ENVIRONMENTAL MONITORING PLAN
GROUNDWATER, SURFACE WATER, LEACHATE & SUBSURFACE GAS COMPONENTS

WEST CARLETON ENVIRONMENTAL CENTRE
OTTAWA, ONTARIO

Submitted to:

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1.0 INTRODUCTION

The purpose of this document is to provide a framework for a rational environmental monitoring plan for the West Carleton Environmental Centre (WCEC). This document represents an updated version of the *Environmental Monitoring Plan, Revision No. 02*, prepared by WESA Inc. in May 2011, and approved by the Ontario Ministry of Environment and Climate Change (MOECC). The Environmental Monitoring Plan (hereafter referred to as the "EMP") is being revised to reflect the closure of the existing WM Ottawa Landfill and the development of a new landfill footprint north of the closed landfill. This EMP is being submitted to the MOECC in support of an application for an Environmental Compliance Approval for the WCEC facilities. It is intended that the EMP will continue to be reviewed and updated periodically; taking into account any recommendations provided in future monitoring reports. The herein revision (Revision 1) to the EMP is based on Corrective Action measures carried out at the WM Ottawa Landfill site and initial review by the MOECC of the proposed EMP (July 2014) for the WCEC facilities in support of the Environmental Compliance Approval.

The WCEC facility is located northwest of the intersection of Carp Road and Highway 417 in Ottawa, Ontario (see Figure 1). The site includes the closed 35 hectare landfill and a proposed 37.8 hectare landfill to be located north of the closed landfill. The total site area is 233 hectares located on Part of Lots 2, 3 and 4, Concession II, and Lots 3, 4 and the South Half of Lot 5, Concession III of the former Township of West Carleton (Geographic Township of Huntley), now in the City of Ottawa. The total site area includes 51.4 hectares of land east of the landfill site which were designated as CAZs in 2006 and 2011. The landfill site layout and current (2013) topography, road network and site features, and the locations of the adjacent CAZs are shown on Figure 2. The existing landfill is closed to further waste disposal, and has been capped with final cover and vegetative layers.

1.1 SCOPE AND OVERVIEW

This document provides a brief summary of the physical setting of the site, the rationale and design of the proposed environmental monitoring network (groundwater, surface water, leachate and landfill gas), monitoring frequencies and parameters for each monitoring location, and an appropriate site-specific method for data evaluation and trigger mechanisms. Contingency plans to mitigate unanticipated impacts are also presented.

The contents of this EMP include the following:

- Physical Setting (Section 2.0);
- Groundwater Monitoring Program (Section 3.0);
- Surface Water Monitoring Program (Section 4.0);

- Landfill Gas Monitoring Program (Section 5.0);
- Landfill Leachate Monitoring Program (Section 6.0);
- Data Evaluation Methods (Section 7.0);
- Contingency Plans (Section 7.4); and,
- Reporting Requirements (Section 8.0)

Details on water elevation measurements, sampling locations and frequencies, groundwater and surface water chemistry, landfill gas and leachate monitoring are included in this document.

The EMP presented herein is a program that includes:

- an effective use of monitoring parameters that are known to be related to the landfill (or "indicator" parameters);
- monitoring locations selected to provide detection of a potential release from the landfill; and,
- sampling frequency to provide timely detection of a potential release from the facility based on site-specific conditions.

The surface water and groundwater portions of this monitoring program are based on the hydrologic and hydrogeological characteristics of the area and the potential influence of the landfill on these systems as they exist today, and are projected to exist in the future (based on the future development of the site).

2.0 PHYSICAL SETTING

A summary description of the hydrogeologic environment that could be potentially affected by the development and operation of the WCEC facilities is provided below. Note that a detailed description of the environment is provided in the Hydrogeologic Assessment Report, prepared for the application for approval of the WCEC waste disposal site, under the Environmental Protection Act (WESA, dated July 2014).

2.1 SITE TOPOGRAPHY AND DRAINAGE

The WCEC property consists of well-drained sandy and glacial till areas, representing the upland side of a post-glacial beach ridge. The topography is relatively flat-lying on the western half of the property with elevations between approximately 125 and 130 metres above sea level (mASL), and slopes downward toward the eastern edge of the ridge, reaching approximately 115 mASL in the northeast corner of the site. The land surface has been modified by former aggregate extraction activities and landfill operations.

North and west of the existing landfill site, surface drainage flows within the Huntley Creek subwatershed. Tributaries of Huntley Creek generally flow northward to Richardson Side Road, and then eastward past Carp Road. Huntley Creek discharges to Carp River east of Huntmar Road.

From within the boundaries of the existing landfill property, there is minimal direct off-site discharge of surface water. Surface water drainage is primarily contained within the landfill property and is directed to on-site ponds. The exceptions to this are the external slopes of the vegetated site perimeter berms along the east and south boundaries of the landfill property; however, this amount of surface runoff is very minor and is not in contact with operational activities at the landfill. Runoff from the vegetated berms flows into the Carp Road and Highway 417 drainage systems. There is also a small area of drainage from the extreme western end of the site, north of the service entrance, which flows into the ditch along William Mooney Road, and then northward into a tributary of Huntley Creek.

The Highway 417 drainage system controls surface water flow immediately south of the existing landfill property. Surface water drainage south of the landfill property is controlled by ditches, catch basins and culverts along Highway 417 and generally flows from west to east, eventually reaching Feedmill Creek and ultimately Carp River.

Surface water drainage around the proposed new landfill footprint will be directed to multi-stage storm water management ponds. The first stage of each pond is lined, and the second stage is unlined to allow water to infiltrate into the subsurface.

2.2 HYDROGEOLOGY

The surficial geology across the WCEC property reflects the glacial history of the Ottawa region. The unconsolidated deposits consist principally of sand, silt, gravel and glacial till, and range in thickness from approximately 3 to 17 metres. The surficial deposits are interpreted to be ice-contact stratified drift sediments, consisting of a mixture of poorly to well-sorted, stratified gravels and sands, interbedded with a silty sand-gravel till. The deposits are interpreted to have been submerged during the Champlain Sea encroachment, and therefore show indications of re-working in a subaqueous environment.

The bedrock surface generally slopes toward the northeast across the property, ranging between elevations of 125 mASL and 110 mASL. The bedrock surface features two apparent topographic highs: one located near the southwest extremity of the property, and the other in the western portion of the existing landfill site.

Bedrock consists of light to medium grey, fine to medium-grained fossiliferous limestone with some shaly and sandy interbeds. The bedrock is classified as the Bobcaygeon Formation which is described regionally as a limestone with shaly partings and intermittent sandstone. The bedrock is generally most fractured in its upper few metres, while the frequency of fractures in the bedrock decreases starting at depths of approximately 6 to 8 metres below the bedrock surface.

In the higher topographic elevations along Carp Road, the water table in the unconsolidated deposits (i.e., sand, silty sand and silty sand-gravel till) is generally found at over 10 metres depth, indicating that the majority of the unconsolidated deposits are unsaturated. The saturated thickness of these deposits, which represents the water table aquifer, is generally limited to 5 metres or less. In areas where the bedrock is closer to the surface or where the topographic elevations decline, the depth to the water table decreases, however, the saturated thickness remains limited. Groundwater is also found in the weathered bedrock at the overburden-bedrock interface. This part of the unit extends to a depth of approximately 6 to 8 metres below the bedrock surface.

Shallow groundwater flow on the property generally follows the bedrock topography, with a water table elevation varying from 128 to 129 mASL in the southwest portion of the landfill property to less than 112 mASL east of Carp Road. The direction of groundwater flow within the overburden-shallow bedrock in the southwest portion of the study area is towards the north-northeast. In the northwest corner of the existing landfill site, the topographic high present in the bedrock appears to influence shallow groundwater flow and induces an area of localized northwesterly flow toward the northwest corner of the site. Across the majority of the study area, the direction of groundwater flow in the overburden-shallow bedrock is towards the northeast. Comparison of the groundwater head contours between different periods of the year illustrates that although there are seasonal variations in the groundwater elevations, the general characterization of the flow directions and gradients remains consistent.

The hydrogeological setting on the WCEC property represents a zone of groundwater recharge, with a relatively shallow water table, an unconfined aquifer, and permeable hydrostratigraphic units.

Groundwater flow in the limestone bedrock is controlled by open joints and fractures. Investigations have indicated that the deeper bedrock, below approximately 6 to 8 metres from the bedrock surface, contains fewer fractures than above, and produces significantly lower groundwater yields in monitoring wells developed into this unit. Although it is reasonable to predict that there is some vertical fracturing from the upper bedrock to the deeper zone, the results from site investigations suggest that the connection is limited. Low groundwater yields observed in the deeper bedrock in combination with the hydraulic head separations between the shallow and the deep bedrock units suggest that this deeper zone is not well connected vertically to the overburden-shallow bedrock unit above or laterally within the deep bedrock. Overall, the water level and hydraulic conductivity data obtained during these studies further supports the distinctiveness of the two hydrostratigraphic units (overburden-shallow bedrock and deep bedrock units).

The regional direction of groundwater flow in the deep bedrock has been interpreted to be toward the northeast. Hydraulic heads are found to be highly variable across the site, as there appears to be limited lateral continuity in this hydrogeologic unit. Groundwater flow in the deep bedrock appears to be controlled by the regional groundwater flow system toward the Carp River and the Hazeldean Fault, located northeast of the site.

2.3 Potential Pathways for Migration

The overburden/shallow bedrock interface zone is the preferential flow path in the vicinity of the facility and monitoring of this zone will provide for the earliest detection of potential migration from the landfill. Therefore, the groundwater monitoring program described in the next section, in particular the sampling and chemical testing components, are focused on the overburden/shallow bedrock unit.

3.0 GROUNDWATER MONITORING PROGRAM

Section 25 of Ontario Regulation 232/98 requires that a groundwater monitoring program be carried out for a landfilling site:

> *25. The owner and the operator of a landfilling site shall ensure that a program is carried out for monitoring ground water quality and quantity.*

The groundwater monitoring program described herein includes water elevation measurements to determine groundwater flow directions and gradients, and sampling to monitor groundwater quality. The following section describes the proposed monitoring network for the facility and presents specific assessment parameters with proposed concentration limits to monitor and manage groundwater quality at the closed WM Ottawa Landfill site and at the new WCEC landfill footprint.

The proposed groundwater monitoring network has been developed to monitor hydraulic and chemical conditions in the preferential flow zones in both vertical and horizontal orientations along the critical flow pathways. The primary interval targeted is the overburden/shallow bedrock zone.

Most of the monitoring wells described in the following sections are already in service; many are currently used to monitor the closed landfill. The exceptions are the proposed monitoring wells to be installed around the new landfill footprint, denoted as “A” to “G”. These monitoring wells will be installed and brought into service before any waste is placed in the new landfill.

In addition to the groundwater monitoring wells, purge wells (PW) and water supply wells, northwest of the CAZ also make up the groundwater monitoring network for the site.

3.1 GROUNDWATER ELEVATION MONITORING

The rationale for monitoring the groundwater elevations is to determine the direction of groundwater flow and the hydraulic gradients. Groundwater elevations have been monitored at the site on an annual basis for over 20 years providing an exhaustive database of water elevations. The direction of groundwater flow and the hydraulic gradient have been shown to be consistent from year to year through this time period. The objectives of the groundwater elevation monitoring are to continue to observe the groundwater flow orientations and to determine how the new landfill footprint and storm water management ponds affect the flow regime. Groundwater elevations will be recorded on a semi-annual basis to monitor the local aquifer system.

