Detailed Site-Specific Risk Assessment and Remedial Options Analysis

West Wharf South –

Oshawa Harbour, Ontario (DFRP #67590)

R.032459.003

November 2010

Prepared for:
Public Works and Government Services Canada
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GENIVAR

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November 2, 2010

Mr. Brad Simpson
Sr. Environmental Officer
Public Works & Government Services Canada
11th Floor, 4900 Yonge Street
Toronto, Ontario, M2N 6A6

Re: Supplemental Soil, Groundwater and Surface Water Sampling, West Wharf South – Oshawa Harbour

Dear Mr Simpson,

GENIVAR Consultants LP (GENIVAR) is pleased to provide the Supplemental Soil, Groundwater and Surface Water Sampling Report for Public Works and Government Services Canada (PWGSC) at the West Wharf South areas, located at the Oshawa Harbour (Directory of Federal Real Property, DFRP #67590). This investigation was completed on behalf of PWGSC to further investigate areas of environmental concern that were identified in previous investigations.

Please do not hesitate to contact the undersigned if you have any questions regarding the findings contained within this report.

We sincerely thank you for your business and look forward to opportunities to collaborate on future projects.

Yours truly,

GENIVAR Consultants LP

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Executive Summary

GENIVAR Consultants LP (GENIVAR) was retained by Public Works and Government Services Canada (PWGSC), acting on behalf of Transport Canada, to conduct a Supplemental Site Investigation, Detailed Site-Specific Risk Assessment and Remedial Options Analysis of the West Wharf property (the "Site) located on Oshawa Harbour Lands (Directory of Federal Real Property, DFRP #67590) in Oshawa, Ontario. The objectives of the study included:

- The refinement of contaminant extents in soil and groundwater;
- Establishing site specific clean-up objectives or Final Site Standards (FSSs) for constituents present in environmental media at concentrations above Federal guidelines (CCME 2008), or where applicable, Provincial standards (MOE 2004);
- The development and evaluation of remedial and risk management options capable of mitigating adverse risks to receptors for those constituents present in environmental media at concentrations above FSSs: and
- The selection of a preferred option for implementation at the site.

Previous environmental site investigations carried out at the site identified a number of organic parameters (BTEX, PHC fractions and several PAHs) and several inorganic parameters [arsenic, selenium, hot water soluble boron, sodium adsorption ratio (SAR) and electrical conductivity (EC)] in soil at concentrations above generic federal guidelines and/or provincial standards. SAR and EC were generally found at levels above federal guidelines in soil samples acquired at depth intervals falling between 2.6 m to 5.3 m below grade. SAR and EC levels in soil samples acquired at depth intervals acquired from surface to 2.3 m below grade did not exceed the federal guideline. Previous groundwater monitoring programs which included testing for VOCs, PHCs, PAHs, metals and general chemistry parameters, identified chloride, sodium, PHC F2, PHC F3 and PHC F4 as contaminants of potential concern in groundwater.

Supplemental site investigation work was conducted by GENIVAR in this study to collect additional information for use in the refinement of contaminant extents and detailed risk assessment. It included the drilling of five boreholes; installation of four monitoring wells including two well nests; soil sampling and chemical testing for BTEX, VOCs, PAHs, PHCs and inorganics; fluid level monitoring and groundwater sampling of new and existing monitoring wells; groundwater sample analysis for BTEX, VOCs, PAHs, PHCs and inorganics; and the acquisition of surface water samples for analysis of inorganics from the Harbour adjacent to the site. TCLP testing on soil was also carried out to establish soil management requirements for the remedial options evaluation component of the study. EC and SAR were detected at levels in excess of the federal guidelines in soil sample intervals falling between 1.8 m to 3.5 m at all of the new borehole locations. SAR and EC levels did not exceed federal guidelines in soil samples intervals acquired between 0.2 to 1.4 m below grade. Arsenic and several PAHs were also detected above federal guidelines in soil samples from two locations. Chloride, several metals, PHC F1 and PHC F2 were detected in groundwater at concentrations above federal guidelines and/or provincial standards.

The detailed risk assessment evaluated risks associated with exposure of site receptors to constituents present in soil and groundwater at concentrations above generic guidelines/standards. It also established FSSs protective of both human and ecological receptors for parameters deemed of concern. For human health, the RA evaluated the Construction Worker and Commercial Worker receptors. For the ecological

component, the RA evaluated semi-quantitative exposure risks for plants, soil invertebrates, soil microorganisms, mammals, birds, and aquatic receptors. The key findings of the RA are summarized as follows:

- Ecological risks of exposure exceed ecological based FSSs for arsenic, hot water soluble boron, EC, SAR, PHC F2 and PHC F3 in soil at the site. These exceedances are distributed in soil in several areas in the north half of the north property wing. An area of subsurface EC/SAR impact above FSSs is also apparent in the north part of the south property wing.
- Both the Construction Worker and Commercial Worker receptors are at risk of exposure to arsenic via the soil contact pathways and benzene and PHC F2 via the vapour inhalation pathway. The impacts are distributed in two localized areas in the north half of the north property wing.
- Constituents detected in groundwater that exceed FSSs include chloride, sodium, PHC F2 and PHC F3. These parameters are deemed to pose a potential adverse risk to aquatic receptors via the groundwater to surface water transport pathway.

Remedial and risk management options capable of removing and/or cutting off the exposure pathways of concern were developed and evaluated. Numerous options were initially considered with four selected for further evaluation. The options evaluated included: Excavation with Offsite Disposal; Excavation with Soil Transfer and Offsite Disposal; Asphalt Capping with Groundwater Mitigation; and Asphalt Capping with Soil Transfer and Groundwater Mitigation. Of these options, Capping with Groundwater Mitigation was selected as preferred because:

- It is an effective risk management measure in that it cuts off active exposure pathways; thereby, preventing receptor exposure to site contaminants;
- It is the lowest cost option, estimated at $918,000;
- It integrates well with the risk management approaches recommended by others on adjacent property parcels (i.e. capping);
- The groundwater mitigation approach addresses groundwater contaminants originating from both the subject site and adjoining property parcels over the long term;
- Groundwater dewatering and treatment during construction is not required; and
- Permits and approvals are not required.

The specific components of the preferred option, Capping with Groundwater Mitigation, presented in the form of a Remedial Action Plan in this study are as follows:

- Asphalt caps constructed atop the site surface in the areas of the site where petroleum hydrocarbons and metals are present at concentrations in excess of FSSs;
- Use of existing sand and gravel cover and asphalt paved areas as a precautionary measure to protect ecological receptors (plants and soil invertebrates) from exposure to subsurface SAR and EC;
- Maintaining existing land use within SAR/EC impacted areas with no vegetation planting or placement of organic topsoil permitted in these areas without further risk analysis;

- The implementation of control measures in the form of a soil management plan to prevent the transfer of subsurface soil impacted with EC/SAR to the surface soil horizon during future excavation and backfilling operations.

- Use of the existing wharf wall as a barrier wall to shallow groundwater flow and dissolved plume migration to adjacent water bodies;
- A groundwater flow and contaminant transport model to validate the effectiveness of the existing groundwater barrier wall and/or establish if additional groundwater mitigative measures are necessary to prevent ingress of dissolved contaminants to surface water at concentrations in excess of FSSs;
- A long term monitoring and maintenance program for the asphalt caps; and
- A long term groundwater monitoring program.

Use of the existing wharf wall as groundwater/dissolved plume barrier to cut-off aquatic receptor exposure by way of the groundwater to surface water transport pathway was deemed valid, due to the following reasons:

- Surface water quality data collected as part of this study, suggests that the wharf wall is effectively containing the chloride plume that resides on the north side of south property wing. Specifically, chloride concentrations in surface water samples (46,200 to 65,600 ug/L) are one order of magnitude lower than the aquatic protection value (180,000 ug/L) established in MOE 2009 and three orders of magnitude lower that the maximum chloride concentration detected in the plume (33,300,000 ug/L).
- Chloride and petroleum hydrocarbon fractions in groundwater extracted from sentinel wells [4 – including one multi-level well nest (2)] situated adjacent to the wharf wall, down-gradient of chloride and PHC plumes situated in the north property wing, have not been detected to date at concentrations in excess of FSSs or aquatic life based component standards.

- Within the regions of the plumes, groundwater flow was towards the Harbour or groundwater barrier wall on March 12, 2010. As a result, the plumes were effectively contained on this monitoring date. Because of the apparent plume containment, the need for an extension of the barrier wall along the beach area at the south limit of the south wing of the property was not considered necessary. It is important to note, however, that groundwater flow and plume migration trends should be monitored over time to ensure that the containment condition remains active. This has been taken into consideration in this evaluation by way of the long term groundwater monitoring program and groundwater flow and contaminant transport model that form part of the preferred option.

