13.0 GROUNDWATER AND SURFACE WATER MONITORING PROGRAMS AND TRIGGER MECHANISMS

13.1 Objectives of Monitoring Program

The objectives of the groundwater, leachate and surface water program are to monitor background water quality, leachate quality and water quality hydraulically downgradient of the landfill and other on-Site facilities. The proposed Site monitoring programs have been developed to adhere to the *Landfill Standards* (MOE, 1998b, revised January 2012).

13.2 Groundwater Monitoring Program

13.2.1 Monitoring Locations

The proposed groundwater monitoring program for the Site is described in the sections below. The groundwater monitoring program has been split into a monitoring program for the processing and treatment facilities north of the Simpson Drain and a monitoring program for the landfill south of the Simpson Drain as summarized in Table 13-1 and Table 13-2, respectively. The groundwater monitoring programs proposed for the CRRRC include maintaining the existing monitoring wells (where possible) and adding additional monitoring well locations to ensure adequate coverage of the Site is attained. The existing and proposed monitoring locations are shown on Figure 13-1.

The groundwater monitoring wells at locations 13-9 and 13-10 are proposed to be converted to flushmount groundwater monitoring wells as they are in high traffic areas. A new multi-level monitoring well (P1-9) is proposed to be installed at the eastern (exterior) toe of the landfill perimeter berm to replace monitoring well 12-1 (not shown on Figure 13-1), which will have to be decommissioned to allow construction of the stormwater management pond. A new multi-level monitoring well (V) is proposed to be installed south of the leachate treatment equalization pond or tank(s) to replace monitoring well 12-4 (not shown on Figure 13-1), which will have to be decommissioned to allow construction of the leachate treatment equalization pond. Borehole P1-9 will have monitoring wells screening the surficial sand/weathered clay, the silty layer in the silty clay deposit (referred to as the silty layer), glacial till and upper bedrock. Groundwater will also be sampled from four manholes (MH1, MH2, MH3 and MH4) located at the low points of the LDSCS that will be positioned below the perimeter berm, within the surficial silty sand layer. The LDSCS will be the first line of monitoring to show changes in groundwater quality if the GCL hydraulic barrier is not performing as expected. In addition to the LDSCS, 16 new boreholes are proposed to be drilled along the eastern toe of the landfill perimeter berm (P1-1, P1-2, P1-3, P1-4, P1-5, P1-6, P1-7, P1-8, P1-10, P2-1, P2-2, P2-3, P2-4, P2-5, P2-6, P2-7) and will have monitoring wells completed in the surficial silty sand/weathered clay and the silty layer at each location. These sentinel monitoring wells are immediately downgradient of the LDSCS, but far enough from the property boundary (approximately 60 metres) to allow for additional monitoring wells to be installed at the property boundary should impacts be observed in the sentinel monitoring wells. The LDSCS and the 16 sentinel monitoring wells are on the exterior side of the landfill closest to a property boundary for approximately the first 10 years of landfill operations. Based on groundwater quality data and groundwater elevations collected during landfill operations, the need for progressive installation of additional groundwater monitoring wells around the external side of other phases of the landfill will be determined as landfilling progresses. The P1 series of wells will be installed one year prior to the start of operation of Phase 1, while the P2 series of wells will be installed one year prior to the start of operation of Phase 2. New boreholes M and N are proposed to be drilled between the north side of the landfill perimeter berm toe and the Simpson Drain.

New monitoring wells completed in the surficial silty sand/weathered clay and the silty layer are proposed for the process and treatment facility area north of the Simpson Drain. Monitoring wells O, P, Q, R, S, T and U are proposed for areas adjacent to facilities north of the Simpson Drain as described in Table 13-1.

Table 13-1: Proposed Groundwater Monitoring Program for the Process and Treatment Facilities

Activity	Geological Unit	Monitoring Well	Description
Off-Site Activities	Surficial Silty Sand/Weathered Clay	13-5-6	Observe potential groundwater impacts from off-Site activities
		13-12-2	
	Silty Layer in Silty Clay	13-5-5	
		13-12-3	
	Glacial Till Deposit	13-5-4A	
	Upper Bedrock	13-5-3	
C&D, MRF	Surficial Silty Sand/Weathered Clay	12-3-6	Downgradient Property Boundary
	Silty Layer in Silty Clay	12-3-5B	
	Glacial Till Deposit	12-3-4A	
	Upper Bedrock	12-3-3	
Leachate Treatment**	Surficial Silty Sand/Weathered Clay	V-B*	Leachate Treatment Equalization Pond or Tank(s)
		T-B	Leachate Treatment (Treated Effluent Ponds or Tanks) (upgradient)/ (Leachate Equalization Pond or Tank(s)) (downgradient)
		U-B	Sludge Dewatering/Leachate Treatment Equalization Pond or Tank(s)
		S-B	Leachate Treatment (Treated Effluent Ponds or Tanks) (downgradient)
	Silty Layer in Silty Clay	V-A*	Leachate Treatment Equalization Pond or Tank(s)
		T-A	Leachate Treatment (Treated Effluent Ponds or Tanks) (upgradient) / (Leachate Equalization Pond or Tank(s)) (downgradient)
		U-A	Sludge Dewatering/Leachate Treatment Equalization Pond or Tank(s)
		S-A	Leachate Treatment (Treated Effluent Ponds or Tanks)
Organics Processing Facility	Surficial Silty Sand/Weathered Clay	13-10-2	Organics Pre-Processing / Compost Processing and Storage Pad
		13-13-2	Downgradient Property Boundary – Organics Processing Facility
		P-B	Compost Processing and Storage Pad
		Q-B	Organics Processing Facility Area
	Silty Layer in Silty Clay	13-10-3	Organics Pre-Processing / Compost Processing and Storage Pad

Activity	Geological Unit	Monitoring Well	Description
		13-13-3	Downgradient Property Boundary – Organics Processing Facility
		P-A	Compost Processing and Storage Pad
		Q-A	Organics Processing Facility Area
Soil Treatment Area	Surficial Silty Sand/Weathered Clay	R-B	Soil Treatment Area
		O-B	
	Silty Layer in Silty Clay	R-A	
		O-A	

Notes: * Existing groundwater monitoring well series V replaces monitoring wells completed in the surficial silty sand and silty layer of monitoring well series 12-4, which is very close to the leachate treatment equalization pond or tank(s). It is intended that the full monitoring well series 12-4 (monitoring wells completed in the bedrock, glacial till, surficial silty sand and silty layer) will be decommissioned as per O.Reg. 903 (MOE, 2011). However, if during final design and construction it is determined that monitoring well series 12-4 can be kept, they will be. If the 12-4 monitoring wells completed in the surficial silty sand and silty clay do not have to be decommissioned, then they will be used in place of monitoring well series V.