3.1.1 Groundwater Elevation Monitoring Locations

The list of groundwater monitors to be included in the semi-annual survey of groundwater elevations is presented in Table 1 and shown on Figure 3(a) (Overburden-shallow bedrock zone) and Figure 3(b) (Deep bedrock). The list in Table 1 includes monitoring wells on and adjacent to the landfill site from background, side gradient and downgradient locations.

Table 1: Groundwater Elevation Monitoring Locations – Semi-annual Survey

Location	Overburden/Shallow Bedrock (78 locations)	Deep Bedrock (23 locations)
East of Carp Road; on the CAZ and along Highway 417	W44-3, W48-2, W49-3, W51-2, W52-2, W53-1, W53-2, W54-2, , W56-2, W79, W82, W84R1, W85, W94, W95, W96, PW25, WS2*	W44-1, W48-1, W54-1, W56-1
West of Carp Road; along the eastern boundary of WM property	P85, W19, W46-2, W66, W67-2, W69, W80, W81, W86, W92, W93, PW1, PW2R1, PW3, PW4, PW5, PW6R1, PW7R1, PW8, PW9, PW10, PW20, PW26, PW27	W46-1, W67-1
West of Carp Road; south and west of the existing landfill	P37, P51, P55, P68, P83, P84, W50-2, W57-2, W59-2, W70, PW11, PW13, PW15, PW17, PW19	W50-1, W57-1, W59-1
West of William Mooney Road	W74, W77-2, W88-2, W89-2, W90-2	W77-1, W88-1, W89-1, W90-1
Surrounding the new landfill footprint and storm water management ponds	P65, P79, P80-1, P80-2, W60-2, W61, W65-2, W73-2, W76-2, W87, A-2‡, B, C-2, D-2, E-2, F-2, G-2	W60-1, W65-1R, W73-1, W76-1, A-1, C-1, D-1, E-1, F-1, G-1

* - Open bedrock well WS2 is to be re-commissioned as a screened monitoring well.
‡ - Monitoring wells designated with a letter (e.g., "A") are proposed locations surrounding the new landfill footprint.

In addition to the semi-annual survey of groundwater elevations, water levels will be measured on a monthly basis in a subset of monitoring wells to observe the influence of the purge well system on the groundwater levels. The list of monitoring wells to be included in the monthly program is presented in Table 2. These locations are shown on Figure 3(a).

Table 2: Groundwater Elevation Monitoring Locations – Monthly Program

Overburden/shallow Bedrock (33 Locations)
PW1, PW2R1, PW3, PW4, PW5, PW6R1, PW7R1, PW8, PW9, PW10, PW11, PW13, PW20, PW25, PW26, PW27 W19, W46-2, W48-2, W49-3, W65-2, W66, W67-2, W69, W80, W81, W82, W84R1, W85, W86, W92, W93, P85

At the same time as collecting the water level measurements, the monitoring wells will be inspected to ensure that they remain in proper operating condition and are adequately protected from damage, with locked well caps and steel casing. Any maintenance requirements are to be reported to the WM Site Manager immediately upon completion of the monitoring event.

3.2 GROUNDWATER QUALITY MONITORING

The rationale for measuring the groundwater chemistry at any landfill site is to determine whether there is any release of leachate to the subsurface environment, and to observe the movement of any leachate-impacted groundwater in relation to the site boundaries. This type of program is intended to monitor for leachate-impacted groundwater at the site boundaries and to determine if the observed concentrations of the parameters are adversely impacting neighbouring properties. This EMP presents a consistent approach that involves monitoring at locations intended to provide a clear and systematic evaluation in consideration of the Ontario Ministry of Environment's Reasonable Use Guidelines (Guideline B-7). The main criteria used in selecting monitoring locations are:

- position within a critical pathway;
- groundwater flow orientation in that pathway;
- landfill and property boundary proximity; and,
- potential source area locations (i.e., unlined areas, storm water ponds, etc.).

3.2.1 Groundwater Quality Monitoring Locations

Monitors screened within the overburden/shallow bedrock interface zone are within the primary groundwater flow path; these monitors comprise the primary monitoring program for the facility. The main emphasis of the groundwater quality monitoring program is to monitor locations that are considered to be downgradient from the landfill footprint.

The groundwater monitoring locations included in this EMP represent the following areas:

- Within and at the boundaries of the Contaminant Attenuation Zones (CAZ);
- Eastern boundary of the landfill site;
- Western boundary of the landfill site;
- Surrounding the new landfill footprint and storm water ponds;
- Background monitoring locations;
- Water supply wells to the northwest; and,
- Selected monitoring wells within the interior of the site boundaries (purge well groundwater quality, other locations).

The groundwater quality monitoring locations are summarized in Table 3 and are illustrated along with pertinent site features on Figure 4.

Table 3: Groundwater Quality Monitoring Locations, General/Inorganic Parameters

Location	Rationale for Location	Selected Monitors (46 locations)
Background Locations	Background groundwater quality, up gradient from WM property	W57-2, W60-2, W61, W70, W74, W76-2, W77-2, W88-2
Existing Closed Landfill		
CAZ East of Carp Road	Primary groundwater flow path from the landfill, on the downgradient CAZ properties	W44-3, W48-2, W53-1, W53-2, W55-2, W56-2, W79, W82, W85, W94, W95, W96, WS2*
CAZ South of Highway 417	Historic groundwater chemistry	W51-2, W52-2
Water Supply Wells	North-west property boundary and CAZ	2383 Carp Road, 2394 Carp Road (1985 well), 2397 Carp Road, 2415 Carp Road (office well), 2413 Carp Road***
Purge Well System	On-site purge well groundwater quality	PW1, PW2R1, PW3, PW4, PW5, PW6R1, PW7R1, PW8**, PW9, PW10, PW20, PW26, PW27
New WCEC Landfill		
Surrounding the New Landfill Footprint and Stormwater Ponds	Downgradient from the closed landfill and new footprint, and infiltration basins for the ponds	P65, P79, P80-1, W65-2, W73-2, W87, A-2‡, B, C-2, D-2, E-2, F-2, G-2

* - Open bedrock well WS2 is to be re-commissioned as a screened monitoring well.
** - Also designated as a leachate monitoring location (PW8 location is shown on Figures 4 and 5).
*** - Monitored for one year only to better characterise background water quality.
‡ - Monitoring wells designated with a letter (e.g., "A") are proposed locations surrounding the new landfill footprint.

3.2.2 Groundwater Quality Monitoring Parameters and Sampling Frequency

Groundwater will be sampled once per year (spring) from the monitoring wells included in Table 3, with the exceptions noted in Table 4.

Table 4: Exceptions to Once-Annual Sampling Frequency, Groundwater Monitoring Locations

Description	Frequency	Monitors (29 locations)
Downgradient of the closed landfill site	Twice per year (spring and fall)	W44-3, W48-2, W53-1, W53-2, W55-2, W56-2, W79, W82, W85, W94, W95, W96, WS2
CAZ southeast of closed landfill site	Twice per year (spring and fall)	W51-2, W52-2
Downgradient of the new storm water management ponds	Twice per year (spring and fall)	D-2, E-2, F-2, W65-2, W73-2
Water Supply Wells North-west property boundary and CAZ	Twice per year (spring and fall)	2383 Carp Road, 2394 Carp Road (1985 well), 2397 Carp Road, 2415 Carp Road (office well), 2413 Carp Road***

All groundwater samples will be analyzed for the list of parameters identified in Table 5 below.

Table 5: Groundwater Quality Monitoring Parameters – General/Inorganic List

General/Inorganic Groundwater Parameters	
Alkalinity	Calcium
Conductivity	Magnesium
Hardness	Sodium
pH	Chloride
Chemical oxygen demand	Potassium
Dissolved organic carbon	Barium
Total dissolved solids	Boron
Ammonia (total)	Chromium (total)
Nitrate	Iron
Nitrite	Manganese
Total Kjeldahl nitrogen	Lead
Sulphate	

In addition, groundwater samples from selected groundwater monitoring locations identified in Table 6 will be analyzed for the volatile organic compounds (VOC) listed in Table 7.

Table 6: Groundwater Quality Monitoring Locations, VOCs

Location	Rationale for Location	Selected Monitors (17 locations)
Existing Closed Landfill		
CAZ East of Carp Road	Primary groundwater flow path from the landfill, on the downgradient CAZ properties	W44-3*, W48-2*, W53-1*, W53-2*, W65-2*, W73-2*, W79*, W82*, W85*, W87*, WS2*
Purge Well System	On-site purge well groundwater quality	PW1, PW2R1, PW3, PW20, PW26, PW27
New WCEC Landfill		
Surrounding the New Landfill Footprint and Storm water Ponds	Downgradient from the new footprint and infiltration basins	W65-2*, W73-2*, W87, A-2*, B*, C-2*, D-2*, E-2, F-2, G-2

*- denotes monitoring wells that will be sampled and analyzed for 1,4 dioxane

Table 7: Groundwater Quality Monitoring Parameters – VOC List

Volatile Organic Compound (VOC) List		
Benzene	1,4-Dichlorobenzene	1,1,1,2-Tetrachloroethane
Bromodichloromethane	1,1-Dichloroethane	1,1,2,2-Tetrachloroethane
Bromoform	1,2-Dichloroethane	Tetrachloroethylene
Bromomethane	1,1-Dichloroethylene	Toluene
Carbon tetrachloride	Cis-1,2-Dichloroethylene	1,1,1-Trichloroethane
Chlorobenzene	Trans-1,2-Dichloroethylene	1,1,2-Trichloroethane
Chloroethane	1,2-Dichloropropane	Trichloroethylene
Chloroform	Cis-1,3-Dichloropropylene	Trichlorofluoromethane
Chloromethane	Trans-1,3-Dichloropropylene	1,3,5-Trimethylbenzene
Dibromochloromethane	Ethylbenzene	m&p-Xylene
1,2-Dibromoethane	Methylene chloride	o-Xylene
1,2-Dichlorobenzene	Styrene	Vinyl chloride
1,3-Dichlorobenzene		

As identified in Table 6, groundwater samples from selected monitoring wells near the site boundaries, as well as the purge well system will also be analyzed for 1,4 dioxane. The 1,4 dioxane analyses will be used to assist in the interpretation of whether there are landfill-related groundwater impacts at these boundaries. Further discussion of 1,4 dioxane as an Assessment Parameter is found in Section 3.2.3.

The groundwater monitoring program is summarized in Table 8.