As part of the preferred approach, a barrier wall integrity assessment was suggested. The integrity assessment would involve an underwater assessment of the water side of the wall to determine if cracks or openings are present which could result in plume release to surface water. A contingency measure for rectification of this potential issue would be to install, on the water side of the wall, an HDPE liner complete with protective UV cover along affected wall sections and/or along the full length of the water side of the wall (if required).

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1. Introduction

GENIVAR Consultants LP (GENIVAR) was retained by Public Works and Government Services Canada (PWGSC), on behalf of Transport Canada, to conduct a Detailed Site-Specific Risk Assessment and Remedial Options Analysis at the West Wharf South area of the Oshawa Harbour Lands (Directory of Federal Real Property, DFRP #67590). The objective of this investigation was to delineate the extent (horizontally and vertically) of contamination identified in previous reports and to develop a Detailed Site Specific Risk Assessment (SSRA) and a Remedial Action Plan (RAP). This report is prepared for the West Wharf South portion of the Harbour.

2. Background

The Oshawa Harbour Lands site is located east of Simcoe Street and south of Harbour Road in Oshawa, Ontario, on the north shore of Lake Ontario. The areas in question include the West Wharf South and South Rail Spur areas.

The instrument of acquisition and federal ownership status of the areas / parcels at the Oshawa Harbour Lands is mixed. There are two classes of properties, one is considered Crown / Oshawa Harbour Commission (OHC) and another is considered Caveated.

The West Wharf comprises the west pier and land from the west pier wall to Simcoe Street to the west and from Lake Ontario to Harbour Road to the north. For this investigation, only the southern part of the West Wharf will be investigated. The west pier has the longest development history and was the site of a number of commercial and industrial activities related to the operation of the harbour since the early 1920s. The majority of the land was used for storage and processing of materials offloaded from ships. Three small blocks of land located on the west side of the west Pier were also used for many years as fuel storage and distribution areas. Two of these areas are still owned by private companies. The third facility (former Lakes Terminal) occupied land leased from the Oshawa Harbour Commission (OHC).

Some of the parcels studied previously under the DCS 2003 Phase I and II Environmental Site Assessment (ESA) are a combination of both crown and caveated properties. In 2009 DCS completed a supplemental Phase I ESA update and identified potential areas of concern for the south rail spur and the southern part of the West Wharf. In 2008, Aqua Terre undertook a Phase II ESA at the south rail spur and the southern West Wharf areas to determine the environmental conditions of the lands. In addition, Aqua Terre completed a limited scope Preliminary Quantitative Risk Assessment on a small section of the southern West Wharf to determine risks specifically associated with impacts from a former salt storage area.

In order to properly determine the environmental conditions of the Oshawa Harbour Lands and to prepare risk management and remedial action plans, additional site investigations and site-specific risk assessment is required for the study sites. For the purpose of this Scope of Work, the study site is comprised of certain parcels of land at Oshawa Harbour, excluding private properties and properties currently under study via site specific risk assessment, namely parts of the West Wharf South lands and the South Rail Spur areas.

2.1 Hydrogeology

The topography on the West Wharf South portion of the site is relatively flat. Existing monitoring wells installed by Aqua Terre in 2008 were surveyed relative to each other in order to determine the shallow groundwater flow direction. The monitoring wells installed by GENIVAR as part of this investigation were tied into the relative elevations created by Aqua Terre in 2008. Aqua Terre determined that groundwater is inferred to be flowing towards Lake Ontario in an easterly direction on the northern portion of the site and in a south easterly direction on the southern portion of the site.

During this investigation, a total of four (4) monitoring wells were installed on the West Wharf South property. Two (2) of the monitoring wells were screened below the lake bottom and two (2) were screened to intercept the lake surface. The survey conducted in 2010 by GENIVAR confirmed the south-easterly inferred groundwater flow direction stated by Aqua Terre in 2008.

2.2 Geology

Observations made of the soil profiles of boreholes indicated that the overburden material is primarily silt and silty sand material with layers of saturated sands. A sandy fill material was found in the surface layer throughout the site. A peat layer was discovered throughout the site at depths ranging from approximately 3.3 m to 7.6 m below ground surface. Clayey silt soils were found inconsistently around the site at depths of approximately 3.2 to 7.6 m below ground surface. Sieve and hydrometer tests performed on six (6) select soil samples confirmed observations made in the field that are presented on the borehole logs appended in Appendix A. Geotechnical lab sheets are included in Appendix C.

2.3 Previous Environmental Reports Review

The following relevant investigation reports were provided by PWGSC for review:

Decommissioning Consulting Services Ltd. (DCS), *Phase I and II Environmental Site Assessments, Oshawa Harbour Lands, Oshawa, Ontario.* October 2003

- A Phase I ESA was conducted on the West Wharf South and South Rail Spur areas during this investigation. Based on the recommendations of the Phase I ESA, a Phase II ESA was conducted to determine if there were any environmental impacts on the site. This investigation found exceedances of petroleum hydrocarbons (PHCs) in this area. A recommendation was made to conduct a Site-Specific Risk Assessment at the site.

Decommissioning Consulting Services Ltd. (DCS), *Supplemental Update of Environmental Conditions, Selected Areas at Oshawa Harbour Land, Oshawa, Ontario.* March 2009

- A historical review and site inspection of the South Rail Spur and West Wharf South found that there were no incidents or activities of concern since the previous 2003 DCS report.
- Additional investigations and the development of a Remedial Action Plan for the sites were recommended in this report.

Aqua Terre Solutions Inc., *South Spur Phase II ESA and Southern Portion of the West Wharf Phase II ESA and Human Health and Ecological PQRA, Oshawa Harbour, Oshawa, ON.* January 2010.

- The Phase II ESA conducted at the West Wharf South had the following findings:
  - Of the six (6) locations investigated, one (1) soil sample exceeded CCME guidelines for BTEX, F2 PHC and arsenic;
  - Four (4) soil samples exceeded MOE Table 1 standards for chloride and CCME guidelines for sodium absorption ratio (SAR) and electrical conductivity (EC); and
  - Seven (7) groundwater samples were obtained from seven monitoring wells and analysed for BTEX, PHCs and metals. One location exceeded the MOE Table 1 standards for toluene. Two locations exceeded the MOE Table 1 standards for dissolved cobalt. Groundwater concentrations for dissolved chloride, dissolved sodium and total cyanide ranged from 450 to 5,900 mg/L, 350,000 to 3,400,000 mg/L and 0.020 to 4.9 mg/L, respectively.

- The Risk Assessment conducted at the West Wharf found that the human health risk to industrial workers at the site was negligible. The ecological risk assessment found that there could be adverse effects to aquatic receptors adjacent to the site.
- This report recommended the remediation of both sites by excavation and off-site removal of contaminated soils. A risk management approach of capping the contaminated areas of both sites and installing subsurface barriers to control groundwater discharge to surface water was provided as an alternative to remediation.

Based on the review of these previous environmental reports, GENIVAR developed a work plan for an additional soil, groundwater and surface water sampling and analysis at the South Rail Spur and West Wharf South. The scope of work for this additional work is described in Section 1.3 of this report.

3. Supplemental Investigation

3.1 Scope of Work

The scope of work for this project was developed based on a review of previous reports and a data gap analysis. The work was carried out in accordance with federal guidelines and adhered to the principals outlined in the *CSA Standard Z769-00* and the federal Contaminated Sites Management Working Group (CSMWG) document *A Federal Approach to Contaminated Sites*. Provincial standards were used when there was an absence of federal guidelines. GENIVAR completed the following work as stated in the Work Plan submitted to PWGSC January 29, 2010:

The following work was conducted in the West Wharf South area as part of this investigation. Borehole/ monitoring well and surface water sample locations are presented on Figure 3:

- One (1) borehole, completed as a monitoring well (MW09-01), was installed where salinity impacts were found on the southern section of the West Wharf South. Soil and groundwater samples were collected from this location to complete the delineation of impacts in the area. Two soil samples were collected from the borehole to vertically delineate the contaminants. This monitoring well is a deep monitoring well located beside the existing shallow monitoring well MW-302. MW09-01 was screened immediately below the depth of the lake bed.
- Four (4) boreholes, three (3) completed as monitoring wells, were drilled in the northern section of the West Wharf South (MW09-02i, MW09-2ii, BH09-03 and MW09-04). MW09-02i and MW09-02ii are a nest consisting of a deep and shallow monitoring well, respectively, located to the east of existing monitoring well, MW17. MW09-04 was a shallow monitoring well located to the south of MW17. Two soil samples were collected from each borehole and analysed for metals, inorganics, PHC including BTEX, PAHs and VOCs.
- Two TCLP samples were collected to characterize soil cuttings produced during drilling. One composite soil sample was collected from each area of concern to determine whether soil cuttings are considered hazardous.
- Groundwater samples were collected from each of the existing wells that could be located during the reconnaissance survey and all the new monitoring wells installed as part of this investigation. All new and extisting monitoring wells were sampled for metals, inorganics, TSS and PHCs including BTEX. Monitoring wells MW09-02i, MW09-02ii, MW09-04, MW308 and MW310 were also sampled for PAHs and VOCs. TSS is included in this program to determine if sediment in the samples is creating a bias for metals and particle-bound PAHs.
- A grain size analysis, TOC, bulk soil density and soil permeability test were conducted on one soil sample from each area of concern.