** If tank(s) are used instead of ponds not all of these monitoring wells may be required.

The groundwater monitoring wells proposed for the landfill monitoring program are summarized in Table 13-2.

Table 13-2: Proposed Groundwater Monitoring Program for the Landfill

Geological Unit	Monitoring Well	Purpose
Surficial Silty Sand/Weathered Clay	12-2-6	Background Control Well
	13-6-6	Adjacent
	13-7-5	Background Conditions
	13-17-2	Downgradient Property Boundary - Compliance
	13-24-2	Adjacent
	13-25-2	Downgradient Property Boundary - Compliance
	M-B	Adjacent – Simpson Drain
	N-B	Adjacent – Simpson Drain
	MH1	LDSCS
	MH2	LDSCS
	MH3	LDSCS
	MH4	LDSCS
	P1-1B	Immediately Downgradient - Sentinel
	P1-2B	Immediately Downgradient - Sentinel
	P1-3B	Immediately Downgradient - Sentinel

Geological Unit	Monitoring Well	Purpose
	P1-4B	Immediately Downgradient - Sentinel
	P1-5B	Immediately Downgradient - Sentinel
	P1-6B	Immediately Downgradient - Sentinel
	P1-7B	Immediately Downgradient - Sentinel
	P1-8B	Immediately Downgradient - Sentinel
	P1-9D	Immediately Downgradient - Compliance
	P1-10B	Immediately Downgradient - Sentinel
	P2-1B	Immediately Downgradient - Sentinel
	P2-2B	Immediately Downgradient - Sentinel
	P2-3B	Immediately Downgradient - Sentinel
	P2-4B	Immediately Downgradient - Sentinel
	P2-5B	Immediately Downgradient - Sentinel
	P2-6B	Immediately Downgradient - Sentinel
	P2-7-B	Immediately Downgradient - Sentinel
Silty Layer in Silty Clay	12-2-5B	Background Control Well
	13-6-5B	Adjacent
	13-7-4-2	Background Conditions
	13-17-3	Downgradient Property Boundary - Compliance
	13-25-3	Downgradient Property Boundary - Compliance
	M-A	Adjacent – Simpson Drain
	N-A	Adjacent – Simpson Drain
	P1-1A	Immediately Downgradient - Sentinel
	P1-2A	Immediately Downgradient - Sentinel
	P1-3A	Immediately Downgradient - Sentinel

Geological Unit	Monitoring Well	Purpose
	P1-4A	Immediately Downgradient - Sentinel
	P1-5A	Immediately Downgradient - Sentinel
	P1-6A	Immediately Downgradient - Sentinel
	P1-7A	Immediately Downgradient - Sentinel
	P1-8A	Immediately Downgradient - Sentinel
	P1-9C	Immediately Downgradient - Compliance
	P1-10A	Immediately Downgradient - Sentinel
	P2-1A	Immediately Downgradient - Sentinel
	P2-2A	Immediately Downgradient - Sentinel
	P2-3A	Immediately Downgradient - Sentinel
	P2-4A	Immediately Downgradient - Sentinel
	P2-5A	Immediately Downgradient - Sentinel
	P2-6A	Immediately Downgradient - Sentinel
	P2-7A	Immediately Downgradient - Sentinel
Glacial Till Deposit	13-6-4A	Adjacent
	13-7-3	Background Conditions
	P1-9B	Immediately Downgradient - Compliance
Upper Bedrock	12-2-3	Background Control Well
	13-6-3	Adjacent
	13-7-2	Background Conditions
	P1-9A	Immediately Downgradient - Compliance

In addition to on-Site groundwater monitoring wells, water wells within 500 metres of the Site will be sampled, with consent from the owner, one time prior to starting operations at the facility.

Groundwater levels will be measured in the LDSCS manholes and all on-Site functional groundwater monitoring wells, including those not listed in groundwater quality monitoring program. If a monitoring well not included in the groundwater quality monitoring program is damaged or has to be removed because of Site development (such as monitoring wells 13-14, 13-15, 13-16, 13-19 and 13-20), it will be decommissioned in accordance with O.Reg 903 (MOE, 2011).

13.2.2 Monitoring Frequency

The on-Site groundwater quality monitoring sessions and groundwater level monitoring will be conducted during the spring, summer and fall of the year at monitoring wells and manholes, except as noted below, as recommended in the *Landfill Standards* (MOE, 1998b, revised January 2012). Groundwater levels will be measured in the LDSCS manholes on a quarterly basis. The groundwater quality from the sentinel monitoring wells (the P1 and P2 series of wells, excluding P1-9) will be monitored in the spring and fall only. Monitoring frequency will be revisited with MOECC over time. It is recommended that the groundwater monitoring program begin one year prior to the start of operation so that two to three monitoring sessions can be completed to obtain baseline data, with the exception of the P2 series of wells that will commence one year prior to the start of operation in Phase 2.

13.2.3 Parameters

As per the *Landfill Standards* (MOE, 1998b, revised January 2012), there is a different recommended list of parameters to be analyzed in the spring, summer and fall. Groundwater samples collected from the groundwater monitoring wells are proposed to be analyzed for the parameters listed in Column 2, Schedule 5 of the *Landfill Standards* during the spring and summer and Column 1, Schedule 5 of *Landfill Standards* in the fall, plus a few additions as requested by the MOECC. The *Landfill Standards* parameters apply to all of the groundwater monitoring wells in the program. In addition, facility specific parameters are recommended for groundwater monitoring wells near the organics processing facility and the soil treatment area. Table 13-3 below outlines the proposed monitoring parameters for groundwater.