Table 8: Summary of Groundwater Monitoring Program

Monitor Locations	Parameters	Monitoring Frequency
Overburden/Shallow Bedrock		
P37, P51, P55, P65, P68, P79, P80-1, P80-2, P83, P84, W44-3, W50-2, W51-2, W52-2, W53-1, W53-2, W54-2, W55-2, W56-2, W57-2, W59-2, W60-2, W61, W65-2, W70, W73-2, W74, W76-2, W77-2, W79, W82, W86, W87, W88-2, W89-2, W90-2, W94, W95, W96, WS2*, PW15, PW17, PW19, PW26, PW27, A-2‡, B, C-2, D-2, E-2, F-2, G-2	Groundwater Elevation	Twice each year, in Spring & Fall
PW1, PW2R1, PW3, PW4, PW5, PW6R1, PW7R1, PW8, PW9, PW10, PW11, PW13, PW20, PW25, PW26, PW27, W19, W46-2, W48-2, W49-3, W65-2, W66, W67-2, W69, W80, W81, W82, W84R1, W85, W86, W92, W93, P85	Groundwater Elevation	Once each month
P65, P79, P80-1; W57-2, W60-2, W61, W70, W74, W76-2, W77-2, W87, W88-2, A-2, B, C-2, G-2	General/Inorganics (Table 5)	Once each year, in Spring
W44-3, W48-2, W51-2, W52-2, W53-1, W53-2, W55-2, W56-2, W65-2, W73-2, W79, W82, W85, W94, W95, W96, WS2, D-2, E-2, F-2, 2383 Carp Road, 2394 Carp Road (1985 well), 2397 Carp Road, 2415 Carp Road (office well), 2413 Carp Road**	General/Inorganics (Table 5)	Twice each year, in Spring and Fall
PW1, PW2R1, PW3, PW4, PW5, PW6R1, PW7R1, PW9, PW10, PW20, PW26, PW27	General/Inorganics (Table 5)	Once each year, in Spring
W44-3, W48-2, W53-1, W53-2, W65-2, W73-2, W79, W82, W85, W87, WS2, PW1, PW2R1, PW3, PW20, PW26, PW27, A-2, B, C-2, D-2, E-2, F-2, G-2	VOCs (Table 7)	Once each year, in Spring
W44-3, W48-2, W53-1, W53-2, W65-2, W73-2, W79, W82, W85, W87, WS2, A-2, B, C-2, D-2	1,4 Dioxane	Once each year, in Spring
Deep Bedrock		
W44-1, W46-1, W48-1, W50-1, W54-1, W56-1, W57-1, W59-1, W60-1, W65-1R, W67-1, W73-1, W76-1, W77-1, W88-1, W89-1, W90-1, A-1, C-1, D-1, E-1, F-1, G-1	Groundwater Elevation	Twice each year, in Spring & Fall

* - Open bedrock well WS2 is to be re-commissioned as a screened monitoring well.
** - sample for one year only to establish baseline water quality.
‡ - Monitoring wells designated with a letter (e.g., "A") are proposed locations surrounding the new landfill footprint.

3.2.3 Groundwater Quality Assessment Limits

Detailed hydrogeological investigations at the WM Ottawa Landfill have demonstrated that there is a high degree of spatial and temporal variability observed in the background groundwater for several water quality parameters that are typically used to indicate leachate from a landfill site, such as iron, manganese, sodium, barium and sulphate. For these parameters, the observed concentrations in the background groundwater routinely exceed the Reasonable Use Limits. Other parameters, such as chloride, are elevated in groundwater as a result of road salting along Carp Road, Highway 7 and 417 and interchanges, as well as dust control on off-site properties.

As a result, no conclusions can be drawn with respect to comparisons with Guideline B-7 (Reasonable Use) at the downgradient boundary of the landfill site for these parameters.

Potential groundwater impacts from the closed WM Ottawa Landfill are more accurately assessed using an alternate suite of sixteen parameters, denoted *Assessment Parameters*, which include the following:

- Alkalinity
- Ammonia
- Boron
- COD
- Nitrate
- Nitrite
- Potassium
- TKN
- Benzene
- Chlorobenzene
- Chloroethane
- Cis-1,2-dichloroethylene
- 1,4-Dichlorobenzene
- 1,1-Dichloroethane
- Trichloroethylene
- Vinyl chloride

The derivation of the Assessment Parameters was presented in a document entitled, *Off-Site Groundwater Assessment, Ottawa Landfill Site*, prepared by WESA, dated February 2005. The findings of this report were accepted by the Ontario Ministry of Environment in 2006. Alkalinity was added as an assessment parameter in 2015 following the MOECC review of the site conditions in support of the Environmental Compliance Approval for the WCEC facilities. The Assessment Parameters have low and relatively uniform background concentrations, elevated concentrations in leachate, and no other apparent significant sources that affect groundwater concentrations at the monitoring locations.

Another parameter that can be used to assess potential leachate impacts at the closed WM Ottawa Landfill is the VOC 1,4 dioxane. The VOC, 1,4 Dioxane is a synthetic industrial chemical that is miscible (i.e., highly soluble) in water, and is often found in landfill leachates containing other VOC solvents, particularly 1,1,1-trichloroethane (TCA). It is used in many products including paint strippers, grease, varnishes, and in some consumer products such as deodorants, shampoo and cosmetics (USEPA Technical fact Sheet, January 2014). Currently, there is no Ontario Drinking Water Standard for this compound.

The Assessment Parameters can be divided into two categories: i) those that have Ontario Drinking Water Standards, Objectives and Guidelines (ODWSOG), and for which concentration limits can be calculated using the approach outlined in Guideline B-7 (Reasonable Use); and ii) those that do not have ODWSOG, and for which Guideline B-7 concentration limits cannot be calculated. The parameters with ODWSOG are listed in Table 9, along with their respective Guideline B-7 limits. The limits have been calculated using the historical background dataset available from 18 monitoring locations that are upgradient from the WCEC property. A summary of the background water quality and Reasonable Use Limits are presented in Appendix A. These parameters and their respective limits will be used to assess compliance to MOECC groundwater standards at the WCEC facility.

Table 9: Groundwater Assessment Parameters and Guideline B-7 (Reasonable Use) Limits

Reasonable Use Limits (mg/L)	
Alkalinity	351
Boron	1.27
Nitrate (as N)	2.54
Nitrite (as N)	0.29
Benzene	0.0013
Trichloroethylene	0.0013
Vinyl chloride	0.0006
Chlorobenzene	0.0150
1,4-Dichlorobenzene	0.0006

As more information becomes available regarding leachate characteristics from the new landfill and groundwater conditions in the immediate area of the new footprint, additional monitoring parameters may emerge as being appropriate for assessing groundwater quality in the areas that are downgradient from the new landfill and storm water management ponds. For example, it is expected that impacts from road salting may be less severe north of the closed landfill; therefore, sodium and chloride may be useful to assess potential impacts from the new landfill or storm water management ponds. On the other hand, preliminary indications of nitrate impacts from agricultural fertilizers and/or septic systems are apparent along Carp Road north of the closed landfill. Consequently, nitrate and nitrite concentrations will have to be interpreted in light of these conditions. In addition, other identified sources of increased alkalinity, such as quarry operation, wash ponds etc. have been identified within the establish CAZ for the site and therefore may not be representative of leachate impacts. Alkalinity is to be used as an assessment parameter in conjunction with other well established assessment parameters, to identify leachate impacts.

It is recommended that an evaluation of whether additional water quality parameters would be appropriate for the new landfill be made after the first two years of monitoring is completed. Until that time, the parameters and limits listed in Table 9 can be used for the WCEC facilities.

The remaining Assessment Parameters do not have OWDSOG, and are not used to assess the compliance of the WM Ottawa Landfill to MOECC groundwater standards. However, they are used to assist in the interpretation of potential impacts from the landfill. For these constituents, the historical monitoring dataset is used to evaluate for geochemical trends using results of major ion analysis, time-series concentrations graphs at individual wells ("intra-well analysis"), and by using Piper and Stiff geochemical diagrams, where appropriate.

3.2.4 Review of Groundwater Monitoring Program

The groundwater monitoring program will be reviewed every year as part of the reporting for the landfill site. Recommendations for revisions will be developed if appropriate, and submitted to the MOECC District Manager for review and approval.

The Guideline B-7 limits listed in Table 9 are derived from a statistical analysis of the background groundwater quality dataset. As the data set is being added to each year, the limits need to be updated on a regular basis so that they continue to accurately reflect natural variability in the data. Therefore, the concentrations will be re-calculated once every five years, using the updated background groundwater quality dataset.

4.0 SURFACE WATER MONITORING PROGRAM

Section 24 of Ontario Regulation 232/98 requires that a surface water monitoring program be carried out for a landfilling site:

> *24. The owner and the operator of a landfilling site shall ensure that a program is carried out for monitoring the quality and quantity of the surface water features on the site and of the surface water features that receive a direct discharge from the site.*

From within the boundaries of the landfill property, there is a limited amount of direct off-site discharge of surface water; the majority of surface water drainage is contained within the landfill property and is directed to on-site ponds, which are engineered, natural or remain following extraction of aggregate. The exceptions to this are the external slopes of the vegetated perimeter berms along the east and south boundaries of the landfill property; however, this amount of surface runoff is very minor and is not in contact with operational activities at the landfill. Runoff from the vegetated berms flows into the Carp Road and Highway 417 drainage systems. There is also a small area of drainage from the extreme western end of the site, north of the service entrance, which flows into the ditch along William Mooney Road, and then northward into a tributary of Huntley Creek. On the northern portion of the WCEC property, an agricultural ditch directs surface water drainage northward to a wooded area. The drainage ditch will be covered by the new landfill, and will not be used in future.

The Highway 417 drainage system controls surface water flow immediately south of the landfill property. Along the north side of the highway, east of the landfill property, shallow groundwater discharges into the highway drainage ditch and provides the base flow for the ditch. This ditch flows eastward along the north side of Highway 417, and empties into Feedmill Creek at a point approximately 1.5 km east of the landfill property.

The purpose of the surface water monitoring program is to determine if the closed landfill or new landfill footprint are having any adverse impacts on the neighbouring surface water environment, and to monitor surface water quality in the new storm water management ponds. The monitoring locations and analytical parameters have been selected to identify the characteristics of the water downgradient from the landfill. Because of the orientations and flow directions of the Highway 417 drainage system and surrounding agricultural drains, there are no suitable locations to monitor background surface water quality so that it can be compared to downgradient water quality.

4.1 Surface Water Elevation Monitoring

Surface water elevations are to be monitored at locations on and adjacent to the landfill property where the surface water level represents the expression of the water table at the ground surface, and in the new storm water infiltration basins. These measurements are used to complement the groundwater elevations to determine the direction of groundwater flow. Surface water elevations will be recorded on a semi-annual basis from staff gauges to monitor potential changes to the local aquifer system. The list of surface water locations to be included in the semi-annual survey of measurements is presented in Table 10 and shown on Figure 3(a).

Table 10: Surface Water Elevation Monitoring Locations – Semi-annual Survey

Location	Surface Water Monitors (7 locations)
South of the closed landfill, on WM property	S17 (southeast storm water recharge pond) Pond (on the former Bradley Pit)
Southeast of closed landfill, along Highway 417 ditch	S1, S2, S3
East of new landfill	Infiltration basin #1, Infiltration basin #2

At the same time as collecting the surface water level measurements, the staff gauges will be inspected to ensure that they remain in proper operating condition and are adequately protected from damage. Any maintenance requirements are to be reported to the WM Site Manager immediately upon completion of the monitoring event.

4.2 Surface Water Quality Monitoring

The purpose of surface water sampling is to monitor the quality of surface water to evaluate whether the quality of the water is impacted by the closed landfill, or by operation of the new landfill and storm water management ponds.

4.2.1 Surface Water Quality Monitoring Locations

A list of surface water quality monitoring locations is provided in Table 11. The respective monitoring points are shown on Figure 4.