- Three (3) surface water samples (SW09-1, SW09-2 and SW09-3) were collected along the edge of the wharf and analysed for metals and inorganics.
- A survey was conducted of the top of pipe of all of the new monitoring wells and the surface of the lake water in the harbour. These elevations were then tied into existing relative top of pipe elevations on the site.
- The data collected from the deep wells mentioned above were used in conjunction with data collected from other local monitoring wells to define groundwater flow and contaminant transport conditions proximate to the wharf wall. Understanding these conditions will lead to the development and evaluation of effective remedial/risk management options for the protection of the adjacent aquatic system (if necessary).
- Conduct a Detailed SSRA for the site.

3.2 Monitoring Well Reconnaissance Survey

On February 4, 2010 GENIVAR personnel performed a monitoring well reconnaissance survey on the site. During the survey existing monitoring wells were located, liquid levels and well depths were obtained, and the condition of the wells was assessed to determine if future groundwater sampling would be indicative of current groundwater conditions. Four (4) out of the eight (8) monitoring wells were found on the West Wharf South property. Ground resurfacing, material storage and standing water interfered with locating the four (4) wells that were not found. The four (4) wells that were found were cased and were in good condition.

3.3 Criteria Selection

The following guidelines and standards were used as part of this investigation:

- Canadian Environmental Quality Guidelines (CEQG); published by the Council of Ministers of the Environment (CCME) (1999, updated 2009)
- Canada Wide Standards (CWS) for Petroleum Hydrocarbons in Soil; published by the CCME (2008)
- Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the *Environmental Protection Act*; published by Ontario Ministry of the Environment (MOE) (March 2004)
- Provincial Water Quality Objectives (PWQO) Appendix A Table 2 - Table of PWQOs and Interim PWQOs - 1994, reprinted 1999

The site is located in an industrial/commercial area within the City of Oshawa. The site is serviced by municipal water and sewer systems. As such, the groundwater in the immediate vicinity of the site is not used as a potable water source.

As the site is located on federal land, CCME guidelines took precedence over MOE standards. CWS for PHC was used to compare the concentration of PHC F1-F4 in soil. The MOE Regulation 153/04 was used for comparison when no value was listed in the CCME or CWS guidelines. Depending on the location where the samples were collected, the MOE Table 1 Standards were applied when the samples were located within 30 m of Lake Ontario and Montgomery Creek. These borehole/monitoring well locations included: MW09-02i, MW09-02ii, MW09-03, MW6, and MW302. The MOE Table 3 Standards for Industrial/Commercial/Community Property uses were applied for the remainder of the samples (located beyond 30 m of the water body). These borehole/monitoring well locations included: MW09-04, MW308 and MW310.

Previous subsurface investigations have indicated the shallow subsurface soil conditions mainly consist of sand and silt with clayey soil at depth. This is consistent with the grain size analysis test of four soil samples collected during this investigation.

3.4 Standard Applied

As both of the federal and provincial standards were selected to be used, this project was completed in accordance with accepted industry standards defined for both the federal standard and the jurisdiction of Ontario. The practices and standards detailed in the following guidance documents were adhered to by GENIVAR throughout the performance of this assignment:

- *CCME EPC-NCS62E Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume I: Main Report, December 1993*
- *CCME EPC-NCS66E Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume II: Analytical Method Summaries, December 1993*
- *CCME EPCNCSRP-48E Subsurface Assessment Handbook for Contaminated Sites, March 1994*
- *Guidance on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario, May 1996*

3.5 Methodology

3.5.1 Preliminary Site Work

Preparatory work was conducted prior to arriving on-site in order to ensure efficient progress. Representatives from GENIVAR and PWGSC conduct an initial site reconnaissance of the two sites to work out logistics and locate existing monitoring wells. A public locate request was made with Ontario One-Call prior to the intrusive work. As well, a private locator from OnSite Locates was retained to clear all on site utilities.

3.5.2 Drilling and Soil Sampling

The borehole drilling was conducted by Atcost Drilling Inc. of Concord, Ontario on March 3rd to 5th, 2010 using a buggy mounted CME 115. Boreholes were advanced to depths ranging from 3.9 m to 8.3 m. Soil samples were collected at regular intervals (i.e. 0.6 m) using a split spoon (SS) sampler to specified depths. The spoons were cleaned between each sample using Alconox and water. The drilling program was conducted under the direct supervision of GENIVAR personnel who logged the boreholes in the field and transported the soil samples to the laboratory for analysis.

Soil collected from the boreholes indicated the area is underlain with a stratum of silt and silty sand material with layers of saturated sands. A sandy fill material was found in the surface layer throughout the site. A peat layer was discovered throughout the site at depths ranging from approximately 3.3 m to 7.6 m below ground surface. Clayey soil was found inconsistently around the site at depths of approximately 3.2 m to 7.6 m below ground surface.

Each sample retrieved was split into two portions of approximately equal mass; one was placed into a Ziploc® bag and the other into a glass sampling jar provided by the laboratory. A MiniRAE 2000 was used to field screen samples for the presence of organic vapour concentrations (OVM). The OVM readings were measured in the headspace of soil samples collected in Ziploc® bags after the samples equilibrated to room temperature. High OVM readings may indicate the presence of PHCs, PAHs or VOCs.

Based on the vapour readings, visual and olfactory observations, samples were selected for submission to AGAT Laboratories, a Canadian Association for Laboratory Accreditation (CALA) approved laboratory, located in Mississauga, Ontario for subsequent analysis of metals, inorganics, PHC F1-F4 including

BTEX, VOCs, and PAHs. In addition, TOC was analysed on selected soil samples. The samples selected for TOC analysis were those which do not exhibit evidence of organic contaminant impact. Soil devoid of anthropogenic organics will serve to represent the natural organic content of the soil, devoid of contaminant interference. TOC may be used in the risk assessment to adjust the site specific standards.

Select soil samples were also submitted to Alston Associates, a geotechnical lab located in Markham, Ontario, to determine grain size distributions of the major soil units apparent beneath the sites (fill and native soil), soil bulk density and permeability.

Samples selected for laboratory analysis were packaged in laboratory-supplied glass jars, equipped with Teflon-lined lids and stored in a cooler containing loose ice in an attempt to maintain the temperatures of samples at approximately 4°C. Samples were submitted to AGAT Laboratories using standard chain-of-custody procedures and related documentation.

During drilling, a field log was compiled for each borehole by the GENIVAR field supervisor. Information was recorded with corresponding depths and includes descriptions of the soil colour, texture, consistency, moisture content (based on the Unified Soil Classification System), odour and any other signs of environmental impacts. Sample numbers and intervals were also recorded on each log. The soil removed from the boreholes was stored in drums and remain on-site in order to wait for the TCLP results to determine the proper disposal method. Soil drums were removed from the site on March 19, 2010 by Newalta.

The sample location plans are provided in Figures 3. The borehole logs are provided in Appendix A.

3.5.3 Monitoring Well Installation and Groundwater Sampling

Monitoring wells were installed to permit sampling of groundwater. All boreholes were completed as monitoring wells except for BH09-04.

Each well has a cross-sectional diameter of 50 mm and with a 3 m length screen. The annular space surrounding the screen was filled with silica sand and the annular space surrounding the pipe was filled with a bentonite seal. Screens were placed either intersecting the water table or below the water table to vertically delineate contamination.

On March 12 and 15, 2010, each new well was developed using dedicated inertial pumps, comprised of low-density polyethylene (LDPE) Waterra tubing and a Delrin foot valve. Prior to sampling all the monitoring wells were purged of approximately three (3) well volumes of water or to dry conditions twice to ensure each groundwater sample is representative of the subsurface conditions. The organic vapour readings within well headspaces were measured using a MiniRAE 2000.

Groundwater samples were stored in laboratory-supplied bottles within an ice-packed cooler in an attempt to maintain sample temperatures at approximately 4°C. The samples were analyzed by AGAT Laboratories and submitted using standard chain-of-custody procedures.