Table 13-3: Proposed Groundwater Monitoring Parameters

Parameter	Spring & Summer [1, 2]	Fall [1, 2]
Alkalinity ($CaCO_3$)	X	X
Ammonia	X	X
Calcium	X	X
Chloride	X	X
Conductivity (Laboratory)	X	X
Hardness	X	X
Magnesium	X	X
Total Phosphorous		X
Potassium	X	X
Sodium	X	X

Parameter	Spring & Summer [1, 2]	Fall [1, 2]
Sulphate	X	X
Nitrate nitrogen	X	X
Nitrite nitrogen		X
Total Kjeldahl nitrogen	X	X
pH (laboratory tested)	X	X
Total Dissolved Solids	X	X
Metals		
Arsenic		X
Barium	X	X
Boron	X	X
Cadmium		X
Chromium		X
Copper		X
Iron	X	X
Lead		X
Manganese	X	X
Mercury		X
Zinc		X
Bulk Organics		
Phenols		X
COD	X	X
DOC	X	X
Volatile Organics		
Complete VOC scan (including 1,4 –dioxane)		X
Field Measured Parameters		
pH	X	X
Conductivity	X	X
Temperature	X	X

Notes:

1 In addition to the listed parameters, groundwater monitors 13-10, 13-13, P and Q (in the vicinity of the organics processing facility) will be analyzed for tannins and lignins.

2 In addition to the listed parameters, groundwater monitors R and O (in the vicinity of the soil treatment area) will be analyzed for ethylbenzene, xylenes and petroleum hydrocarbons fractions 1 through 4.

The groundwater samples collected from the monitoring wells would be submitted to a private laboratory for analysis of parameters indicated in Table 13-3.

An appropriate number of field duplicates (i.e., approximately one duplicate for every 10 samples collected) would be prepared during each monitoring session as part of the QA/QC program. In addition, one field and trip blank will be prepared for the fall sampling event for evaluation of 1,4-dichlorobenzene, benzene, methylene chloride, toluene, vinyl chloride, ethylbenzene and xylenes.

13.2.4 Monitoring System Maintenance

During each monitoring event all existing monitors will be visually inspected and groundwater levels will be obtained. Changes in the physical condition of each well will be noted and minor repairs undertaken. Groundwater monitors that are shown to be damaged beyond repair or whose integrity is in doubt for further monitoring will be abandoned in accordance with O.Reg. 903 (MOE, 2011) and replaced, if necessary.

13.3 Surface Water Quality Monitoring Program

13.3.1 Monitoring Locations

The proposed surface water monitoring program for the Site is described in the sections below and is summarized in Table 13-4. The proposed monitoring locations are shown on Figure 13-1.

Table 13-4: Proposed Surface Water Monitoring Stations

Water System	Monitoring Sites*	Description
Surface Water	BSW1	Discharge adjacent to landfill
	BSW2	Discharge for Simpson Drain
	BSW3	Discharge from northern portion of Site
	BSW4	Control location in the Simpson Drain

Notes: * Regimbald Drain (upstream of Simpson Drain) and Wilson-Johnston Drain at Devine Road will be sampled during baseline monitoring starting in 2014 provided permission to access the locations can be obtained and they are practically accessible. These locations will be removed from the program once the Site becomes operational.

13.3.2 Monitoring Frequency

The surface water quality monitoring sessions will be conducted during the spring, summer and fall of the year plus a monitoring session after a large rainfall event as recommended in the *Landfill Standards* (MOE, 1998b, revised January 2012). Surface water sampling that was undertaken as part of the existing conditions work can be used as baseline information for the proposed surface water monitoring program. It is recommended that monitoring events begin in 2014 to observe any changes in the baseline data.

13.3.3 Parameters

As per the *Landfill Standards* (MOE, 1998b, revised January 2012), there is a different recommended list of parameters to be analyzed in the spring, summer and fall. Surface water samples collected from the surface water monitoring locations are proposed to be analyzed for the parameters listed in Column 4, Schedule 5 of the *Landfill Standards* during the spring and summer and Column 3, Schedule 5 of *Landfill Standards* in the fall. In addition, facility specific parameters are recommended for surface water monitoring locations north of the Simpson Drain. Table 13-5 below outlines the proposed monitoring parameters for surface water.

Table 13-5: Proposed Surface Water Monitoring Program Parameters

Parameter	Spring & Summer [1,2]	Fall[1,2]
Alkalinity ($CaCO_3$)	X	X
Ammonia	X	X
Chloride	X	X
Conductivity (Laboratory)	X	X
Total Phosphorous	X	X
Sulphate	X	X
Nitrate nitrogen	X	X
Nitrite nitrogen	X	X
Total Kjeldahl nitrogen	X	X
pH (laboratory tested)	X	X
Total Dissolved Solids	X	X
Metals		
Arsenic		X
Barium		X
Boron		X
Cadmium		X
Chromium		X
Copper		X
Iron	X	X
Lead		X
Mercury		X
Zinc		X
Bulk Organics		
Phenols	X	X
BOD_5	X	X
COD	X	X
Field Measured Parameters		
pH	X	X
Conductivity	X	X
Temperature	X	X
Dissolved Oxygen	X	X
Flow	X	X

Notes:

1 Unionized ammonia nitrogen calculated for surface water based on field measured pH and temperature.

2 In addition to the listed parameters, surface water stations BSW2, BSW3 and BSW4 will be analyzed for tannins and lignins, benzene, toluene, ethylbenzene, xylene and petroleum hydrocarbons fractions 1 through 4.

The surface water samples collected from the surface water stations would be submitted to a private laboratory for analysis of the parameters listed in Table 13-5.

An appropriate number of field duplicates (i.e., approximately one duplicate for every monitoring session) would be prepared during each monitoring session as part of the QA/QC program.

13.4 Leachate Monitoring Program

13.4.1 Monitoring Locations

The proposed leachate monitoring program for the Site is described in the sections below. It is proposed that a leachate sample is collected from the leachate treatment facility prior to treatment and from monitoring wells LW-1, LW-2 and LW-3 that will be completed within the leachate collection system. The proposed leachate monitoring well locations are shown on Figure 13-1. The leachate monitoring wells will be constructed as the landfill progresses and therefore will only be included in the monitoring program once constructed.

13.4.2 Monitoring Frequency

The leachate quality monitoring sessions will be conducted during the spring, summer and fall of the year as recommended in the *Landfill Standards* (MOE, 1998b, revised January 2012). Leachate collection, and hence leachate quality monitoring, is expected to terminate at some point post-closure when residual leachate quality permits.

