW-7	Down-gradient	Quarterly	GC, M, TSS for each event	Nine Mile River
SW-8A	Down-gradient	Quarterly	GC, M, TSS for each event	Duck Pond
SW-9	Down-gradient	Annually	GC, M, TSS for each event	Duck Pond
SW-10	Down-gradient, outside RDF watershed	Annually	GC, M, TSS for each event	Otter Lake

Table 5-2 Surface Water Sampling Recommendations (cont.)

Station ID #	Status	2015 Sampling Frequency	Analysis	Location
SW-11	Down-gradient, outside RDF watershed	Annually	GC, M, TSS for each event	Otter Lake
SW-13	On-Site	Quarterly (note: more frequent as part of operations)	pH and TSS either weekly or during rain events (part of operations) GC, M, TSS, COD/BOD for each event	North Sedimentation Pond
SW-14	On-Site	Quarterly (note: more frequent as part of operations)	pH and TSS either weekly or during rain events (part of operations) GC, M, TSS, COD/BOD for each event	South Sedimentation Pond
SW-15	On-Site	Quarterly (note: more frequent as part of operations)	pH and TSS either weekly or during rain events (part of operations) GC, M, TSS, COD/BOD for each quarterly event Collection of a sediment sample on one occasion	Ditch (FEP)
SW-16	Down-gradient	Quarterly	GC, M, TSS, for each event VOCs, PAHs, TPH/BTEX on one event (Sept)	Down-gradient of FEP ditch

Notes:

GC	General Inorganic Chemistry Scan
M	Metals
TSS	Total Suspended Solids
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
VOCs	Volatile Organic Compounds (modified EPA 624 Scan)
PAHs	Polycyclic Aromatic Hydrocarbons (priority pollutants, part of an EPA 625 Scan)
TPH/BTEX	Petroleum Hydrocarbon Components (Atlantic RBCA Analysis)

Table 5-3 Other Environmental Quality Monitoring Recommendations

Well ID #	2015 Sampling Frequency	Analysis
Underdrain Samples – Cell 1/2, Cell 3, Cell 4, Cell 5 and Cell 6	Quarterly	GC, M for each quarterly event VOCs, PAHs, TPH/BTEX on one event only (Sept)
Leachate	Quarterly	GC, M and TSS for each quarterly event VOCs, PAHs, TPH/BTEX on one event only (Sept)
Leak Detection Sump Cell 1/2, Cell 3, Cell 4, Cell 5 and Cell 6	Quarterly	GC parameters chloride, sodium and COD on a monthly basis as part of operations GC, M for each event VOCs, PAHs, TPH/BTEX on one event only (Sept)

Notes:

GC	General Inorganic Chemistry Scan
M	Metals
TSS	Total Suspended Solids
BOD	Biological Oxygen Demand
COD	Chemical Oxygen Demand
VOCs	Volatile Organic Compounds (modified EPA 624 Scan)
PAHs	Polyaromatic Hydrocarbons (priority pollutants, part of an EPA 625 Scan)
TPH/BTEX	Petroleum Hydrocarbon Components (Atlantic RBCA Analysis)

Appendix A
Field Methodology

APPENDIX A
FIELD METHODOLOGY

LABORATORY

Analytical services were contracted to Maxxam Analytics (Maxxam) in Bedford, Nova Scotia. Maxxam is accredited to ISO 17025 by the Standards Council of Canada. Communication between the Dillon project manager conducting the sampling and the project manager designated by the laboratory was maintained throughout the sampling program. The laboratory was advised of the details pertaining to the monitoring event. This included the number and type of samples to be collected, the analysis required, and the schedule. Prior to each monitoring event, the laboratory provided bottles, chemical preservatives, icepacks, labels, chain of custody forms and coolers for shipping.

FIELD EQUIPMENT PREPARATION

All of the monitor wells are *dedicated* with self-contained pumping units. These units consist of 13 mm diameter polyethylene tubing and an attached 25 mm diameter Delrin™ (acetal resin thermoplastic) foot valve. Although they are considered to be a part of the well, the tubing and/or foot valve can easily be removed for cleaning or replaced.