Table 11: Summary of Surface Water Quality Monitoring Program

Drainage Course	Monitoring Location (10 locations)	Parameters	Monitoring Frequency
Highway 417 ditch	S1, S3, S10	Surface water (Table 12)	Twice per year (spring and fall)
CAZ southeast of closed landfill	M4, M5	Surface water (Table 12)	Twice per year (spring and fall)
Western boundary of closed landfill	Culvert G	Surface water (Table 12)	Twice per year (spring and fall)
New storm water management ponds	Infiltration basin #1, Infiltration basin #2	Surface water (Table 12) and VOCs (Table 7)	Quarterly (Mar, June, Sept, Dec)
	Lined pond #1, Lined pond #2	Chloride, sodium, pH, TDS & conductivity	Once every two months

4.2.2 Surface Water Quality Monitoring Parameters and Sampling Frequency

Surface water will be sampled from the locations specified in Table 11 and analyzed for the lists of parameters that are specified in the table. The general suite of analytical parameters for surface water is presented below in Table 12. Sampling frequencies are listed in Table 11.

Table 12: Surface Water Quality Monitoring Parameters

Surface Water Quality Parameters	
Alkalinity	Sodium
Conductivity	Chloride
Hardness	Potassium
pH	Sulphate
Chemical oxygen demand	Barium
Dissolved organic carbon	Boron
Total dissolved solids	Chromium (total, Cr^{6+}, Cr^{3+})
Ammonia (total, un-ionized)	Iron
Nitrate	Manganese
Nitrite	Lead
Total Kjeldahl nitrogen	Field measurements:
Calcium	pH, temperature, conductivity,
Magnesium	estimate of flow rate

4.2.3 Surface Water Quality Assessment Limits

Representative parameters for surface water monitoring were chosen based on the historic monitoring results from the Highway 417 ditch and the former Metcalfe Realty property, which is located southeast of the Highway 417 Carp Road interchange. The surface water parameters to be included in the assessment are listed in Table 13 with their respective limits. The Assessment Limits for un-ionized ammonia, alkalinity, chromium species and lead are the Provincial Water Quality Objective (PWQO) values. The Assessment Limit for boron of 1.0 mg/L is based on a review of scientific literature and experience from other jurisdictions. It is a concentration below which adverse effects are not expected to occur to aquatic life and/or habitat.

The results from the Highway 417 ditch samples (S1, S3 and S10), the downstream location on the CAZ property southeast of the closed landfill (M4), and the discharge culvert on the western side of the site (Culvert G) will be compared to the Assessment Limits specified in Table 13. Surface water from the lined storm water management ponds and infiltration basins constructed for the new landfill will not discharge directly to a surface watercourse; therefore, the monitoring results will not be compared to surface water criteria. Instead, the information will be used to monitor and interpret groundwater conditions downgradient from the storm water management ponds and infiltration basins.

Table 13: Surface Water Assessment Parameters and Limits

Parameter	Assessment Limits (mg/L)
Un-ionized Ammonia	0.02
Chromium (VI)	0.001
Chromium (III)	0.0089
Boron	1.0
Lead*	0.005

*Interim revised PWQO, with hardness >80.

4.2.4 Review of Surface Water Monitoring Program

The surface water monitoring program will be re-evaluated every year as part of the reporting for the landfill site. Recommendations for revisions will be developed if appropriate, and submitted to the MOECC Ottawa District Manager for review and approval.

5.0 LANDFILL GAS MONITORING PROGRAM

The major constituents of landfill gas are methane and carbon dioxide. Smaller amounts of other gaseous compounds such as hydrogen sulphide, mercaptans and non-methane organic compounds (NMOC) may also be present. Landfill gas can migrate laterally through unsaturated soil and fractured rock horizons for considerable distances away from the landfill footprint.

The rationale for landfill gas migration monitoring is primarily the explosive nature of the methane component of the landfill gas if it accumulates in enclosed spaces to concentrations between 5 and 15% by volume.

5.1 LANDFILL GAS MONITORING LOCATIONS

Continuous gas sensors and alarms are installed in all on-site buildings that are used regularly by WM personnel, such as the scale house, the GDT building and the maintenance garage. The leachate collection pumphouses and flare building have gas sensors and/or prescribed health and safety procedures for entering. These facilities are, therefore, not included in the landfill gas EMP.

A series of gas monitoring probes have been installed around the perimeter of the closed landfill. These are located between the landfill footprint and the maintenance area (GM1 and GM2), and downstream of the air barrier along Carp Road (GM3, GM4, GM7 and GM8). The locations of these monitors are shown on Figure 5. The historical monitoring results from these locations have demonstrated that landfill gas migration is being controlled by the air barrier system. The gas probes will be monitored once-quarterly with a portable landfill gas analyzer for the concentration of methane. Five landfill gas probes will be installed around the perimeter of the new landfill footprint (refer to GM9 to GM 13 on Figure 5). The gas probes will consist of screened pipe sections sealed into the unsaturated zone, with riser pipes extending to ground surface for access. The gas probes will be protected at surface with lockable, steel casing. The new gas probes will be monitored once-quarterly along with the existing gas probes.

At the same time as collecting the landfill gas measurements, the subsurface probes will be inspected to ensure that they remain in proper operating condition and are adequately protected from damage. Any maintenance requirements are to be reported to the WM Site Manager immediately upon completion of the monitoring event.

The subsurface landfill gas migration monitoring program is summarized in Table 14.

Table 14: Summary of Subsurface Landfill Gas Monitoring Program

Site Area	Monitoring Location (11 locations)	Parameters	Monitoring Frequency
Closed Landfill	GM1, GM2, GM3, GM4, GM7 and GM8	Methane, Gas pressure	Quarterly
New Landfill	GM9, GM10, GM11, GM12 and GM13	Methane, Gas pressure	Quarterly

5.1.1 Landfill Gas Assessment Limits

The recorded measurements of landfill gas from the monitoring locations will be compared to the assessment limits shown in Table 15.

Table 15: Landfill Gas Assessment Concentrations

Parameter	Assessment Limit
Methane	Concentrations at subsurface landfill gas probes to be less than 2.5% methane (50% LEL)

6.0 LANDFILL LEACHATE MONITORING PROGRAM

Section 26 of Ontario Regulation 232/98 requires that a leachate monitoring program be carried out for a landfilling site:

> *26. The owner and the operator of a landfilling site shall ensure that a program is carried out for monitoring leachate quality and quantity.*

Considerable information has already been gathered on the quality of leachate that is generated at the closed WM Ottawa Landfill. This understanding of leachate quality has allowed the selection of unique indicator compounds that are used to monitor the groundwater and surface water environments. Future efforts on monitoring leachate quality from the closed landfill will focus on the leachate and impacted groundwater that is discharged from the site through the forcemain connected to the City of Ottawa's sanitary sewer system.

The new landfill will be constructed with a double-composite leachate containment and collection system. Leachate monitoring at the new landfill is designed to characterize the leachate quality as the landfill is developed, and to ascertain whether there are unique indicators specific to the new landfill's leachate as compared to the older closed landfill.

6.1 Leachate Monitoring Locations

6.1.1 Closed Landfill Monitoring

Leachate samples from the closed landfill will be collected at the discharge from Pumping Station No. 3 (denoted P3) at the GDT treatment building. This leachate is generated within the lined areas of the landfill. A leachate sample will also be collected from purge well PW8 (drilled through waste at the downgradient end of the closed south cell). This leachate is representative of older waste disposed in the south cell. The leachate sampling locations for the closed landfill are shown on Figure 5. The samples will be collected once per year, coinciding with the Spring groundwater monitoring event. The samples will be analyzed for the list of General/Inorganic and VOC parameters specified in Tables 5 and 7 as well as 1-4 Dioxane. The leachate monitoring program for the closed landfill is summarized in Table 16.

Table 16: Summary of Leachate Monitoring Program – Closed Landfill

Monitoring Location	Parameters	Monitoring Frequency
P3, PW8	Groundwater General/Inorganic (Table 5), VOCs (Table 7) and 1-4 Dioxane	Once per year (spring)

6.1.2 New Landfill Monitoring

Leachate collected by the primary leachate collection system will be pumped to the leachate pre-treatment plant. Leachate samples will be collected three times per year from the primary leachate collection system and once-annually from the secondary leachate collection system, and analyzed for the lists of parameters specified in Table 17 outlined below as supported by Schedule 5 of Ontario Regulation 232/98. The samples will be collected from the primary and secondary leachate collection sumps (P-LCS and S-LCS, respectively), located in the northeast corner of the new landfill footprint. Since there is no discharge of leachate from the primary or secondary leachate collection systems to the surrounding environment, there are no assessment limits required for any follow-up action.

The sampling locations at the new landfill footprint are shown on Figure 5, and the new landfill monitoring program is summarized in Table 17.

Table 17: Summary of Leachate Monitoring Program – New Landfill

Monitoring Location	Parameters		Monitoring Frequency
Primary & Secondary Leachate Collection Sumps	Alkalinity Ammonia Arsenic Barium Boron Cadmium Calcium Chloride Chromium Conductivity Copper Iron Lead Magnesium Manganese Mercury	Nitrate Nitrite Total Kjeldahl nitrogen pH Phenols Total phosphorus Potassium Sodium Total suspended solids Total dissolved solids Sulphate Zinc Biochemical oxygen demand Chemical oxygen demand Dissolved organic carbon VOC List (Table 7) 1,4 Dioxane	Once per year (spring)
Primary Leachate Collection Sump	Alkalinity Ammonia Barium Boron Calcium Chloride Conductivity Iron Magnesium	Nitrate pH Sodium Total suspended solids Total dissolved solids Sulphate Biochemical oxygen demand Chemical oxygen demand Dissolved organic carbon	Twice per year (summer and fall)

7.0 DATA EVALUATION AND CONTINGENCY PLANS

This section outlines the evaluation methods that will be used in the event that observed concentrations at the groundwater, surface water or landfill gas monitoring locations exceed the assessment limits specified in Table 9, Table 13 or Table 15, respectively. A contingency plan process is also described in Section 7.4. This section of the EMP is intended to meet the information requirements of Sections 12 and 27 of Ontario Regulation 232/98 regarding leachate contingency planning for landfills.

7.1 GROUNDWATER EVALUATION

The groundwater monitoring program is summarized in Table 8. The rationale for this program is to monitor groundwater flow and groundwater quality around the closed WM Ottawa Landfill and the new WCEC facilities including the new landfill footprints and the storm water infiltration basins.

Corrective action implemented at the former WM Ottawa Landfill has included the installation of a boundary purge well system, on-site pre-treatment of the impacted water, pumping of the pre-treated water to the City of Ottawa's Robert O. Pickard Environmental Centre for final treatment, performance monitoring of the system, and the establishment of CAZ on downgradient lands.

The groundwater quality on the CAZs will continue to be monitored to observe trends in the water quality concentrations. Concentrations that remain stable or decrease over time are indications that the purge well system continues to operate as designed. The monitoring wells that are included in the CAZ monitoring program are:

- **CAZ properties east of Carp Road:** W44-3, W53-1, W53-2, W56-2, W79, W82, W85, W94, W95, W96, WS2[1].
- **CAZ property southeast of landfill property:** W48-2, W51-2, W52-2.