13.4.3 Parameters

As per the *Landfill Standards* (MOE, 1998b, revised January 2012), there is a different recommended list of parameters to be analyzed in the spring, summer and fall. Leachate samples are proposed to be analyzed for the parameters listed in Column 2, Schedule 5 of the *Landfill Standards* during the spring and summer and Column 1, Schedule 5 of *Landfill Standards* in the fall, plus a few additions as recommended by the MOECC. Table 13-6 below outlines the proposed monitoring parameters for leachate.

Table 13-6: Proposed Leachate Monitoring Parameters

Parameter	Spring & Summer	Fall
Alkalinity ($CaCO_3$)	X	X
Ammonia	X	X
Calcium	X	X
Chloride	X	X
Conductivity (Laboratory)	X	X
Hardness	X	X
Magnesium	X	X
Total Phosphorous		X
Potassium	X	X
Sodium	X	X
Sulphate	X	X
Nitrate nitrogen	X	X
Nitrite nitrogen		X

Parameter	Spring & Summer	Fall
Total Kjeldahl nitrogen	X	X
pH (laboratory tested)	X	X
Total Dissolved Solids	X	X
Total Suspended Solids	X	X
Metals		
Arsenic		X
Barium	X	X
Boron	X	X
Cadmium		X
Chromium		X
Copper		X
Iron	X	X
Lead		X
Manganese	X	X
Mercury		X
Zinc		X
Bulk Organics		
Phenols		X
BOD_5	X	X
COD	X	X
DOC	X	X
Volatile Organics		
Complete VOC scan (including 1,4 –dioxane)		X
Field Measured Parameters		
pH	X	X
Conductivity	X	X
Temperature	X	X

The leachate samples would be submitted to a private laboratory for analysis of parameters indicated in Table 13-6.

13.4.4 Leachate Level Measurement

During each monitoring event, leachate levels will be measured in the cleanout at any constructed manhole sumps in the landfill as well as in the leachate monitoring wells. The leachate measurements will assist in understanding the amount of leachate mounding within the leachate collection system.

13.5 Future Modifications to Monitoring Program

Each annual monitoring report would include a re-evaluation of the groundwater and surface water monitoring requirements at the Site. In the event that the monitoring program presented above requires modification so as to adequately monitor the future performance of the Site, or such modification (i.e., reduction in frequency) is otherwise appropriate, the proposed modifications for the subsequent year would be discussed with the MOECC to obtain their approval for the changes prior to implementation. As the groundwater velocity in all units is low at the Site, it is anticipated that a recommendation for reduced groundwater monitoring frequency would be made after several years of demonstrated performance.

Groundwater monitoring wells at location 13-7 will be decommissioned in accordance with O.Reg. 903 (MOE, 2011) and removed from the groundwater monitoring program as landfilling progresses into that area.

13.6 Objectives of Trigger Mechanism

The objectives of trigger mechanisms at the Site are to utilize the results of the ongoing surface water and groundwater monitoring programs to assess Site compliance and to trigger implementation of the contingency plans, when and if necessary. The purposes of the trigger mechanisms are to prevent leachate-impacted groundwater exceeding the MOECC *Guideline B-7: Incorporation of the Reasonable Use Concept into MOE Groundwater Management* (Guideline B-7) (MOE, 1994b) from migrating beyond the Site boundaries, and to prevent adverse impact on surface water quality.

13.7 Compliance Evaluation Parameters and Trigger Concentrations

13.7.1 Preamble

A *Leachate Indicator Parameter* for a landfill site is defined as being a parameter which is useful in determining the presence/absence of landfill leachate impact on water resources; assessing the degree of leachate impact on water resources; and, is useful in determining the extent of leachate impact near the landfill site. Because there is no existing site-specific leachate quality to determine the *Leachate Indicator Parameter* list for the CRRRC, the *Leachate Indicator Parameters* for groundwater will be a combination of those listed in Column 2 and Column 4 of Schedule 5 of the *Landfill Standards* (MOE, 1998b, revised January 2012) with some modifications. Hardness will be used for groundwater as opposed to calcium and magnesium because there is an operational guideline ODWQS for hardness but not for calcium and magnesium. Hardness will only be a *Leachate Indicator Parameter* for groundwater. Also, unionized ammonia, BOD and TSS will be *Leachate Indicator Parameters* for surface water and not groundwater, and DOC and sodium will be *Leachate Indicator Parameters* for groundwater and not surface water. Benzene, toluene, ethylbenzene and xylenes will also be added to the Leachate Indicator Parameter list for surface water to detect potential impacts to surface water from the soil treatment facility. The following is a list of *Leachate Indicator Parameters* for the Site: alkalinity, ammonia (unionized ammonia for surface water), barium, boron, chloride, BOD (surface water only), COD, DOC (groundwater only), hardness (groundwater only), iron, nitrate, nitrite, TKN, total phosphorus, phenols, sodium (groundwater only), sulphate, TDS, TSS (surface water only), benzene (surface water only), toluene (surface water only), ethylbenzene (surface water only) and xylenes (surface water only). The Site compliance will be evaluated in the surficial silty sand, the silty layer, the glacial till and the upper bedrock.

Compliance Evaluation Parameters are defined as the site-specific *Leachate Indicator Parameters* which have established Provincial Water Quality Objectives (surface water) or Ontario Drinking Water Quality Standards (groundwater). Note that if the upper tolerance limit of a groundwater parameter exceeds the ODWQS, then the parameter is not considered a compliance evaluation parameter for groundwater within that unit.

A *Reasonable Use Performance Objective* refers to the maximum allowable concentration for a *Compliance Evaluation Parameter* in groundwater at the point of compliance under MOECC Guideline B-7. It is a specified calculation using the median for each parameter based on the existing background data.

A *Surface Water Compliance Concentration* generally refers to the higher of either the upper tolerance limit or the Provincial Water Quality Objectives for each *Compliance Evaluation Parameter* based on the existing background data. Under the tolerance interval approach, the natural variation in background surface water quality is recognized and the surface water compliance concentrations are not lower than the corresponding tolerance limits for the *Compliance Evaluation Parameters*.

A *Trigger Concentration* is an agreed upon threshold of the *Leachate Indicator Parameters*.

It is noted that future *Compliance Evaluation Parameters* may differ from those discussed herein, in consultation with MOECC, due to the addition or deletion of site-specific *Leachate Indicator Parameters*, changes to background groundwater concentrations as future monitoring programs are added to the database, or changes to the ODWQS and/or PWQO in the future.