3.5.4 Surface Water Sampling

Surface water sampling was conducted on March 12th and 15th, 2010, in the harbour immediately adjacent to the shore to determine if there are any surface water impacts associated with the sites. Samples were collected by submerging laboratory supplied bottles beneath the surface of the water to ensure no surface impacts were sampled. Special care was taken not to disturb sediment while sampling.

Surface water samples were stored in laboratory-supplied bottles within an ice-packed cooler in an attempt to maintain sample temperatures at approximately 4°C. The samples were analyzed by AGAT Laboratories and submitted using standard chain-of-custody procedures.

3.5.5 QA/QC

Samples were placed in pre-labelled sample containers supplied by the laboratory, wrapped with bubble wrapping and stored within in an ice-packed cooler to ensure that sample integrity was maintained throughout transport. A new pair of nitrile gloves was worn during the collection of each sample to reduce opportunities for cross contamination between samples. AGAT Laboratories performed several internal quality control checks, including a laboratory duplicate, a method blank, a matrix spike and spiked blank. Results from all quality control checks were found to be within acceptable ranges. The laboratory quality assurance data are provided with the certificates of analysis in Appendix C.

A blind duplicate soil sample collected from MW09-02 and was submitted for QA/QC purposes and were analyzed for metals and inorganics, VOC, PAH and PHC F1-F4 including BTEX concentrations.

A blind duplicate groundwater sample was collected from MW09-02i and was submitted for analysis of metals and inorganics, TSS, VOC and PHC F1-F4 including BTEX concentrations. As the major contaminate of concern relates to petroleum hydrocarbon.

3.6 Results of Investigation

A total of five (5) boreholes were drilled, four (4) of which were completed as monitoring wells. Four (4) additional groundwater samples were collected from existing monitoring wells located on site (MW302, MW6, MW308 and MW310). A total of three (3) surface water samples were collected from Lake Ontario along the shoreline of the sites.

3.6.1 Soil Analytical Results

Nine (9) soil samples, including one duplicate, were collected from four (4) new boreholes at the West Wharf South site and were submitted for analysis of metals and inorganics, PHC F1-F4 including BTEX and in select boreholes for VOCs and PAHs. The soil samples were pre-screened based on OVM levels, and visual and olfactory indications of contamination. The head space vapour reading for each samples collected ranged from non-detect to 0.6 ppm during the pre-screening process.

The only detections of PHC parameters were found in BH09-3B and BH09-3A at concentrations below the applicable CCME guidelines. There were no detections of any BTEX parameters in any of the soil samples at the West Wharf South site.

The analytical soil results revealed that arsenic exceeded the CCME soil guidelines in BH09-03 at the West Wharf South Site. Inorganic parameters, SAR and EC where well above the CCME guidelines in the soil at MW09-01 which is located in the area of the former salt storage. Concentrations of SAR were also above the CCME guidelines in MW09-2B, MW09-04A and MW09-04B. Chloride exceeded the most applicable MOE standard in MW09-1B, MW09-2B, MW09-3B, MW09-4B and MW09-4B.

Most VOC parameters were below the laboratory detection limits and all were below the applicable guidelines/standards. It should be noted the detection limited for BH09-3B was raised due to sample dilution. Although the sample was analyzed and found to be below the laboratory detection limit, these values exceeded the applicable guidelines/standards.

Naphthalene was found at concentrations above the CCME guidelines in samples MW09-2A, MW09-3A and MW09-4A. Although the samples showed naphthalene concentration below the detection limit, it should also be noted that the laboratory detection limit for Naphthalene was above the applicable CCME guideline. Phenanthracene exceedances were also found in BH09-3A and MW09-4A. All other PAH parameters were below the applicable guidelines.

The soil analytical results for the West Wharf South are summarized in Tables 3.1 to 3.4 and shown in Appendix B Analysis Summary Tables. Laboratory Certificates of Analysis are provided in Appendix C.

Table 3.1 Summary of PHC and BTEX Analytical Results for Soil – West Wharf (all units are ug/g)

Parameter	CCME[1]	MOE Table 1[2]	MOE Table 2[3]	RDL	MW09-01A[4]	MW09-01B[4]	MW09-02A[4]		MW09-02B	BH09-03A[4]	RDL	BH09-03B[4]	RDL	MW09-04A[5]	MW09-04B[5]
							Org.	Dup							
Benzene	0.030	0.002	5.3	0.002	<0.02	<0.02	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Toluene	0.37	0.002	34	0.002	<0.02	<0.02	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Ethyl-benzene	0.082	0.002	290	0.002	<0.02	<0.02	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Xylenes (Total)	11	0.002	34	0.002	<0.04	<0.04	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
C6 - C10 (F1)	320	230	230	5	<5	<5	<5	<5	<5	<5	10	<10	5	<5	<5
C>10 - C16 (F2)	260	150	150	10	<10	<10	<10	<10	<10	53	20	<20	10	<10	<10
C>16 - C34 (F3)	1700	1700	1700	50	<50	<50	<50	<50	<50	370	100	320	50	<50	<50
C>34 - C50 (F4)	3300	3300	3300	50	<50	<50	<50	<50	<50	130	100	<100	50	<50	<50

[1] Refers to CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2009) for BTEX, CWS (Updated 2008) for F1-F4
[2] Refers to MOE Table 1 All Other Types of Property Uses for BTEX parameters, Table 2 Industrial/Commercial/Community Property Uses for F1-F4.
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004
[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
Highlight & Bold – Exceeds most applicable Guideline/Standard

Table 3.2 Summary of Metals and Inorganics Analytical Results for Soil – West Wharf (all units are ug/g except where noted)

Parameters	CCME[1]	MOE Table 1[2]	MOE Table 3[3]	RDL	MW09-01A[4]	MW09-01B[4]	MW09-02A[4]		MW09-02B[4]	BH09-03A[4]	BH09-03B[4]	MW09-04A[5]	MW09-04B[5]
							Org	Dup					
Antimony	40*	1.0	40	0.8	<0.8	<0.8	<0.8	<0.8	<0.8	<0.8	1.5	<0.8	<0.8
Arsenic	12	17	40	1	3	4	3	3	3	**110**	**91**	8	3
Barium	500	210	1500	2	36	108	64	67	83	79	202	40	81
Beryllium	8*	1.2	1.2	0.5	<0.5	0.6	<0.5	<0.5	<0.5	0.9	2.8	<0.5	<0.5
Boron	NV	NV	NV	5	6	8	8	8	7	22	16	8	9
Boron (Hot Water Extractable)	NV	NV	2	0.10	0.19	0.43	1.46	1.55	0.5	1.57	4.17	2.17	1.5
Cadmium	10	1.0	12	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	64	71	750	2	10	31	18	25	26	12	15	9	28
Cobalt	300*	21	80	0.5	3	7.2	3.6	4.2	4.9	7.7	7.9	4.7	4.7
Copper	63	85	225	1	9	15	8	8	11	16	38	12	12
Lead	140	120	1000	1	13	12	6	6	8	9	21	17	9
Molybdenum	40*	2.5	40	0.5	0.6	0.6	<0.5	<0.5	<0.5	1.1	8.5	0.7	<0.5
Nickel	50	43	150	1	8	14	7	8	10	18	20	12	9
Selenium	2.9+	1.9	10	0.4	<0.4	0.7	0.6	0.5	<0.4	2.2	2.7	0.7	0.6
Silver	40*	0.42	40	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	1	2.5	32	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	0.7	<0.4	<0.4
Uranium	33		NV	0.5	0.5	0.9	0.6	0.8	0.8	0.7	1.5	0.6	0.8
Vanadium	130	91	200	1	11	30	17	17	23	20	30	11	22
Zinc	360	160	600	5	53	56	27	30	40	46	36	50	40
Chromium, Hexavalent	0.4	2.5	8	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide, Free	0.9	0.12	100	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	6.6	0.23	10	0.01	0.02	0.054	0.03	0.03	0.04	0.069	0.353	0.052	0.058
Electrical Conductivity (2:1)	4*	0.57	1.4	0.002	0.179	**9.05**	0.7	0.763	2.52	2.94	2.32	2.51	1.71
Sodium Adsorption Ratio (2:1)	12*	2.4	12	N/A	0.491	**85.8**	1.49	1.38	**14.7**	2.52	11.2	**27.2**	**13**
pH, 2:1 CaCl2 Extraction	6 to 8*	5 to 9	5 to 9		7.84	7.6	7.22	7.27	7.29	7.33	7.73	7.62	7.3
Chloride (2:1)	NV	330	NV	2	16	**5310**	16	21	**1010**	140	**978**	**1160**	**504**
Nitrate + Nitrite	NV	61	NV	1	<1	<10	<1	<1	<1	<1	<1	<1	<1