Monitoring wells along the downgradient WM property boundaries (including the CAZ) will be evaluated following the procedures outlined below. The monitoring wells, denoted trigger wells, will include the following:

- **Northern side of site:** A-2, B, C-2, W73-2
- **Western side of site:** W60-2, W61, W76-2
- **Eastern side of site:**
  - **CAZ:** W53-1, W53-2, W79, W82, W94, W95, W96, WS2
  - **North of CAZ:** D-2, E-2, F-2

The Groundwater Evaluation procedures will be triggered in the event concentrations of groundwater Assessment Parameters within the trigger wells reach an Action Level of 80% of the Guideline B-7 (Reasonable Use) limits presented in Table 9.

The monitoring approach includes a confirmation step whereby observations in excess of the limits listed in Table 9 are verified through verification re-sampling. This approach improves the accuracy of the detection monitoring program by eliminating potential false positives from cross-contamination, laboratory error, etc. An examination for significant geochemical trends will be undertaken using results of major ion analysis and using Piper and Stiff geochemical diagrams, where appropriate. A significant trend will be noted when the inorganic chemistry of a monitor shifts progressively towards the geochemical signature typical of leachate or other potential source for two consecutive monitoring events. A minimum of five baseline events must exist prior to the beginning of the trend evaluation. Following the verification re-sampling procedure, if a geochemical trend is documented, an alternate source evaluation will be completed to ascertain

[1] To be re-commissioned as a screened monitoring well.

the source of the trend or exceedance. The specific steps to groundwater data evaluation are detailed, as follows:

Groundwater Data Evaluation Method

Step 1 – Compliance Assessment

If there is a documented new exceedance of the Guideline B-7 (Reasonable Use) concentrations (Table 9), complete a comprehensive water quality assessment within 90 days of receiving the laboratory analysis that indicates an exceedance. The major ion chemistry, VOC and other tools such as time-series graphs, Piper and Stiff diagrams will be used, as appropriate, with the current and historical monitoring program results to further evaluate any changes in leachate indicator concentrations. If the water quality assessment indicates that leachate could be a potential source of the observed exceedance and increasing concentrations, proceed to Step 2.

Step 2 – Confirmation Re-sampling

Confirmation sampling will occur at the next scheduled sampling event. If the initial exceedance is verified, begin accelerated monitoring and proceed to Step 3. If unverified, return to Step 1.

Accelerated monitoring will consist of the following procedure. The monitoring frequency of the monitor(s) with the elevated concentrations is increased to quarterly for one year and groundwater is sampled for all parameters included in the General and VOC lists (Tables 5 and 7, respectively).

Step 3 – Alternate Source Evaluation

The geochemical results from the accelerated monitoring program will be used with the interpretative tools described above (time-series graphs, Piper and Stiff diagrams, etc.) to evaluate the source(s) of the observed exceedance or increasing trend in leachate indicator concentration. This will be completed within 90 days of receiving the laboratory analysis from the last quarterly sampling round. If leachate is confirmed as the source, proceed to Step 4. If the source is not confirmed to be leachate, adjust the program if warranted to prevent re-occurrence (i.e., review sampling procedures, re-evaluate limits) and return to Step 1.

Step 4 – Development and Implementation of Corrective Action Plan

At this point a Corrective Action Plan (CAP) is developed, approved and implemented to prevent exceedance of Reasonable Use concentrations at the facility property boundary. See further explanation of the contingency planning process in Section 7.4 below. The CAP will be prepared and submitted to the MOECC within 90 days of leachate being identified as the source of water quality exceedances (i.e., 90 days from completion of Step 3).

Data evaluation according to the aforementioned methods will be completed annually and submitted as part of the Annual Monitoring Report.

7.2 SURFACE WATER EVALUATION

The applicable objectives for surface water monitoring are listed in Table 13. At the WCEC facility, surface water monitoring will be conducted in the ditch along the north side of Highway 417, on the CAZ southeast of the closed landfill, and at a culvert where surface water discharges at William Mooney Road, on the west side of the property. It is known that shallow groundwater discharges into the ditch on the north side of Highway 417, and that the water quality is impacted by historical waste disposal operations. The purge wells now capture groundwater upstream of the highway ditch, and water quality in the ditch has improved since implementation of the purge well system.

The surface water monitoring locations along the Highway 417 ditch (S1, S3 and S10), the downstream location on the CAZ property southeast of the closed landfill (M4), and the discharge culvert on the western side of the site (Culvert G) will be evaluated as described above for the groundwater monitoring wells included in the performance monitoring. Stable or decreasing water quality concentrations are indications that the purge well system is operating as designed. Any new exceedances of the parameter concentrations listed in Table 13 will be evaluated using the procedure outlined in Section 7.1, beginning with accelerated monitoring (Step 2) along with Step 3, *Alternate Source Evaluation*.

There are no surface water features on the proposed WCEC landfill property that directly discharge off-site. All of the storm water runoff generated on the site will be directed to on-site storm water management ponds, where the water will infiltrate into the subsurface. Surface water will be monitored in the lined and unlined portions of the storm water management ponds. However, because there is no direct discharge from the ponds, the water quality results are not compared to the surface water objectives.

7.3 Landfill Gas Evaluation

Methane monitoring will be completed in subsurface gas probes located between the landfill footprint and buildings in the southwest corner of the site (GM1 and GM2); along the eastern boundary of the property, adjacent to the air barrier system (GM3, GM4, GM7 and GM8), and surrounding the new landfill footprint (GM9 to GM13). If the methane concentration exceeds the criterion listed in Table 15, then the source of the gas is to be determined. If the source is determined to be landfill gas, action is to be implemented.

Subsurface Landfill Gas Data Evaluation Method

Step 1 – Compliance Assessment

Compare results to criterion in Table 15; if concentration exceeds criterion, proceed to Step 2.

Step 2 – Confirmation Resampling

Conduct resampling within one week. If the initial exceedance is verified, proceed to Step 3. If unverified, return to Step 1. If confirmed, ensure that health and safety procedures are in place through active temporary means until further steps are completed and further data indicate that no problem exists or a permanent solution is put into place.

Step 3 – Alternate Source Evaluation

Conduct investigation to determine the source of the exceedance. If landfill gas is confirmed as the source, proceed to Step 4. If the source is not confirmed to be of landfill origin (in the case of background sources), identify the sources and consider these sources or adjust the program to prevent reoccurrence (i.e., review sampling procedures, re-assess limits) and return to Step 1.

Step 4 – Development and Implementation of Corrective Action Plan (CAP)

At this point a CAP is developed, approved and implemented to prevent exceedance of the Landfill Gas Assessment Concentrations at the facility property boundary. See further explanation of the contingency planning process in Section 7.4 below. The CAP will be prepared and submitted to the MOECC within 90 days of landfill gas being identified as the source of methane exceedances (i.e., 90 days from completion of Step 3).

Data evaluation according to the aforementioned methods will be completed annually and submitted as part of the Annual Monitoring Report.

7.4 CONTINGENCY PLANS

A contingency plan is an organized set of procedures for identifying and reacting to an unexpected, but possible, occurrence[2]. Contingency plans for groundwater and surface water are outlined below. Within the scope of this report, contingency plans are defined as general procedures that will be followed to respond to potential future environmental impacts associated with the closed WM Ottawa Landfill and the new WCEC facility. These plans typically include assessing the scope of a potential problem, additional investigation to determine the precise extent of a problem, assessing potential remedial alternatives ("contingency measures") and the installation of any additional engineered facilities not originally part of the landfill design, or the implementation of other mitigative action.

A flow chart illustrating the process of implementing a contingency plan is presented in Figure 6. Contingency plans would be implemented as part of Step 4 of the Data Evaluation procedures as described above. Note that the contingency plans for leachate management are beyond the scope of this document. The Design & Operations Report for the landfill should be referred to for these engineered components.

Brief descriptions of the contingency measures that potentially could be implemented as part of the contingency plans are provided below.

7.4.1 Groundwater Contingency Plan

Groundwater monitoring programs will continue at the WCEC facility, with the data evaluation methods and trigger mechanisms in place, as described in Section 7.1. In addition to current monitoring programs and trigger mechanisms, the planned contingency for addressing groundwater impacts will be to first evaluate the degree of impact (in consultation with the MOECC District Office) and the need to carry out additional subsurface investigation, as per Step 3 of the Groundwater Data Evaluation Method (refer to Section 7.1).

The results of any additional investigations will be used to determine the extent of off-site migration and to assess the feasibility of various remedial alternatives. Potential remedial activities to be implemented, also known as contingency measures will depend on the scope and extent of groundwater impacts. For example, localized impacts of limited scope (e.g., shallow contaminants from a well-defined source) may be managed differently than extensive impacts from a broad range of parameters. Examples of contingency measures that could be implemented include the following:

2 MOE Landfill Standards Guideline (January 2012)

Contaminant Attenuation Zone: A CAZ is a three-dimensional area of land adjacent to a landfilling site that extends into the subsurface and is intended to be used for the attenuation of contaminants from the landfill site to a level that will not have an unacceptable impact beyond the boundary of the zone. Once approved by the MOECC upon submission of an application by a proponent and completion of a technical review, the CAZ is incorporated onto the Environmental Compliance Approval for the site, and is registered on title to the property covered by the CAZ. Section 4.0 of MOE Procedure B-7-1 stipulates that the MOECC may support an application for a CAZ when alternate sources of water are available, and when the extent of the CAZ is limited.

Containment and groundwater collection: Groundwater can be intercepted and collected by inducing zones of hydraulic depression (low head) through pumping wells or drains. Contaminated groundwater flows toward these zones and is pumped to the surface. The pumping wells or interceptor drains prevent contaminated groundwater from moving downgradient toward receptors. Purge wells operate using pumps to remove groundwater from the subsurface; whereas interceptor drains can act passively (by gravity) or actively (using pumps). Treatment of contaminated groundwater occurs above ground, and the cleaned groundwater can be discharged to surface water bodies, into sewer systems or re-injected into the subsurface (Reference: *Groundwater Remediation and Treatment Technologies.* 2013. Nicholas P. Cheremisinoff. Published by Elsevier Science. 406pp). If the pumping rate is to exceed 50,000 litres/day, a Permit to Take Water is required from the MOECC.

The results from groundwater flow and transport modeling completed for the Hydrogeologic Assessment of the WCEC facility indicate that as a contingency measure, a series of purge wells could be installed along the northern site boundary, northwest of the new footprint, to capture leachate-impacted groundwater flowing from the existing closed WM Ottawa Landfill. The geologic conditions in the area consist of sand to sand-gravel overburden, underlain by fractured limestone bedrock. The modeling results indicate that sufficient capture could be achieved by installing purge wells along the northern site boundary, completed in the overburden-shallow bedrock zone. The actual number and spacing of purge wells required and the design pumping rates would be determined during the detailed design of the contingency measures, if required.

In-situ remedial methods: In-situ methods involve leaving contaminated groundwater in the subsurface and introducing treatment agents to treat the contamination in-place. The flow of groundwater may be manipulated to enhance the rate of remediation or it may be left under natural gradient conditions. In-situ methods include permeable reactive barriers (PRBs), chemical oxidation, enhanced bioremediation, etc.

PRBs involve placing reactive materials into the subsurface, through which a dissolved contaminant plume will flow. Treated water discharges from the downgradient side of the barrier. Chemical oxidation typically involves injecting chemical compounds into the subsurface that cause reduction/oxidation (redox) reactions that convert contaminants to compounds that are more stable, less mobile, or inert. Enhanced bioremediation uses naturally occurring or introduced micro-organisms to degrade contaminants in the groundwater (Reference: US Environmental Protection Agency, Hazardous Waste Clean-Up Information (CLU-IN) web site: http://www.clu-in.org).