13.7.2 Groundwater

The background groundwater quality and upper tolerance limits for each of the *Leachate Indicator Parameters* for the surficial silty sand, the silty layer, the glacial till and the upper bedrock are presented in Table 13-7 to Table 13-10 below:

Table 13-7: Groundwater Quality for Leachate Indicator Parameters in the Surficial Silty Sand

Leachate Indicator Parameters	ODWQS[2] (mg/L)	Surficial Silty Sand Deposit[1]		
		Background Range (mg/L)	Upper Tolerance Limit (mg/L)	Median (mg/L)
Alkalinity	- -	140 – 660	705	340
Ammonia	- -	0.03 – 0.52	0.5	0.17
Barium	1(H)	0.03 – 0.36	0.3	0.07
Boron	5 (H)	<0.01 – 0.07	0.1	0.03
Chloride	250(AO)	30 – 950	1,023	185
COD	- -	13 – 270	236	48
DOC	5 (AO)	2 – 32	24.6	4.3
Hardness	- -	204 – 830	844	415
Iron	0.3 (AO)	<0.1 – 0.16	0.1	<0.1
Nitrate	10(H)	<0.1 – 5.9	4.7	<0.1
Nitrite	1(H)	<0.01 – 0.024	0.021	<0.01
TKN	- -	0.73 – 6.8	7.4	2.8
Sodium	200 (AO)	23 – 540	629	195
Total Phosphorus	- -	0.5 – 27	32.1	5.5
Phenols	- -	<0.001 – 0.004	0.003	<0.001
Sulphate	500 (AO)	25 – 160	176	74
TDS	500 (AO)	150 – 2,320	2,569	781

Notes:
mg/L - milligrams per Litre.
ODWQS - Ontario Drinking Water Quality Standards (2003).
[1] Background groundwater quality based on 2013 groundwater quality from monitoring wells 12-1-6, 12-2-6, 12-3-6, 12-4-6, 13-5-6, 13-6-6 and 13-7-5.
[2] ODWQS values presented relate specifically to non-health related parameters (i.e., aesthetic parameters) and health-related parameters for which a maximum acceptable concentration (MAC) or interim maximum acceptable concentration (IMAC) has been established.
(H) Health-related parameter.
(AO) Aesthetic objective parameter.
- - No ODWQS for health-related or aesthetic objective parameters

Table 13-8: Groundwater Quality for Leachate Indicator Parameters in the Silty Layer

Leachate Indicator Parameters	ODWQS[2] (mg/L)	Silty Layer[1]		
		Background Range (mg/L)	Upper Tolerance Limit (mg/L)	Median (mg/L)
Alkalinity	- -	200 – 750	909	575
Ammonia	- -	1.0 – 3.4	3.3	1.7
Barium	1(H)	0.04 – 0.24	0.29	0.16
Boron	5 (H)	0.13 – 0.34	0.38	0.23
Chloride	250(AO)	200 – 1,600	2026	930
COD	- -	22 – 740	640	96
DOC	5 (AO)	3.7 – 45	33.3	6.1
Hardness	- -	257 – 752	867	393
Iron	0.3 (AO)	<0.1 – 0.37	0.34	<0.1
Nitrate	10(H)	<0.1	<0.1	<0.1
Nitrite	1(H)	<0.01 – 0.31	0.2	<0.01
TKN	- -	2.8 – 19	18.4	5.9
Sodium	200 (AO)	240 – 1,200	1,403	720
Total Phosphorus	- -	13 – 130	143	25
Phenols	- -	<0.001 – 0.002	0.002	<0.001
Sulphate	500 (AO)	<1 – 130	114	11.5
TDS	500 (AO)	834 – 3,460	4,048	2,085

Notes:
mg/L - milligrams per Litre.
ODWQS - Ontario Drinking Water Quality Standards (2003).
1 Background groundwater quality based on 2013 groundwater quality from monitoring wells 12-1-5B, 12-2-5B, 12-3-5B, 12-4-5B, 13-5-5, 13-6-5B and 13-7-4-2.
2 ODWQS values presented relate specifically to non-health related parameters (i.e., aesthetic parameters) and health-related parameters for which a maximum acceptable concentration (MAC) or interim maximum acceptable concentration (IMAC) has been established.
(H) Health-related parameter.
(AO) Aesthetic objective parameter.
- - No ODWQS for health-related or aesthetic objective parameters

Table 13-9: Groundwater Quality for Leachate Indicator Parameters in the Glacial Till Deposit

Leachate Indicator Parameters	ODWQS[2] (mg/L)	Glacial Till Deposit[1]		
		Background Range (mg/L)	Upper Tolerance Limit (mg/L)	Median (mg/L)
Alkalinity	- -	340 – 860	961	600
Ammonia	- -	2.7 – 12	14.9	6.7
Barium	1(H)	0.5 – 17	24.1	4.3
Boron	5 (H)	0.8 – 1.8	2.2	1.4
Chloride	250(AO)	2,300 – 7,500	9,555	5,600
COD	- -	48 – 210	244	110
DOC	5 (AO)	7.6 – 16	17.9	9.7
Hardness	- -	286 – 1,564	1,956	909
Iron	0.3 (AO)	<0.1 – 1.5	1.6	0.25
Nitrate	10(H)	<0.1	0.1	<0.1
Nitrite	1(H)	<0.01 – 0.025	0.02	<0.01
TKN	- -	4.7 – 14	15.2	8.3
Sodium	200 (AO)	1,800 – 4,900	5,972	3,500
Total Phosphorus	- -	0.11 – 11	14.2	3.3
Phenols	- -	<0.001 – 0.01	0.01	<0.001
Sulphate	500 (AO)	2 – 84	85	11
TDS	500 (AO)	4,540 – 12,900	16,267	9,900

Notes:
mg/L - milligrams per Litre.
ODWQS - Ontario Drinking Water Quality Standards (2003).
1 Background groundwater quality based on 2013 groundwater quality from monitoring wells 12-1-4A, 12-3-4A, 12-4-4A, 13-5-4A, 13-6-4A and 13-7-3.
2 ODWQS values presented relate specifically to non-health related parameters (i.e., aesthetic parameters) and health-related parameters for which a maximum acceptable concentration (MAC) or interim maximum acceptable concentration (IMAC) has been established.
(H) Health-related parameter.
(AO) Aesthetic objective parameter.
- - No ODWQS for health-related or aesthetic objective parameters

Table 13-10: Groundwater Quality for Leachate Indicator Parameters in the Upper Bedrock