[1] Refers to CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2009)
[2] Refers to MOE Table 1 All Other Types of Property Uses (2004)
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004
[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
* Refers to Interim Remediation Criteria for soil that has not been replaced by Canadian Soil Quality Guidelines.
Highlight & Bold – Exceeds applicable CCME Guideline/ MOE Standard when no CCME Guideline is available

Table 3.3 Summary of Volatile Organic Compounds Analytical Results for Soil – West Wharf (all units are ug/g)

Parameters	CCME[1]	MOE Table 1[2]	MOE Table 3[2]	RDL	MW09-02A[4]		MW09-02B[4]	BH09-03A[4]	MW09-04A[5]	MW09-04B[5]	RDL	BH09-03B[4]
					Org	Dup						
Dichlorodifluoromethane	NV	NV	NV	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.010	<0.005
Chloromethane	NV	NV	NV	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Vinyl Chloride	NV	0.003	0.003	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Bromomethane	NV	0.003	0.061	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Chloroethane	NV	NV	NV	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.010	<0.005
Trichlorofluoromethane	NV	NV	NV	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.008	<0.008	<0.004
Acetone	NV	NV	3.8	0.130	<0.130	<0.130	<0.130	0.22	<0.130	0.26	<0.260	<0.130
1,1-Dichloroethylene	50	0.002	0.0024	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Methylene Chloride	NV	0.003	140	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	<0.003
TRANS-1,2-Dichloroethylene	50	0.003	4.1	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	<0.003
Methyl tert-butyl Ether	NV	NV	120	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.008	<0.008	<0.004
1,1-Dichloroethane	50	0.002	22	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Methyl Ethyl Ketone	NV	NV	38	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.2	<0.20	<0.10
CIS 1,2-Dichloroethylene	50	NV	2.3	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Chloroform	50	0.006	0.79	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
1,2- Dichloroethane	50	0.002	0.022	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
1,1,1-Trichloroethane	50	0.009	26	0.002	<0.005	<0.005	<0.005	<0.005	<0.002	0.004	<0.004	<0.002
Carbon Tetrachloride	NV	0.002	0.1	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Benzene	0.03	0.002	5.3	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
1,2-Dichloropropane	50	0.002	0.019	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Trichloroethylene	0.01	0.004	1.1	0.004	<0.005	<0.005	<0.005	<0.005	<0.004	0.008	<0.008	<0.004
Bromodichloromethane	NV	NV	25	0.003	<0.004	<0.004	<0.004	<0.004	<0.003	0.006	<0.006	<0.003
CIS-1,3-Dichloropropene	NV	NV	NV	0.002	<0.130	<0.130	<0.130	0.22	<0.002	0.004	<0.004	<0.002
Methyl Isobutyl Ketone	NV	NV	58	0.10	<0.002	<0.002	<0.002	<0.002	<0.10	0.2	<0.20	<0.10
TRANS-1,3-Dichloropropene	NV	NV	NV	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	<0.003
1,1,2-Trichloroethane	NV	0.002	3.1	0.002	<0.003	<0.003	<0.003	<0.003	<0.002	0.004	<0.004	<0.002
Toluene	NV	0.002	34	0.002	<0.004	<0.004	<0.004	<0.004	<0.002	0.004	<0.004	<0.002
2-Hexanone	NV	NV	NV	0.470	<0.002	<0.002	<0.002	<0.002	<0.470	0.94	<0.940	<0.470
Dibromochloromethane	NV	0.003	18	0.003	<0.10	<0.10	<0.10	<0.10	<0.003	0.006	<0.006	<0.003
Ethylene Dibromide	NV	0.004	0.0056	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Tetrachloroethylene	NV	0.002	0.45	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
1,1,1,2-Tetrachloroethane	NV	NV	0.019	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Chlorobenzene	10*	0.002	8	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Ethylbenzene	NV	0.002	290	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
m & p-Xylene	NV	NV	NV	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Bromoform	NV	0.002	2.3	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
Styrene	50*	0.002	1.2	0.002	<0.004	<0.004	<0.004	<0.004	<0.002	0.004	<0.004	<0.002
1,1,2,2-Tetrachloroethane	50	0.004	0.037	0.004	<0.003	<0.003	<0.003	<0.003	<0.004	0.008	<0.008	<0.004
o-Xylene	NV	NV	NV	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
1,3-Dichlorobenzene	10*	0.002	30	0.002	<0.10	<0.10	<0.10	<0.10	<0.002	0.004	<0.004	<0.002

Parameters	CCME[1]	MOE Table 1[2]	MOE Table 3[2]	RDL	MW09-02A[4]		MW09-02B[4]	BH09-03A[4]	MW09-04A[5]	MW09-04B[5]	RDL	BH09-03B[4]
					Org	Dup						
1,4-Dichlorobenzene	10*	0.002	30	0.002	<0.003	<0.003	<0.003	<0.003	<0.002	0.004	<0.004	<0.002
1,2-Dichlorobenzene	10*	0.002	30	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	<0.002
1,2,4-Trichlorobenzene	10	NV	30	0.007	<0.002	<0.002	<0.002	<0.002	<0.007	0.014	<0.014	<0.007
Xylene Mixture (Total)	NV	0.002	34	0.002	<0.470	<0.470	<0.470	<0.470	<0.002	0.004	<0.004	<0.002
1,3-Dichloropropene (Cis + Trans)	NV	0.003	0.0066	0.002	<0.003	<0.003	<0.003	<0.003	<0.002	0.004	<0.004	<0.002
n-Hexane	NV	NV	NV	0.005	<0.002	<0.002	<0.002	<0.002	<0.005	0.01	<0.010	<0.005

[1] Refers to CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2009)
[2] Refers to MOE Table 1 All Other Types of Property Uses
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004
[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
* Refers to Interim Remediation Criteria for soil that has not been replaced by Canadian Soil Quality Guidelines.
Highlight & Bold – Exceeds applicable CCME Guideline/ MOE Standard when no CCME Guideline is available

Table 3.4 Summary of Polycyclic Hydrocarbon Analytical Results for Soil – West Wharf (all units are ug/g)

Parameters	CCME[1]	MOE Table 1[2]	MOE Table 3[2]	RDL	MW09-02A[4]		MW09-02B[4]	BH09-03A[4]	MW09-04A[5]	MW09-04B[5]	RDL	BH09-3B[4]
					Org	Dup						
Naphthalene	0.013	0.09	40	0.03	**0.07**	**<0.03**	**<0.03**	**0.41**	**0.22**	**<0.03**	0.06	**<0.06**
Acenaphthylene	320	0.08	840	0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	0.04	<0.04
Acenaphthene	0.28	0.07	1300	0.03	<0.03	<0.03	<0.03	0.05	<0.03	<0.03	0.06	<0.06
Fluorene	0.25	0.12	350	0.02	<0.02	<0.02	<0.02	0.11	<0.02	<0.02	0.04	<0.04
Phenanthrene	0.046	0.69	40	0.02	0.04	<0.02	<0.02	**1.1**	**0.76**	0.03	0.04	<0.04
Anthracene	32	0.16	28	0.02	<0.02	<0.02	<0.02	0.12	<0.02	<0.02	0.04	<0.04
Fluoranthene	180	1.1	40	0.02	0.02	<0.02	<0.02	0.15	0.12	<0.02	0.04	<0.04
Pyrene	NC	1.0	250	0.02	0.02	<0.02	<0.02	0.25	0.15	<0.02	0.04	<0.04
Benzo(a)anthracene	NC	0.74	40	0.02	<0.02	<0.02	<0.02	0.13	0.08	<0.02	0.04	<0.04
Chrysene	NC	0.69	19	0.02	0.03	<0.02	<0.02	0.21	0.19	0.02	0.04	<0.04
Benzo(b)fluoranthene	NC	0.47	19	0.02	<0.02	<0.02	<0.02	0.06	0.05	<0.02	0.04	<0.04
Benzo(k)fluoranthene	NC	0.48	19	0.02	<0.02	<0.02	<0.02	0.02	<0.02	<0.02	0.04	<0.04
Benzo(a)pyrene	72	0.49	1.9	0.02	<0.02	<0.02	<0.02	0.1	0.04	<0.02	0.04	<0.04
Indeno(1,2,3-cd)pyrene	NC	0.38	19	0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	0.04	<0.04
Dibenzo(a,h)anthracene	NC	0.16	1.9	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.04
Benzo(g,h,i)perylene	NC	0.68	40	0.02	<0.02	<0.02	<0.02	0.08	0.04	<0.02	0.04	<0.04
2-and 1-methyl Naphthalene	NC	NV	280	0.05	0.09	<0.05	<0.05	1.6	1.1	<0.05	0.1	<0.10

[1] Refers to CCME Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2009)
[2] Refers to MOE Table 1 All Other Types of Property Uses
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004
[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
* Refers to Interim Remediation Criteria for soil that has not been replaced by Canadian Soil Quality Guidelines.
Highlight & Bold – Exceeds most applicable Guideline/Standard

3.6.2 Groundwater Analytical Results

A total of eight (8) groundwater samples were collected from the four (4) newly installed monitoring wells and four (4) existing wells with one (1) blind duplicate sample submitted for QAQC purposes at the West Wharf South site. Samples were analysed for concentrations of metals and inorganics, PHCs F1-F4 including BTEX and in select wells for PAHs and VOCs.