The following items are considered to be standard equipment used for measuring hydraulic head level, well development, purging and sampling:

- Water Level Indicator – measures the depth to water. The probe was wiped with distilled water and a clean cloth after each measurement;

- Conductivity/Temperature Meter – measures specific conductance and temperature. This meter was used to monitor these parameters throughout the development process. Generally, the readings were taken in a bucket; hence the probe did not contact the water in the well. The probe was, however, wiped with distilled water and a clean cloth after the completion of each well development;

- Waterra Pump/Generator – is a hydrolift pump operated by a generator. There was no contact between either the pump or the generator and the well water. The pump was supported on the side of the well casing. The tubing was clamped onto the arm of the pump and the open end secured so that the discharge waters were directed away from the wellhead. The arm of the pump, and hence the tubing moves up and down, activating the foot valve. A control dial regulated speed;

    - It is noted, that purging and sampling was also effectively completed by manually working the tubing up and down. This was often practical in instances where the wells are either shallow or low producing.

- In-line Filters – used for on-site filtration of samples. These are disposable aids, discarded after each sample use.
- Gloves – disposable latex and/or nitrile gloves used during well purging and sampling. They were discarded subsequent to the completion of each sample.

FIELD QA/QC MEASURES

In addition to the careful use of field equipment, as described in the previous section, and standard laboratory procedures, the following measures were included in each sampling event to determine that the samples collected were representative of water quality:

Chain of custody forms, providing the sample identification, time of collection, analytical requirements and specific instructions were completed. One (1) copy was retained by Dillon Consulting Limited. Confirmation of sample shipment receipts and laboratory requirements were issued from the laboratory, and also retained in files.

All information, pertaining to site conditions including water level data was documented in a waterproof field book. This information was copied and maintained in Dillon's file.

SURFACE WATER SAMPLING

Surface water samples were collected as unfiltered grabs in order to assess the total (dissolved and un-dissolved) components in a manner representative of natural conditions. Care was taken to avoid disturbing sediment or collecting items floating on the water.

Physical changes to the surface water station and surrounding area, or unusual flow quantity or quality which may affect sample quality were noted at the time of sampling.

GROUNDWATER SAMPLING

Measurement of Hydraulic Head Levels

Each well was inspected to ensure its integrity as a sampling station. Inspection included an assessment of drainage to ensure that surface water is diverted away from the wellhead, checking the lock for security and checking the protective casing and PVC pipe for stability. Wells were rehabilitated as required.

Static water levels were measured to obtain a reading before aquifer disturbance. The depth to water in the monitor wells was determined by recording the depth to water from a reference point marked on the lip of the PVC casing (this reference point elevation and coordinates have been surveyed to geodetic datum). Levels were taken at all monitor well locations within a limited time period.

Well Purging

The monitor wells were developed upon completion of installation. This procedure involved the removal of, at a minimum three (3) borehole volumes to ensure 1) the removal of stagnant waters, and 2) to enhance the operation of the screen and sandpack as an effective particulate filter system. Pumping was accomplished using the Waterra pump system, which was either operated by the hydrolift pump or manually. Field specific conductance/temperature readings were recorded throughout the process. The stabilization of these parameters in addition to improvement of water clarity was used as indication that the process was complete.

Subsequent well purging was completed prior to the collection of each sample suite. This process, similar to the initial development, is done to remove stagnant water from within the well casing and sandpack prior to sample collection, thus allowing the collection of samples that are representative of true aquifer quality. Generally, this involved the removal of no less than three (3) volumes of water. Exceptions to this were, specifically, the shallow surficial wells, where the well was purged dry. Purging was accomplished using the Waterra system with field specific conductance/temperature readings recorded throughout. The stabilization of these parameters, in addition to water clarity was used as indication that the process was complete.

Sample Collection

In instances where the well exhibited sufficient recharge, samples were collected immediately upon completion of well purging. The time interval between completion of well purging and sample collection did not exceed 24 hours.

The pump was regulated, such that the flow rate was steady, generally less than one (1) liter per minute. Samples for semi-volatile and volatile compounds, which require filling with no air, were collected first. Once filled, the bottles were inverted to check for the presence of air bubbles. If observed, the sample was retaken.

Samples for general inorganic chemistry and metals were field-filtered using a 0.45 micron in-line disposable filter.

Whenever possible, samples requiring preservation was prepared by the laboratory.

Once collected, samples were immediately stored in coolers and kept at a constant temperature, four (4) degrees Celsius, during transport. Coolers were sealed.

LABORATORY PROCEDURES/PERFORMANCE STANDARDS

Refer to Statement of Qualifications, provided as follows. Results were received from the laboratory in both digitized and hard copy format.

Appendix B
Hydraulic Head Data and Site Analytical Results
(CD in Pouch)