Leachate Indicator Parameters	ODWQS[2] (mg/L)	Upper Bedrock[1]		
		Background Range (mg/L)	Upper Tolerance Limit (mg/L)	Median (mg/L)
Alkalinity	- -	47 – 710	1,079	535
Ammonia	- -	5.8 – 28	26.4	8.3
Barium	1(H)	0.09 – 17	29	15
Boron	5 (H)	0.3 – 1.9	2.7	1.6
Chloride	250(AO)	2,800 – 9,600	12,034	6,950
COD	- -	45 – 210	218	105
DOC	5 (AO)	3.7 – 47	36	7.1
Hardness	- -	384 – 3,310	3,878	1,330
Iron	0.3 (AO)	<0.1 – 1.2	1.1	0.5
Nitrate	10(H)	<0.1	0.1	<0.1
Nitrite	1(H)	<0.01 – 0.5	0.04	<0.01
TKN	- -	6.7 – 28	26	9
Sodium	200 (AO)	2,000 – 5,400	6,843	4,300
Total Phosphorus	- -	0.06 – 3	3.2	0.2
Phenols	- -	<0.001 – 0.4	0.03	0.003
Sulphate	500 (AO)	<1 – 260	308	23
TDS	500 (AO)	5,560 – 19,700	22,335	12,150

Notes:
mg/L - milligrams per Litre.
ODWQS - Ontario Drinking Water Quality Standards (2003).
1 Background groundwater quality based on 2013 groundwater quality from monitoring wells 12-1-3.1, 12-2-3, 12-3-3, 12-4-3, 13-5-3, 13-6-3 and 13-7-2.
2 ODWQS values presented relate specifically to non-health related parameters (i.e., aesthetic parameters) and health-related parameters for which a maximum acceptable concentration (MAC) or interim maximum acceptable concentration (IMAC) has been established.
(H) Health-related parameter.
(AO) Aesthetic objective parameter.
- - No ODWQS for health-related or aesthetic objective parameters

The upper tolerance limits represent the maximum parameter concentrations that can be expected in the background groundwater in the surficial silty sand, the silty layer, glacial till and upper bedrock near the Site based on statistical analysis. The median from the background groundwater quality data set is used to derive the revised *Reasonable Use Performance Objectives* (if possible) and corresponding *Trigger Concentrations* for the *Compliance Evaluation Parameters,* with the exception where the upper tolerance limit exceeds the ODWQS, then the parameter is excluded as a *Compliance Evaluation Parameter*. For the parameters that have upper tolerance limit concentrations above the ODWQS (referred to as *Other Evaluation Parameters*), the *Trigger Concentration* will be based on the background range of each of those parameters within the corresponding stratigraphic unit. The background range will be derived from the maximum and minimum data obtained from 2013 to present in each stratigraphic unit and at any future wells installed. The background ranges will be updated annually using the most recent data. An exceedance of the background range is considered an exceedance of the trigger mechanism and is discussed further below.

Based on the calculated statistical median and upper tolerance limits for the background groundwater quality data in the surficial silty sand, the silty layer, the glacial till and the upper bedrock, the current *Reasonable Use Performance Objectives* and the current *Trigger Concentrations* are presented in the following tables.

Table 13-11: Groundwater Reasonable Use Performance Objectives and Trigger Concentrations for Surficial Silty Sand

Compliance Evaluation Parameters	Median (mg/L)	Reasonable Use Performance Objective (mg/L)	Trigger Concentration (mg/L)
Barium	0.07	0.31	0.23
Boron	0.03	1.28	0.96
Iron	<0.1	0.18	0.13
Nitrate	<0.1	2.5	1.9
Nitrite	<0.01	0.25	0.19
Sulphate	74	287	215
Other Evaluation Parameter	**Median (mg/L)**	**Reasonable Use Performance Objective (mg/L)**	**Trigger Concentration (mg/L)**
Chloride	185	--	950*
DOC	4.3	--	32*
Sodium	195	--	540*
TDS	781	--	2,320*

Note: mg/L - milligrams per Litre
* Maximum background concentration in the surficial silty sand

Table 13-12: Groundwater Reasonable Use Performance Objectives and Trigger Concentrations for the Silty Layer

Compliance Evaluation Parameters	Median (mg/L)	Reasonable Use Performance Objective (mg/L)	Trigger Concentration (mg/L)
Barium	0.16	0.37	0.28
Boron	0.23	1.4	1.1
Nitrate	<0.1	2.5	1.9
Nitrite	<0.01	0.25	0.19
Sulphate	11.5	256	192
Other Evaluation Parameter	**Median (mg/L)**	**Reasonable Use Performance Objective (mg/L)**	**Trigger Concentration (mg/L)**
Chloride	930	--	1,600*
DOC	6.1	--	45*
Iron	<0.1	--	0.37*
Sodium	720	--	1,200*
TDS	2,085	--	3,460*

Note: mg/L - milligrams per Litre.
* Maximum background concentration in the silty layer

Table 13-13: Groundwater Reasonable Use Performance Objectives and Trigger Concentrations for the Glacial Till

Compliance Evaluation Parameters	Median (mg/L)	Reasonable Use Performance Objective (mg/L)	Trigger Concentration (mg/L)
Boron	1.4	2.3	1.7
Nitrate	<0.1	2.5	1.9
Nitrite	<0.01	0.25	0.19
Sulphate	11	256	192
Other Evaluation Parameter	**Median (mg/L)**	**Reasonable Use Performance Objective (mg/L)**	**Trigger Concentration (mg/L)**
Barium	4.3	--	17*
Chloride	5,600	--	7,500*
DOC	9.7	--	16*
Iron	0.25	--	1.5*
Sodium	3,500	--	4,900*
TDS	9,900	--	12,900*

Note: mg/L - milligrams per Litre.
* Maximum background concentration in the glacial till

Table 13-14: Groundwater Reasonable Use Performance Objectives and Trigger Concentrations for the Upper Bedrock

Compliance Evaluation Parameters	Median (mg/L)	Reasonable Use Performance Objective (mg/L)	Trigger Concentration (mg/L)
Boron	1.6	2.5	1.8
Nitrate	<0.1	2.5	1.9
Nitrite	<0.01	0.25	0.19
Sulphate	23	261	196
Other Evaluation Parameter	**Median (mg/L)**	**Reasonable Use Performance Objective (mg/L)**	**Trigger Concentration (mg/L)**
Barium	15	--	17*
Chloride	6,950	--	9,600*
DOC	7.1	--	47*
Iron	0.5	--	1.2*
Sodium	4,300	--	5,400*
TDS	12,150	--	19,700*

Note: mg/L - milligrams per Litre.
* Maximum background concentration in the upper bedrock

The calculated maximum allowable boundary concentrations for these parameters under MOECC Guideline B-7 and the trigger concentrations will be modified, as required, based on additional background groundwater quality data which will be obtained during future monitoring programs.