Analytical results indicated that concentrations of PHC F1-F4, BTEX, VOCs and PAHs did not exceed the applicable O. Reg. 153 Standards in any of the samples collected that were analysed for such parameters.

Various metals and inorganics were found to exceed the applicable CCME Guideline and/or O. Reg 153 Standards for monitoring wells MW09-01, MW09-2i, MW09-2i Dup, MW09-04, MW302, MW308 and MW6.

The groundwater analytical results for the West Wharf South are summarized in Tables 3.5 to 3.8 and shown in Appendix B Analysis Summary Tables. The Certificates of Analysis are provided in Appendix C.

Table 3.5 Summary Metal and Inorganics Analytical Results for Groundwater – West Wharf (all units are ug/L)

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1[3]	O. Reg. 153 Table 3[4]	RDL	MW09-01[5]	RDL	MW09-2i[5]		MW09-2ii[5]	RDL	MW09-04[6]	RDL	MW302[5]	MW308[6]	MW6[5]	MW310[6]
								Org	Dup								
Metals and Inorganics																	
Antimony	6	NV	6.0	16,000	0.5	2.8	0.5	<0.5	<0.5	<0.5	0.5	0.7	0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	10	5	25	480	1.0	3.3	1.0	4.5	4.4	<1.0	1.0	**73.2**	1.0	3.6	1.7	1.8	3.3
Barium	1000	NV	NV	23,000	2.0	1540	2.0	90.9	91.6	40.7	2.0	102	2.0	122	97.6	157	91.2
Beryllium	NV	NV	4.0	53	0.5	<0.5	0.5	<0.5	<0.5	<0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5
Boron	5000	NV	200	50,000	10.0	17.1	10.0	190	182	59.1	10.0	1230	10.0	48.2	145	97.9	89.1
Cadmium	5	0.017	0.5	11	0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
Chromium	50	8.9	8.9	2000	2.0	2.5	2.0	<2.0	<2.0	<2.0	2.0	2	2.0	4.3	5.2	**9.7**	2.1
Cobalt	NV	NV	0.9	100	0.5	**4.2**	0.5	**1**	0.8	0.7	0.5	15.8	0.5	**1**	2.7	0.7	2.1
Copper	1000	2 to 4[a]	2.5	23	1.0	**4.7**	1.0	1.4	1.1	2.4	1.0	**4.4**	1.0	1.8	1.4	1.5	1.1
Lead	10	1 to 7[b]	1	32	0.5	<0.5	0.5	**1.2**	<0.5	<0.5	0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5
Molybdenum	NV	73	40	7300	0.5	1.7	0.5	<0.5	<0.5	0.9	0.5	15.1	0.5	1.8	1.1	0.8	1
Nickel	NV	25 to 150[c]	25	1600	1.0	<1.0	1.0	<1.0	<1.0	3.3	1.0	21.2	1.0	2.7	3.2	3.2	5.4
Selenium	10	1	5.0	50	1.0	<1.0	1.0	<1.0	**2**	**2**	1.0	**3.6**	1.0	<1.0	**1.5**	**2.4**	<1.0
Silver	NV	0.1	0.25	1.2	0.2	<0.2	0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
Thallium	1	NV	0.5	400	0.3	<0.3	0.3	<0.3	<0.3	<0.3	0.3	<0.3	0.3	<0.3	<0.3	<0.3	<0.3
Uranium	20*	NV	NV	NV	0.5	0.8	0.5	<0.5	<0.5	0.9	0.5	1	0.5	0.6	1.5	<0.5	1.4
Vanadium	130	NV	6.0	200	0.4	<0.4	0.4	2.9	3.5	<0.4	0.4	0.5	0.4	2.8	0.4	2.3	0.6
Zinc	5000	30	20	1100	5.0	15.9	5.0	<5.0	<5.0	<5.0	5.0	16.5	5.0	7.2	6.2	<5.0	<5.0
Mercury	0.001	0.026	0.02	0.12	0.02	<0.02	0.02	<0.02	<0.02	<0.02	0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02
Chromium VI	NV	1	10	110	5	<5	5	<5	<5	<5	5	<5	5	<5	<5	<5	<5
Cyanide, Free	0.2	5	5.0	52	2	<2	2	<2	<2	<2	2	<2	2	**15**	<2	2	<2
Sodium	NV	NV	NV	NV	50	17800000	50	1100000	1100000	67400	50	8240000	50	1040000	234000	350000	54200
Chloride	≤250000+	NV	NV	NV	2000	**33300000**	100	**1650000**	**1600000**	66200	1000	**6740000**	100	**1860000**	**254000**	**455000**	20300
Nitrate as N	45000	13000	NV	NV	1000	<1000	50	<50	<50	940	500	<500	50	<50	<50	<50	<50
Nitrite as N	NV	60	NV	2000	1000	<1000	50	<50	<50	<50	500	<500	50	<50	<50	<50	<50
Electrical Conductivity (uS/cm)	NV	NV	NV	NA	2	72500	2	6390	6290	1650	2	20600	2	5700	2560	3740	1070
pH (pH units)	6.5 to 8.5 +	NV	NV	NA	NA	7.15	NA	7.76	7.73	7.89	NA	7.51	NA	7.97	7.7	7.91	7.59

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1[3]	O. Reg. 153 Table 3[4]	RDL	MW09-01[5]	RDL	MW09-2i[5]		MW09-2ii[5]	RDL	MW09-04[6]	RDL	MW302[5]	MW308[6]	MW6[5]	MW310[6]
Other																	
Total Suspended Solids	NV	NV	NV	NV	10	16800	10	5020	3820	378	10	7420	10	6840	1800	1640	1210

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines
[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004
[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004
[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
[a] Hardness as CaCO3 at 0 - 120 mg/L, guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 3 ug/L; CaCO3 at >180 mg/L, guideline = 4 ug/L
[b] Hardness as CaCO3 at 0 - 60 mg/L, guideline = 1 ug/L; CaCO3 at 60 - 120 mg/L, guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 4 ug/L; CaCO3 at >180 mg/L, guideline = 7 ug/L
[c] Hardness as CaCO3 at 0 - 60 mg/L, guideline = 25 ug/L; CaCO3 at 60 - 120 mg/L, guideline = 65 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 110 ug/L; CaCO3 at >180 mg/L, guideline = 150 ug/L
Highlight & Bold – Exceeds most applicable Guideline/Standard

Table 3.6 Summary VOCs Analytical Results for Groundwater – West Wharf (all units are ug/L)