Natural attenuation: Natural attenuation relies on natural processes to attenuate contaminants in groundwater. Natural attenuation processes include biodegradation, sorption, dilution and dispersion, molecular diffusion, volatilization, redox and precipitation reactions, etc. Natural attenuation will occur to some degree to all types of contaminants; however, the right conditions must exist to ensure that sufficient attenuation occurs within the landfill property boundaries, which may include a CAZ. Monitoring of contaminant concentration trends and natural attenuation indicators must be conducted at sites using this approach as a contingency measure.

On-site effluent treatment: Groundwater that is intercepted or pumped from the subsurface is brought to the surface for treatment. Treatment technologies for contaminated groundwater can be grouped into three general areas: physical, chemical and biological. Physical treatment may include settling, adsorption, filtration, air stripping and thermal methods. Chemical treatment methods may include precipitation, reduction/oxidation, ion exchange, pH adjustment, etc. Biological methods, such as activated sludge processes, fixed film bioreactors, etc., rely on natural or enhanced biological activity to break down contaminants in water. The treated water is typically discharged to surface water bodies. Engineered wetlands can be used for effluent polishing prior to discharge.

Off-site effluent discharge: Contaminated groundwater may also be collected and discharged for treatment. This is typically done when a site is serviced by a piped municipal sewer that can accommodate the discharge. If the volume of effluent to be treated is not excessive, it can also be managed by using tanker trucks to haul the contaminated water directly to a wastewater treatment plant or to a discharge station.

The selected remedial approach will represent the most viable technical and economic option.

7.4.2 Surface Water Contingency Plan

The main concerns associated with potential surface water impacts relate to the discharge of leachate from surface seeps or the discharge of shallow impacted groundwater into the Highway 417 ditch. Routine visual inspections and surface water sampling will be carried out to identify leachate seeps, characterize the surface water chemistry in the ditch in relation to the applicable objectives, and determine if contingency measures are warranted. The data evaluation methods and trigger mechanisms for contingency action are described in Section 7.2.

The planned contingency measure for this potential impact will be to repair any leachate seepage areas, re-direct surface water to the collection areas, and/or to investigate the feasibility of on-site treatment and polishing of surface water discharge. Any shallow impacted groundwater that is contributing to the need for contingency action will be addressed as described above in Section 7.4.1.

7.4.3 Landfill Gas Migration Contingency Plan

The main concern associated with subsurface landfill gas is migration away from the landfill footprint. This is highly unlikely in the case of the new landfill, which will be constructed with a double-composite liner system and an active landfill gas extraction system. In addition, the landfill gas collection system on the closed landfill and the air barrier system east of the closed landfill will continue to be operated. Gas monitoring probes will be used around the closed landfill and the new landfill to observe for any landfill gas concentrations, and to determine if contingency measures are warranted. The data evaluation methods and trigger mechanisms for contingency action are described in Section 7.3.

If subsurface gas migration away from the landfill footprint is confirmed, possible contingency measures would include the installation of vertical extraction wells or horizontal collectors to capture the gas and control the migration. The wells and/or collectors would be connected to the existing landfill gas extraction system and the migrating gas would be managed with the remainder of the landfill gases.

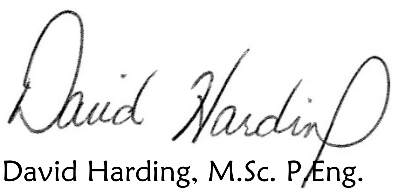
The current status of contingency plans will be reviewed annually as part of the reporting process. Proposed contingency actions will be implemented if necessary in consultation with the MOECC District Office.

8.0 REPORTING OF MONITORING RESULTS

Annual monitoring reports will be submitted to the MOECC Ottawa District Manager, the City of Ottawa, and the Public Liaison Committee (PLC), and will be posted on a publicly accessible website. The reports will be submitted within 90 days following the end of the calendar year period being reported on. The reports will present the data, results and interpretations derived from the monitoring conducted during the previous twelve-month period.

In addition, property owners and tenants of the water supply wells sampled as part of the EMP will be provided with a copy of the water quality testing results for the wells located on their properties. An interpretation of the data will be provided and a copy of the letter communicating the results provided as part of the annual monitoring report for the site.

Respectfully Submitted,



David Harding, M.Sc. P.Eng.
Senior Consulting Engineer

Karen Greer, M.Sc., P.Geo.
Senior Hydrogeologist

FIGURES

LEGEND

- Proposed Access Roads
- WCEC Site Boundary
- Proposed WCEC Landfill Footprint
- Proposed Stormwater Management Ponds

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR DIVULGED WITHOUT PRIOR WRITTEN CONSENT OF BLUMETRIC ENVIRONMENTAL INC.
DO NOT SCALE DRAWING.
THIS DRAWING MAY HAVE BEEN REDUCED. ALL SCALE NOTATIONS INDICATED ARE BASED ON 11"x17" FORMAT DRAWINGS.
PROJECTION: NAD27, MTM ZONE 9

0 100 200 400
Meters

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT
WEST CARLETON ENVIRONMENTAL CENTRE

TITLE

SITE LOCATION MAP

BluMetric Environmental
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE		
C-B8831	2014-02-28		
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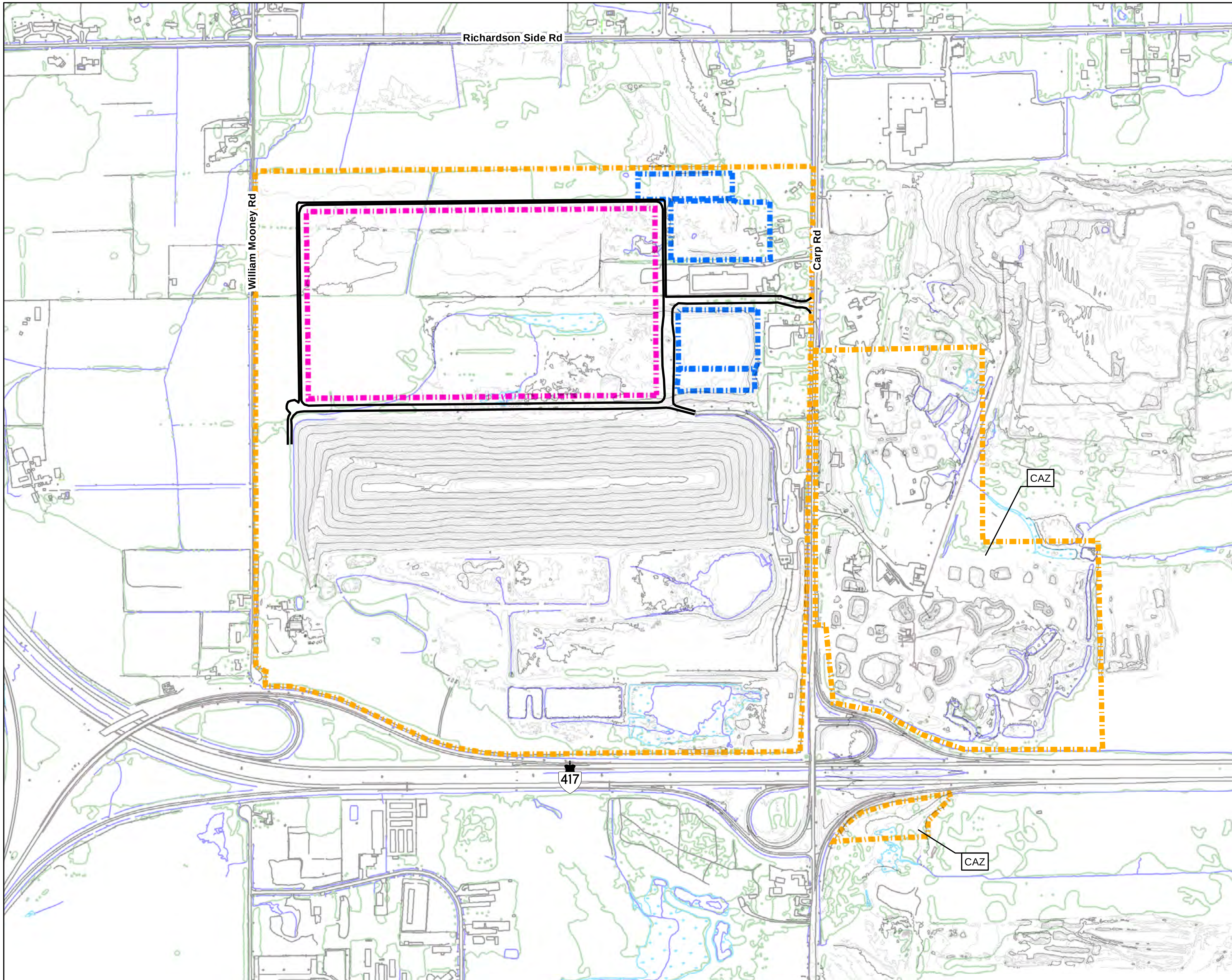
YL	DH	01	0



LEGEND

- Proposed Access Roads
- WCEC Site Boundary
- Proposed WCEC Landfill Footprint
- Proposed Stormwater Management Ponds

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

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PROJECTION: NAD27, MTM ZONE 9

0 250 500 Meters

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT
WEST CARLETON ENVIRONMENTAL CENTRE

TITLE

SITE TOPOGRAPHY AND LAYOUT

BluMetric Environmental
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
C-B8831	2014-02-24