13.7.3 Surface Water

The background surface water quality and upper tolerance limits for each of the *Leachate Indicator Parameters* are presented below:

Table 13-15: Surface Water Quality for Leachate Indicator Parameters

Leachate Indicator Parameters	PWQO (ug/L)	Surface Water[1]	
		Background Range (µg/L)	Upper Tolerance Limit (µg/L)
Alkalinity	127,500[2]	54,000 – 250,000	11,506 [3]
Unionized Ammonia	20	0.03 – 7.1	5
Barium	--	18 – 83	89
Boron	200	<10 – 65	67
Chloride	- -	30,000 – 440,000	442.900
COD	- -	18,000 – 170,000	171,400
BOD	- -	<2,000 – 38,000	23,725
Iron	300	<100 – 3,100	3,100
Nitrate	- -	<100 – 1,200	845
Nitrite	- -	<10 – 58	55
TKN	- -	660 – 3,400	3,200
Total Phosphorus	30	17 – 140	159
Phenols	- -	<1 – 55	40
Sulphate	- -	<5,000 – 200,000	189,300
TDS	- -	170,000 – 1,070,000	1,199,200
TSS	- -	500 – 8,000	10,500

Notes:
µg/L – micrograms per Litre.
PWQO – Provincial Water Quality Objectives (1994, re-print 1999).
[1] Background surface water quality based on BSW1, BSW2, BSW3, BSW4 (2013).
[2] Alkalinity should not be decreased by more than 25% of the natural concentration. This value was calculated as 75% of the median background concentration.
[3] Lower tolerance limit.
- - No PWQO.

The upper tolerance limits represent the maximum parameter concentrations that can be expected in the background surface water near the Site.

The compliance concentrations based on the higher of the upper tolerance limits or PWQO for the background surface water quality data are presented in Table 13-16.

Table 13-16: Surface Water Compliance and Trigger Concentrations

Compliance Evaluation Parameters	Compliance Concentrations (µg/L)	Trigger Concentrations (µg/L)
Alkalinity	>11,056*	<13,820
Boron	<200	>150
Iron	<3,093	>2,320
Total Phosphorus	<159	>119
Unionized Ammonia	<20	>15
Benzene	<100 [1]	>75
Toluene	<0.8 [1]	>0.6
Ethylbenzene	<8 [1]	>6
Xylene, m-	<2 [1]	>1.5
Xylene, o-	<40 [1]	>30
Xylene, p-	<30 [1]	>22.5

Notes:
µg/L - micrograms per Litre
* In the case of alkalinity the compliance concentration is the lesser of the lower tolerance limit or the PWQO
[1] Interim PWQO

The trigger concentrations are 75% of the compliance concentrations or in the case of alkalinity 125% of the compliance concentration. The calculated trigger concentrations will be modified, as required, based on additional background surface water quality data which will be obtained during future monitoring programs.

13.8 Trigger Formats

13.8.1 Groundwater Trigger

The trigger parameters are barium, boron, chloride, DOC, iron, nitrate, nitrite, sodium, sulphate and TDS. The trigger concentrations will be those calculated using 75% of the MOECC Guideline B-7 value or the maximum background concentration for those parameters where the upper tolerance limit is greater than the ODWQS. The calculated trigger concentrations will be based on all the background data which exists at the time of each comparison with the trigger criteria. These trigger concentrations may vary over time as background concentrations from future monitoring programs are added to the data base.

The groundwater trigger will be considered to have been exceeded when one or more of the above trigger parameters exceed the maximum trigger concentration during two consecutive monitoring sessions (not including non-compliance verification re-sampling).

Any observed exceedances of the trigger concentrations will be verified by re-sampling for the parameter(s) of concern within one month of the original sampling session at which time non-compliance was measured. The time frame of one month is to allow time for the initial chemical analyses to be performed, received from the analytical laboratory and interpreted by the proponent. If the non-compliance is not confirmed by the follow-up sample, then the initial non-compliance will be considered anomalous and will be discounted. The historical trends in the *Compliance Evaluation Parameter* concentrations at the points of compliance would also be used in concluding that monitoring results are anomalous.

If exceedances of the trigger concentrations are confirmed at the trigger location (i.e., confirmed non-compliance or trigger concentration exceedance during two consecutive monitoring sessions), a three-step process will be initiated for the purpose of determining whether implementation of the contingency plan is warranted. The three-step process is as follows:

Step 1 - Assess the concentrations reported for other *Leachate Indicator Parameters* at the monitoring location. If more than one *Leachate Indicator Parameter* experiences an increase, assess two subsequent sampling sessions to determine if the parameters continue to increase. If an exceedance is followed by two subsequent increasing monitoring sessions, assess whether the non-compliance or trigger concentration exceedance is due to leachate, or whether it is partially or wholly explicable by other factors. This will be achieved by considering trends in *Leachate Indicator Parameter* concentrations at all relevant monitoring locations or could include an expanded suite of monitoring parameters and/or an increased sampling frequency (if warranted depending on the on-going monitoring results and/or an increased sampling frequency). This step would be completed within two months of receipt of laboratory analyses that indicated a confirmed exceedance;

Step 2 - If the conclusion of Step 1 is affirmative, then an assessment of the results of Step 1 would be conducted to decide whether implementation of the contingency plan is warranted. The MOECC would be consulted with respect to this decision. This step would be completed within three months of the completion of Step 1; and,

Step 3 - If the conclusion of Step 2 is affirmative, then the groundwater contingency plan would be implemented. A detailed evaluation of contingency options would be completed and a suitable contingency option would be selected within six months of Step 2 being affirmative. Following the selection of a suitable contingency option, a schedule would be submitted to the MOECC outlining the anticipated timing of design, approval and construction of the selected contingency option.