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1[3]	O. Reg. 153 Table 3[4]	RDL	MW09-2i[5]		RDL	MW09-2ii[5]	RDL	MW308[6]	MW310[6]
						Org	Dup					
Dichlorodifluoromethane	NV	NV	NV	NV	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Chloromethane	NV	NV	NV	NV	0.8	<0.80	<0.80	0.40	<0.40	0.8	<0.80	<0.80
Vinyl Chloride	2	NV	0.5	0.5	0.34	<0.34	<0.34	0.17	<0.17	0.34	<0.34	<0.34
Bromomethane	NV	NV	0.9	3.7	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Chloroethane	NV	NV	NV	NV	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Trichlorofluoromethane	NV	NV	NV	NV	0.8	<0.80	<0.80	0.40	<0.40	0.8	<0.80	<0.80
Acetone	NV	NV	NV	3300	2	<2.0	<2.0	1.0	<1.0	2	<2.0	<2.0
1,1 Dichloroethene	NV	NV	0.66	0.66	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
Methylene Chloride	NV	98.1	50	50,000	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
trans- 1,2-dichloroethylene	NV	100-	100	100	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Methyl tert-butyl ether	15	10000	200	50,000	0.4	<0.40	<0.40	0.20	<0.20	0.4	23	<0.40
1,1-Dichloroethane	5	NV	70	9000	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
Methyl Ethyl Ketone	NV	NV	350	50,000	2	<2.0	<2.0	1.0	<1.0	2	<2.0	<2.0
cis-1,2-Dichloroethylene	NV	100-	70	70	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Chloroform	NV	NV	0.5	430	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
1,2 - Dichloroethane	5	100	5.0	17	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
1,1,1-Trichloroethane	NV	NV	10	200	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1 [3]	O. Reg. 153 Table 3 [4]	RDL	MW09-2i[5]		RDL	MW09-2ii[5]	RDL	MW308[6]	MW310[6]
Carbon Tetrachloride	5	13.3	0.5	17	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Benzene	5	370	5.0	1,900	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	8.7
1,2-Dichloropropane	NV	NV	0.7	3.8	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Trichloroethylene	NV	21	20	50	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Bromodichloromethane	16	NV	5.0	50,000	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
cis-1,3-Dichloropropene	NV	NV	NV	NV	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Methyl Isobutyl Ketone	NV	NV	NV	50,000	2	<2.0	<2.0	1.0	<1.0	2	<2.0	<2.0
trans-1,3-Dichloropropene	NV	NV	NV	NV	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
1,1,2-Trichloroethane	NV	NV	5	16,000	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Toluene	24	2	0.8	5,900	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	**7.2**
2-Hexanone	NV	NV	NV	NV	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
Dibromochloromethane	NV	NV	0.5	50,000	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
Ethylene Dibromide	NV	NV	1.0	3.3	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
Tetrachloroethene	5	111	5.0	5	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	<0.40
1,1,1,2-Tetrachloroethane	NV	NV	5.0	6	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
Chlorobenzene	NV	1.3	15	500	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
Ethylbenzene	2.4	90	2.4	28,000	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	69
m & p-Xylene	NV	NV	NV	5,600	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	17
Bromoform	NV	NV	5.0	840	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
Styrene	NV	72	4.0	940	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
1,1,2,2-Tetrachloroethane	NV	NV	1.0	22	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
o-Xylene	NV	NV	NV	5,600	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	2.4
1,3-Dichlorobenzene	NV	150	2.5	7,600	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
1,4-Dichlorobenzene	5	26	1.0	7,600	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
1,2-Dichlorobenzene	200	0.7	2.5	7,600	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	<0.20
1,2,4-Trichlorobenzene	NV	24	0.5	500	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
1,3-Dichloropropene (Cis + Trans)	NV	NV	1.4	3.8	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	<0.60
Xylenes (Total)	300	NV	72	5,600	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	19
n-Hexane	NV	NV	NV	NV	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	1.5

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines
[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007
[3] Refers to MOE Table 1 All Other Types of Property Uses (2004).
[4] Refers to MOE Table 3 All Other Types of Property Uses (2004).
[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
Highlight & Bold – Exceeds applicable CCME Guideline/ MOE Standard (when CCME Guideline is not available).

Table 3.7 Summary Petroleum Hydrocarbons Analytical Results for Groundwater – West Wharf (all units are ug/L)

Parameters	CCME, 1999 revised 2007[1]	CCME, 1999 revised 2008[2]	O. Reg. 153 Table 1 [3]	O. Reg. 153 Table 3 [4]	RDL	MW09-01[5]	RDL	MW09-2i[5]		RDL	MW09-2ii[5]	MW09-04[6]	RDL	MW302[5]	RDL	MW308[6]	MW310[6]
								Dup	Org								
Benzene	5	370	5	1900	0.2	<0.2	0.4	<0.40	<0.40	0.2	<0.20	<0.40	0.2	<0.2	0.4	<0.40	8.7
Toluene	24	2	0.8	5900	0.2	<0.2	0.4	<0.40	<0.40	0.2	<0.20	<0.40	0.2	<0.2	0.4	<0.40	**7.2**
Ethylbenzene	2.4	90	2.4	28000	0.1	<0.1	0.2	<0.20	<0.20	0.1	<0.10	<0.20	0.1	<0.1	0.2	<0.20	69
Xylenes (total)	300	NV	72	5600	0.2	<0.2	0.4	<0.40	<0.40	0.2	<0.20	<0.40	0.2	<0.2	0.4	<0.40	19
F1 (C6-C10)	NV	NV	NV	1000[a]	25	<25	25	<25	<25	25	<25	<25	25	<25	25	27	610
F2 (C10-C16)	NV	NV	NV		100	<100	100	<100	<100	100	<100	<100	100	<100	100	<100	430
F3 (C16-C34)	NV	NV	NV	1000[a]	100	<100	100	<100	<100	100	<100	<100	100	<100	100	<100	500
F4 (C34-C50)	NV	NV	NV		100	<100	100	<100	<100	100	<100	<100	100	<100	100	<100	<100

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines
[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004
[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004
[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
Highlight & Bold – Exceeds applicable CCME Guideline/ MOE Standard when no CCME Guideline is available.

Table 3.8 Summary PAHs Analytical Results for Groundwater – West Wharf (all units are ug/L)

Parameters	CCME, 1999 revised 2009[1]	CCME, 1999 revised 2009[2]	O. Reg. 153 Table 1 [3]	O. Reg. 153 Table 3 [4]	RDL	MW09-2i[5]		MW09-2ii[5]	MW09-04	MW308[6]	MW310[6]
						Dup	Org				
Naphthalene	NV	1.1	7.0	5900	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Acenaphthylene	NV	NV	1.0	2000	0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11
Acenaphthene	NV	5.8	1.0	1700	0.10	<0.10	<0.10	<0.10	<0.10	1.6	0.51
Fluorene	NV	3	1.0	290	0.09	<0.09	<0.09	<0.09	<0.09	2	0.55
Phenanthrene	NV	0.4	1.0	63	0.10	<0.10	<0.10	0.22	<0.10	<0.10	<0.10
Anthracene	NV	0.012	0.05	12	0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
Fluoranthene	NV	0.04	1.0	130	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Pyrene	NV	0.025	0.05	40	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Benzo(a)anthracene	NV	0.018	0.1	5	0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Chrysene	NV	NV	0.05	3	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)fluoranthene	NV	NV	0.05	7	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(k)fluoranthene	NV	NV	0.05	0.4	0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Benzo(a)pyrene	0.01	0.015	0.005	1.9	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	NV	NV	0.1	0.27	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Dibenzo(a,h)anthracene	NV	NV	0.1	0.25	0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
Benzo(g,h,i)perylene	NV	NV	0.10	0.2	0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
2-and 1-methyl Naphthalene	NV	NV	2.5	13000	0.20	<0.20	<0.20	<0.20	<0.20	0.2	7.6

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines
[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007
[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004
[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004
[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body
[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body
* Interim Maximum Acceptable Concentration (IMAC)
+ Aesthetic Objectives (AO) applied when no MAC available.
[a] Hardness as CaCO3 at 0 - 120 mg/L, guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 3 ug/L; CaCO3 at >180 mg/L, guideline = 4 ug/L
[b] Hardness as CaCO3 at 0 - 60 mg/L, guideline = 1 ug/L; CaCO3 at 60 - 120 mg/L, guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 4 ug/L; CaCO3 at >180 mg/L, guideline = 7 ug/L
[c] Hardness as CaCO3 at 0 - 60 mg/L, guideline = 25 ug/L; CaCO3 at 60 - 120 mg/L, guideline = 65 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 110 ug/L; CaCO3 at >180 mg/L, guideline = 150 ug/L

3.6.3 Surface Water Analytical Results

A total of four (4) surface water grab samples were collected from Lake Ontario along the shoreline of the site. There were no exceedances of the CCME guidelines; however, the laboratory detection limits for cadmium, and chromium VI were higher than the guidelines.

The surface water analytical results are summarized in Table 3.9 and shown in Appendix B Analysis Summary Tables. The Certificates of Analysis are provided in Appendix C.

Table 3.9 Surface Water Analytical Results (all units are ug/L)

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	Provincial Water Quality Objectives[3]	RDL	SW09-02 (West Wharf)	SW09-03 (West Wharf)	SW09-04 (West Wharf)
Antimony	6	NV	20	0.5	<0.5	<0.5	<0.5
Arsenic	10	5	100	1.0	<1.0	<1.0	<1.0
Barium	1000	NV	NV	2.0	39.6	38.9	33.6
Beryllium	NV	NV	11 or 1100[#a]	0.5	<0.5	<0.5	<0.5
Boron	5000	NV	200[#]	10.0	17.6	14.6	17
Cadmium	5	0.017	0.1 or 0.5[#b]	0.2	**<0.2**	**<0.2**	**<0.2**
Chromium	50	8.9	8.9	2.0	<2.0	<2.0	<2.0
Cobalt	NV	NV	0.9	0.5	<0.5	<0.5	<0.5
Copper	1000	2 to 4	1 or 5[#c]	1.0	1.6	1.6	1.3
Lead	10	1 to 7	5, 10 , 20 or 25[#d]	0.5	0.9	1	1
Molybdenum	NV	73	40	0.5	0.7	0.7	0.9
Nickel	NV	25 to 150	25	1.0	1.2	1.6	1.8
Selenium	10	1	100	1.0	<1.0	<1.0	<1.0
Silver	NV	0.1	0.1	0.2	<0.2	<0.2	<0.2
Thallium	1	NV	0.3[#]	0.3	<0.3	<0.3	<0.3
Uranium	20*	NV	5[#]	0.5	0.7	0.6	0.6
Vanadium	130	NV	6	0.4	1	0.9	0.4
Zinc	5000	30	20[#]	5.0	20.5	19.2	6.3
Chromium VI	NV	1	1	5	**<5**	**<5**	**<5**
Sodium	NV	NV	NV	50	34600	34900	26600
Chloride	≤250000+	NV	NV	100	64300	65600	56500
Nitrate as N	45000	13000	NV	1000	1090	1190	817
Nitrite as N	NV	60	NV	1000	<50	<50	<50
Electrical Conductivity	NV	NV	NV	2	509	511	4790
pH	6.5 to 8.5 +	NV	6.5 to 8.5	NA	8.32	8.33	8.35