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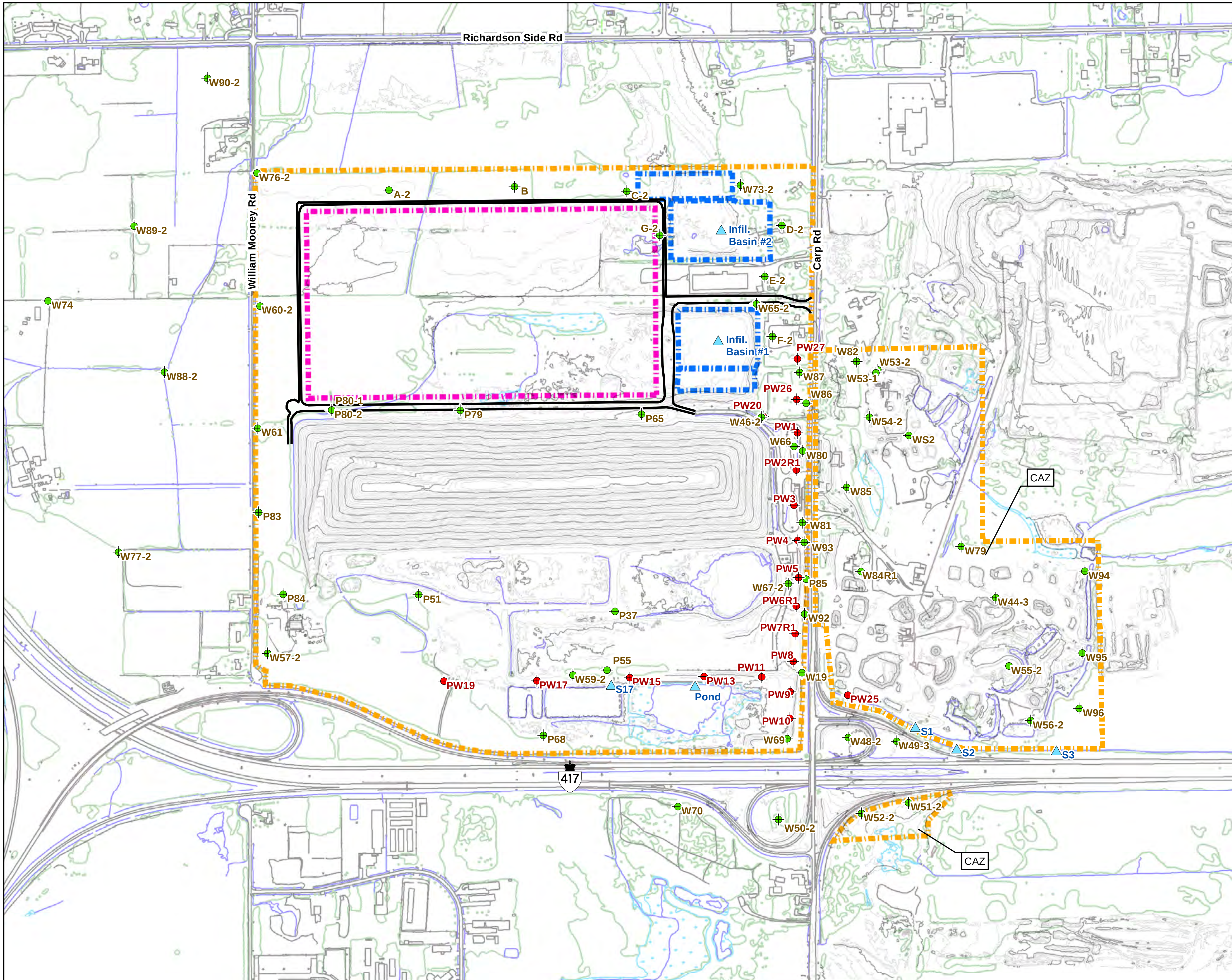

LEGEND

- Overburden-Shallow Bedrock Wells
- Purge Wells
- Surface Water Locations
- Proposed Access Roads
- WCEC Site Boundary
- Proposed WCEC Landfill Footprint
- Proposed Stormwater Management Ponds

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1	AMENDED LOCATIONS	15/10/14	IB	KDG

REFERENCES

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PROJECTION: NAD27, MTM ZONE 9

0 250 500 Meters

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT
WEST CARLETON ENVIRONMENTAL CENTRE

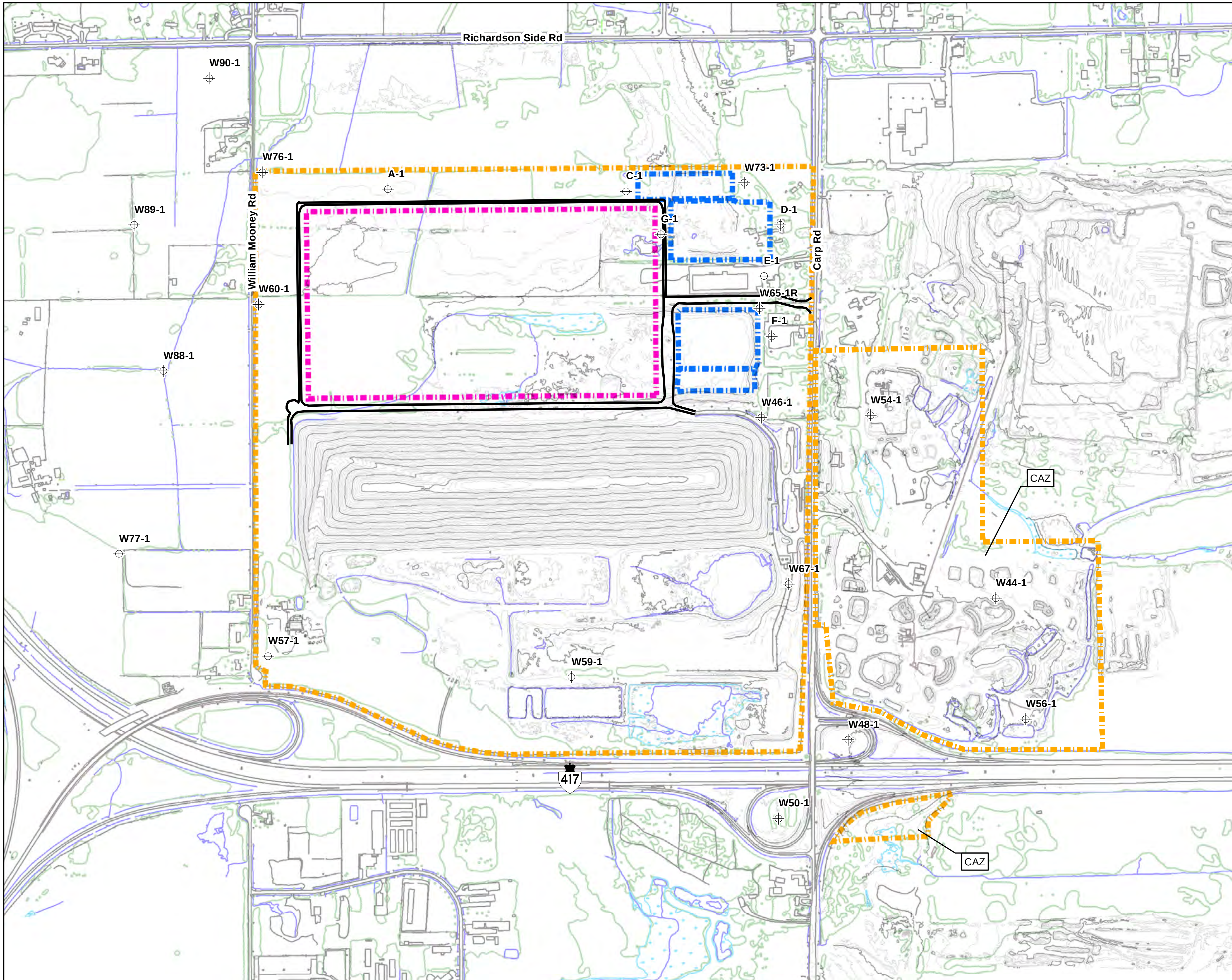
TITLE

GROUNDWATER AND SURFACE WATER ELEVATION MONITORING (OVERBURDEN-SHALLOW BEDROCK)

BluMetric Environmental
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
C-B8831	2014-04-11

DRAWN	CHECKED	FIG NO.	REV
YL	DH	03A	1



LEGEND

- Deep Bedrock Wells
- Proposed Access Roads
- WCEC Site Boundary
- Proposed WCEC Landfill Footprint
- Proposed Stormwater Management Ponds

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

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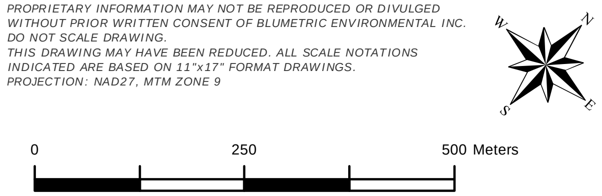
PROJECTION: NAD27, MTM ZONE 9



CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT
WEST CARLETON ENVIRONMENTAL CENTRE

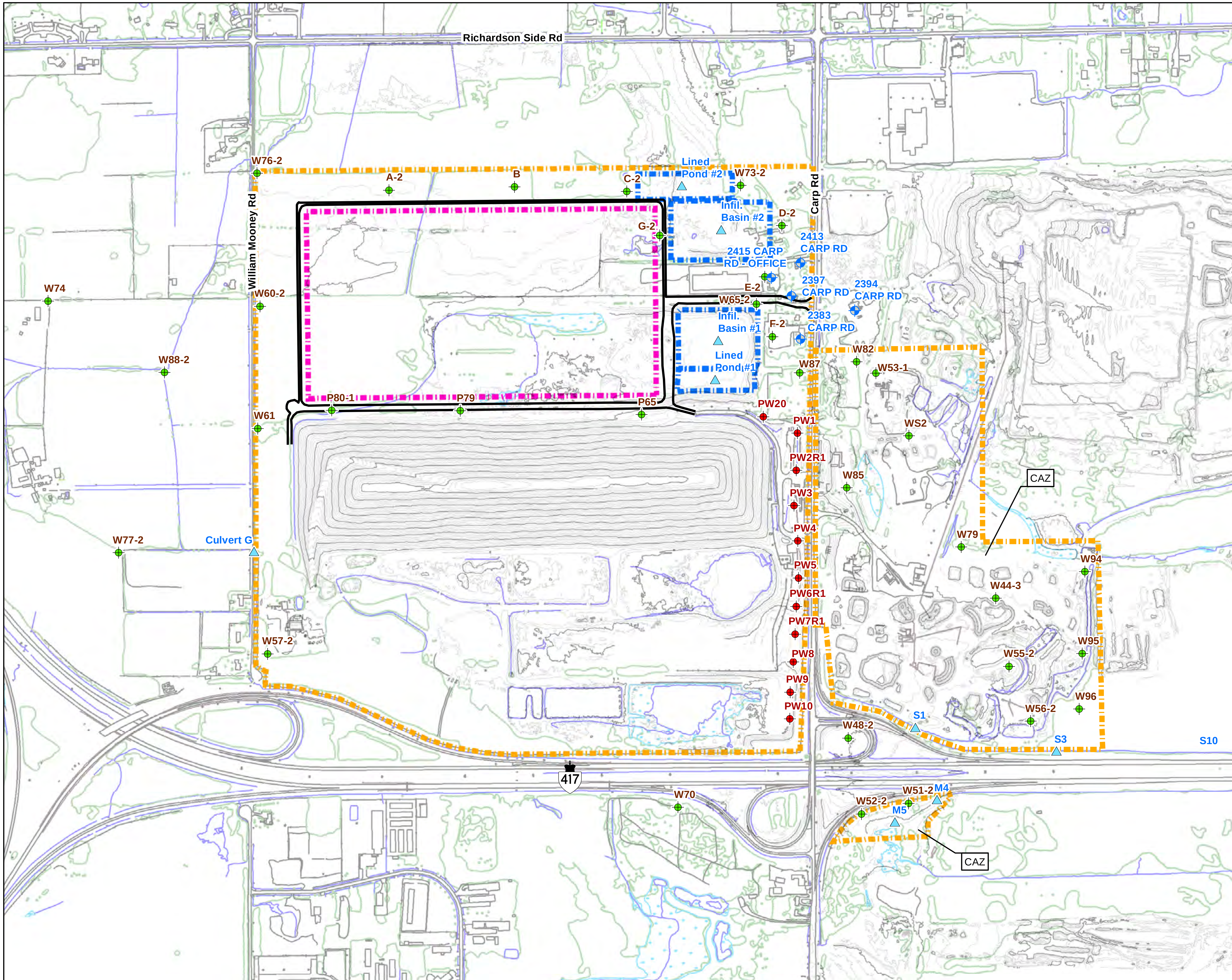
TITLE

GROUNDWATER ELEVATION
MONITORING (DEEP BEDROCK)

BluMetric Environmental

3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #		DATE	
C-B8831		2014-04-11	
DRAWN	CHECKED	FIG NO.	REV
YL	DH	03B	0