13.8.2 Surface Water Trigger

The trigger parameters are alkalinity, boron, iron, total phosphorus, unionized ammonia, benzene, toluene, ethylbenzene and xylenes. The trigger concentrations will be based on 75% of either the upper tolerance limit for all background data or the PWQO that exists at the time of each comparison with the trigger concentration, whichever is higher. The exception would be alkalinity, which would be 125% of either the lower tolerance limit for all background data or the PWQO that exists at the time of each comparison with the trigger concentration, whichever is lower. These trigger concentrations may vary over time as background concentrations from future monitoring programs are added to the data base.

The surface water trigger will be considered to have been exceeded when one or more of the above trigger parameters exceeds the maximum allowable concentration (i.e., trigger concentrations) during two consecutive monitoring sessions (not including non-compliance verification re-sampling). The exception would be alkalinity, which will be considered to not meet compliance when it is below the lowest allowable concentration (i.e., trigger concentration) during two consecutive monitoring sessions (not including non-compliance verification re-sampling).

Any observed non-compliance will be verified by re-sampling for the parameter(s) of concern within one month of the initial sampling session. The time frame of one month is to allow time for the initial chemical analyses to be performed, received from the analytical laboratory and interpreted by the proponent. If the non-compliance is not confirmed by the follow-up sample, then the initial non-compliance will be considered anomalous and will be discounted. The historical trends in the *Compliance Evaluation Parameter* concentrations at the point of compliance would also be used in assuming whether or not these monitoring results are anomalous.

If non-compliance is confirmed at the trigger location (i.e., confirmed non-compliance during two consecutive monitoring sessions), a three-step process will be initiated for the purpose of determining whether implementation of the contingency plan is warranted. The three-step process is as follows:

Step 1 - Assess whether the non-compliance is due to leachate, or whether it is partially or wholly explicable by other factors. This will be achieved by considering trends in *Leachate Indicator Parameter* concentrations at all relevant monitoring locations or could include an expanded suite of monitoring parameters and/or an increased sampling frequency. This step would be completed within two months of receipt of laboratory analyses indicated a confirmed exceedance. If additional monitoring (e.g., expanded suite of parameters) is required, then this step would be completed within five months of receipt of laboratory analyses indicating a confirmed exceedance. Five months is a maximum time to allow for seasonality of sampling;

Step 2 - If the conclusion of Step 1 is affirmative, then a discussion of the results of Step 1 would be conducted to decide whether implementation of the contingency plan is warranted. The MOECC would be consulted with respect to this decision. This step would be completed within three months of the completion of Step 1; and,

Step 3 - If the conclusion of Step 2 is affirmative, then the surface water contingency plan would be implemented. A detailed evaluation of contingency options would be completed and a suitable contingency option would be selected within six months of Step 2 being affirmative. Following the selection of a suitable contingency option, a schedule would be submitted to the MOECC outlining the anticipated timing of design, approval and construction of the selected contingency option.

13.9 Trigger Locations

For the purpose of establishing distinct trigger mechanisms for this Site, each of the four Site boundaries are discussed separately in the following subsections. These Site boundaries, together with their associated trigger mechanisms (when appropriate), are as follows, with rationale provided in Subsections 13.9.1 and 13.9.2.

13.9.1 North, West and South Boundaries

Because the interpreted direction of groundwater flow and the direction of surface water flow are ultimately towards the eastern property boundary, there is a buffer zone, and there are leachate collection system components, no trigger mechanisms are required for these three boundaries during the first 10 years of landfill operation. Based on groundwater quality data and groundwater elevations collected during landfill operations, the need for additional compliance locations on the north, west and south sides of the landfill will be determined as landfilling progresses.

13.9.2 East Boundary

At the down-gradient property boundary, groundwater quality is monitored at five nests of groundwater monitoring wells. These wells are located at the northeast corner of the Site near the Site processing and treatment facilities (monitoring well nests 12-3, 13-13, S), northeast corner of the landfill (monitoring well nests 13-17), and at the southeast corner of the landfill (monitoring well nests 13-25) as shown on Figure 13-1. These groundwater monitoring wells are referred to as compliance wells. In addition, the monitoring well nest P1-9, located midway along the landfill's eastern boundary and located approximately 60 metres from the down-gradient property boundary, has also been considered a compliance well as it has monitoring wells screened in the 4 stratigraphic units at the Site, Along with the compliance locations, the sentinel groundwater monitoring wells along the eastern boundary of the landfill (P1-1, P1-2, P1-3, P1-4, P1-5, P1-6, P1-7, P1-8, P1-10, P2-1, P2-2, P2-3, P2-4, P2-5, P2-6, P2-7) will also be included as trigger locations.

The surface water stations BSW1, BSW2 and BSW3 represent the surface water discharge points from the Site and will be the compliance surface water stations.

13.9.2.1 Surficial Silty Sand

The down-gradient surficial silty sand trigger locations include monitoring wells 12-3-6, 13-13-2, S-B, P1-1B, P1-2B, P1-3B, P1-4B, P1-5B, 13-17-2, P1-6B, P1-7B, P1-8B, P1-9D, P1-10B, P2-1B, P2-2B, P2-3B, P2-4B, P2-5B, P2-6B, P2-7B and 13-25-2. Of these locations, monitoring wells 12-3-6, 13-13-2, S-B, 13-17-2, P1-9D and 13-25-2 are compliance locations.

13.9.2.2 Silty Layer

The down-gradient silty layer trigger locations include monitors 12-3-5B, S-A, 13-13-3, P1-1A, P1-2A, P1-3A, P1-4A, P1-5A, 13-17-3, P1-6A, P1-7A, P1-8A, P1-9C, P1-10A, P2-1A, P2-2A, P2-3A, P2-4A, P2-5A, P2-6A, P2-7A and 13-25-3. Of these locations, monitoring wells 12-3-5B, 13-13-3, S-A, 13-17-3, P1-9C and 13-25-3 are compliance locations.

13.9.2.3 Glacial Till

The down-gradient glacial till trigger locations include monitors 12-3-4A and P1-9B. Both of these locations are compliance locations.

13.9.2.4 Bedrock

The down-gradient bedrock trigger locations include monitors 12-3-3 and P1-9A. Both of these locations are compliance locations.

13.10 Modification to Trigger Mechanism

If, depending on observations and ongoing Site monitoring results, there is a need in the future to modify the trigger mechanisms, a formal application would be made by the CRRRC to the MOECC District Manager requesting the necessary changes.