LEGEND

- Overburden-Shallow Bedrock Wells
- Purge Wells
- Surface Water Locations
- Proposed Access Roads
- WCEC Site Boundary
- Proposed WCEC Landfill Footprint
- Proposed Stormwater Management Ponds

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1	AMENDED LOCATIONS	15/10/14	IB	KDG

REFERENCES

PROPRIETARY INFORMATION MAY NOT BE REPRODUCED OR DIVULGED WITHOUT PRIOR WRITTEN CONSENT OF BLUMETRIC ENVIRONMENTAL INC.
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PROJECTION: NAD27, MTM ZONE 9

0 250 500 Meters

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT
WEST CARLETON ENVIRONMENTAL CENTRE

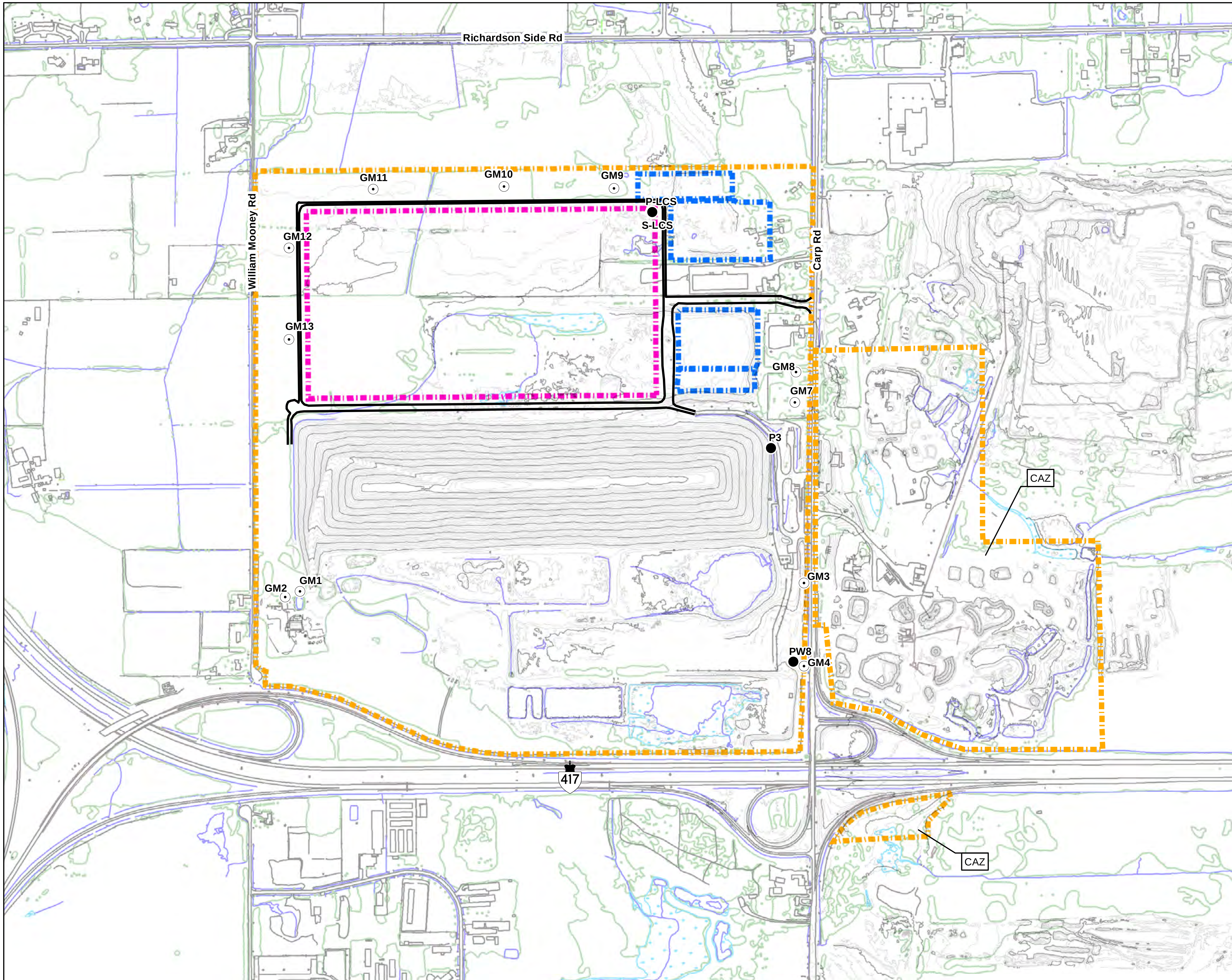
TITLE

GROUNDWATER AND SURFACE WATER SAMPLING LOCATIONS

BluMetric Environmental
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
C-B8831	2014-04-11

DRAWN	CHECKED	FIG NO.	REV
YL	DH	04	1



LEGEND

- Leachate Locations
- Subsurface Gas Probes
- Proposed Access Roads
- WCEC Site Boundary
- Proposed WCEC Landfill Footprint
- Proposed Stormwater Management Ponds

REV.	DESCRIPTION	YY/MM/DD	BY	CHK
1				

REFERENCES

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PROJECTION: NAD27, MTM ZONE 9

W N S E

0 250 500 Meters

CLIENT

WASTE MANAGEMENT

PROJECT

WASTE MANAGEMENT
WEST CARLETON ENVIRONMENTAL CENTRE

TITLE

LEACHATE AND LANDFILL GAS SAMPLING LOCATIONS

BluMetric Environmental

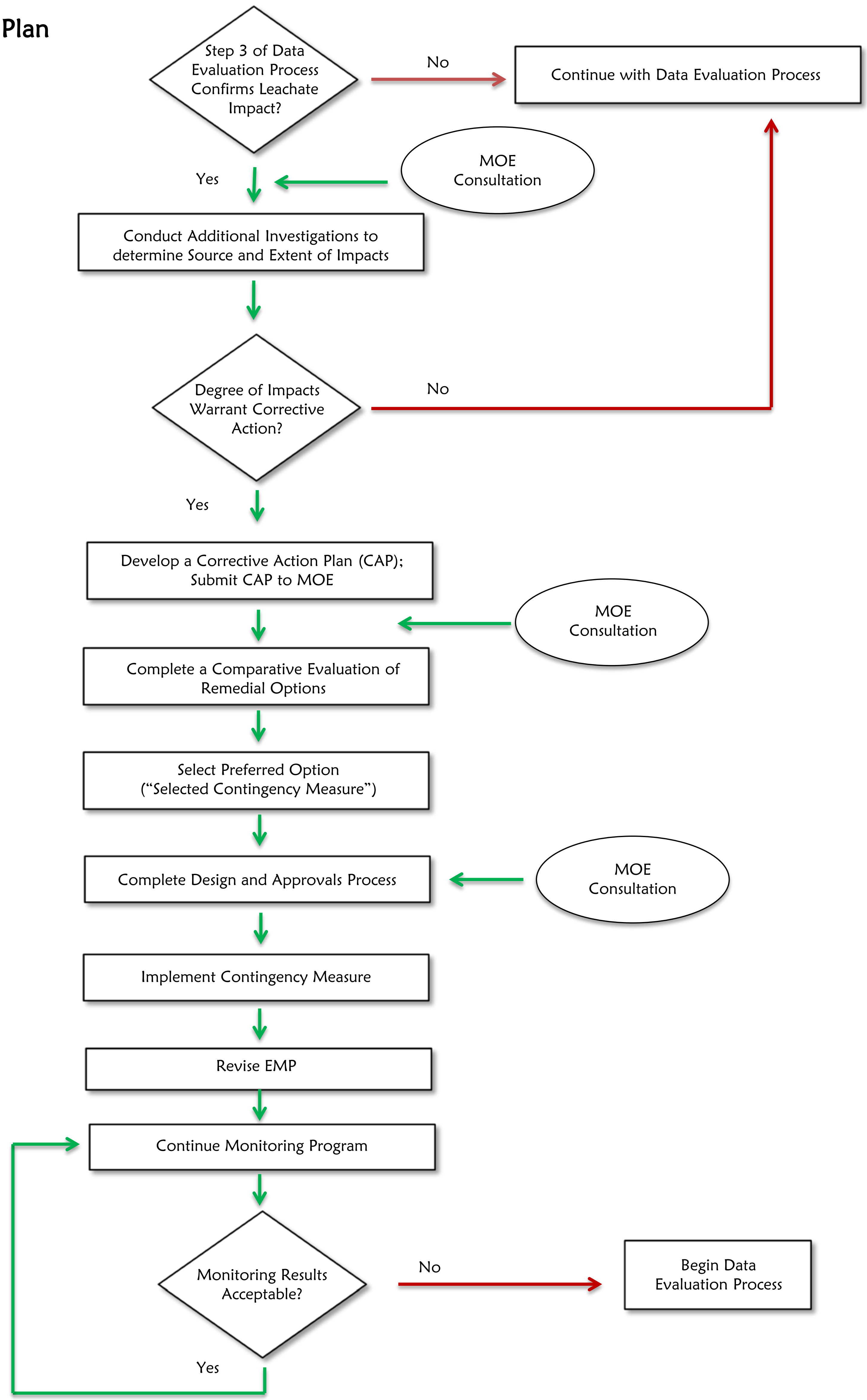
3108 Carp Road PO Box 430
Ottawa, Ontario K0A 1L0
TEL: (613) 839-3053
FAX: (613) 839-5376
Email: info@blumetric.ca
Web: http://www.blumetric.ca

PROJECT #	DATE
C-B8831	2014-04-11

DRAWN	CHECKED	FIG NO.	REV
YL	DH	05	0

CB8831-15-00

Figure 6: Contingency Plan Process



APPENDIX A

Summary of Assessment Parameters, Background Concentrations and Reasonable Use Limits

Summary of Assessment Parameters, Background Concentrations and Reasonable Use Limits

			Overburden-Shallow Bedrock		
Parameter	ODWS	X	Background Range	Median Background	RUL
General and Inorganic Parameters					
alkalinity	500	0.5	127 - 367	202	351
ammonia	---	---	< 0.02 - 1.36	< 0.15	---
boron	5.0	0.25	< 0.01 - 0.67	0.03	1.27
COD	---	---	< 3 - 120	5	---
nitrate	10.0	0.25	< 0.01 - 8.44	< 0.1	2.54
nitrite	1.0	0.25	< 0.01 - 0.17	< 0.1	0.29
potassium	---	---	< 1 - 12	2	---
TKN	---	---	< 0.05 - 5	< 0.7	---
Volatile Organic Compounds (VOCs)					
trichloroethylene	0.005	0.25	---	< 0.0001	0.0013
cis-1,2-dichloroethylene	---	---	---	< 0.0001	---
1,1-dichloroethane	---	---	---	< 0.0001	---
chloroethane	---	---	---	< 0.0002	---
vinyl chloride	0.002	0.25	---	< 0.0002	0.0006
benzene	0.005	0.25	< 0.0001 - 0.0011	< 0.0001	0.0013
chlorobenzene	0.03	0.5	---	< 0.0001	0.0150
1,4-dichlorobenzene	0.001	0.5	---	< 0.0002	0.0006

Note: All units expressed as mg/L, except where noted.
ODWS - Ontario Drinking Water Standards, Objectives and Guidelines (MOE, June 2006).
X - denotes the factor used in the Reasonable Use calculations:
- 0.25 for health-related parameters;
- 0.5 for aesthetic parameters.

Rev 1 Oct 2015