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines
[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007
[3] MOE Provincial Water Quality Objectives (PWQO) Appendix A Table 2 - Table of PWQOs and Interim PWQOs - 1994, reprinted 1999
* Interim Maximum Acceptable Concentration (IMAC)
\+ Aesthetic Objectives (AO) applied when no MAC available.
[#] Interim PWQO
[a] Hardness as CaCO3 at 0 - 120 mg/L, guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 3 ug/L; CaCO3 at >180 mg/L, guideline = 4 ug/L
[b] Hardness as CaCO3 at 0 - 60 mg/L, guideline = 1 ug/L; CaCO3 at 60 - 120 mg/L, guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 4 ug/L; CaCO3 at >180 mg/L, guideline = 7 ug/L
[b] Hardness as CaCO3 at 0 - 60 mg/L, guideline = 25 ug/L; CaCO3 at 60 - 120 mg/L, guideline = 65 ug/L; CaCO3 at 120 - 180 mg/L, guideline = 110 ug/L; CaCO3 at >180 mg/L, guideline = 150 ug/L
Purple highlight indicates detection limit exceeds the guidelines/standards
Highlight & Bold – Exceeds applicable CCME Guideline/ MOE Standard when no CCME Guideline is available.

3.6.4 Toxicity Characteristic Leaching Procedure (TCLP)

Two (2) composite soil samples were submitted to the laboratory for TCLP analysis. Composite soil samples were collected from each area of concern (South Spur, West Wharf South and West Wharf North).

Analytical results from the TCLP analysis of the two (2) composite samples did not find the concentrations for any parameters to exceed the applicable leachate quality criteria concentrations. Therefore, the material encountered during this investigation was not considered to be "leachate toxic waste" under Ontario Regulation 347 Schedule 4 and was classified as non-hazardous and non-registerable material. These materials were removed and disposed off site as non-hazardous waste on April 1, 2010.

A summary of analytical results for the TCLP analysis is provided in Table 3.10. The Certificates of Analysis are provided in Appendix C.

Table 3.10 Summary of TCLP Analysis

Parameters	Hazardous Waste	Registrable Waste	RDL	Unit	West Wharf (South)	West Wharf (North)
Inorganics						
Fluoride	150	15	0.05	mg/L	0.1	0.19
Free Cyanide	20	2	0.05	mg/L	<0.05	<0.05
Nitrate and Nitrite	1000	100	0.7	mg/L	<0.70	<0.70
Metals						
Arsenic	2.5	0.25	0.010	mg/L	0.075	<0.010
Barium	100	10	0.100	mg/L	2.04	0.747
Boron	500	50	0.050	mg/L	0.063	0.051
Cadmium	0.5	0.05	0.010	mg/L	<0.010	<0.010
Chromium	5	0.5	0.010	mg/L	<0.010	<0.010
Lead	5	0.5	0.010	mg/L	<0.010	<0.010
Mercury	0.1	0.01	0.005	mg/L	<0.005	<0.005
Selenium	1	0.1	0.010	mg/L	<0.010	<0.010
Silver	5	0.5	0.010	mg/L	<0.010	<0.010
Uranium	10	1	0.050	mg/L	<0.050	<0.050
Volatiles						
Benzene	0.5	0.05	0.02	mg/L	<0.020	<0.020
Carbon Tetrachloride	0.5	0.05	0.02	mg/L	<0.020	<0.020
Chlorobenzene	8	0.8	0.01	mg/L	<0.010	<0.010
Chloroform	10	1	0.02	mg/L	<0.020	<0.020
1,2-Dichlorobenzene	20	2	0.01	mg/L	<0.010	<0.010
1,4-Dichlorobenzene	0.5	0.05	0.01	mg/L	<0.010	<0.010
1,2-Dichloroethane	0.5	0.05	0.02	mg/L	<0.020	<0.020
1,1 Dichloroethene	1.4	0.14	0.02	mg/L	<0.020	<0.020
Dichloromethane	5	0.5	0.03	mg/L	<0.030	<0.030
Methyl Ethyl Ketone	200	20	0.09	mg/L	<0.090	<0.090
Tetrachloroethene	3	0.3	0.01	mg/L	<0.010	<0.010
Trichloroethene	5	0.5	0.02	mg/L	<0.020	<0.020
Vinyl Chloride	0.2	0.02	0.03	mg/L	<0.030	<0.030
Semi Volatiles						
Pyridine	5.0	0.5	0.010	mg/L	<0.010	<0.010
Cresols	200	20	0.012	mg/L	<0.012	<0.012
Ortho-Cresol	200	20	0.004	mg/L	<0.004	<0.004
Meta & Para-Cresol	200	20	0.008	mg/L	<0.008	<0.008
Hexachloroethane	3.0	0.3	0.004	mg/L	<0.004	<0.004
Nitrobenzene	2.0	0.2	0.004	mg/L	<0.004	<0.004
Hexachlorobutadiene	0.5	0.05	0.004	mg/L	<0.004	<0.004

Parameters	Hazardous Waste	Registrable Waste	RDL	Unit	West Wharf (South)	West Wharf (North)
2,4,6-Trichlorophenol	0.5	0.05	0.05	mg/L	<0.05	<0.05
2,4,5-Trichlorophenol	400	40	0.004	mg/L	<0.004	<0.004
2,4-Dinitrotoluene	0.13	0.013	0.004	mg/L	<0.004	<0.004
2,3,4,6-Tetrachlorophenol	10.0	1	0.004	mg/L	<0.004	<0.004
Hexachlorobenzene	0.13	0.013	0.004	mg/L	<0.004	<0.004
Dinoseb	1.0	0.1	0.004	mg/L	<0.004	<0.004
Benzo(a)pyrene	0.001	0.0001	0.001	mg/L	<0.001	<0.001
Polychlorinated Biphenyls						
PCB	0.3	0.03	0.005	mg/L	<0.005	<0.005

3.6.5 Results of QA/QC

The relative percent differences (RPD) were calculated for 98 independent analytical parameters taken within the duplicate soil sample as compared to the sample duplicated. All were found to be within allowable percentage difference of 50% as set out by the US EPA Revised Data Validation Guidance Document (12/96) for non-aqueous samples in metals/inorganics or semi-volatiles compounds.

The relative percent differences (RPD) were calculated for the parameters taken within the duplicate groundwater samples as compared to the sample duplicated. All were found to be within acceptable ranges of 30% percent difference.

The detailed percentage difference calculations between duplicate samples are provided in Appendix B of this report.

3.7 Discussion of Results

Based on samples collected previously and during this current investigation, two areas of concern were identified at the West Wharf, namely the northern section of the West Wharf South and the area in the vicinity of MW302.

Soil contamination in the northern part of the West Wharf South site is characterized by exceedances of metals, PHC, BTEX and PAHs. Arsenic exceedances were found during this investigation in BH09-03 and MW09-04 as well as various metal impacts in MW4 and MW308 in previous investigations. Inorganic parameters (Electrical Conductivity, and Sodium Adsorption Ratio) exceeding the CCME guidelines were found in all boreholes (MW09-01B, MW09-02B, BH09-03B and MW09-04B). PHC and BTEX impacts were not found during this current investigation, however, pockets of these parameters were found in previous investigations in the vicinity of BH10, MW308, MW17 and BH54. This indicates that PHC and BTEX impacts area present in the western and southern portion of this area of concern. PAH impacts were found in all new boreholes drilled during this investigation and in MW4 in a previous investigation indicating that these impacts are present in the eastern portion of this area of concern near the water edge.

Groundwater metal impacts in the northern section of the West Wharf South were found during this investigation and previously in MW4 and MW307 (not sampled during this investigation since they could not be found). High chloride concentrations were also found in this area in MW09-2i, MW09-04 and MW308. These high chloride concentrations may be the result of salting in the parking lot area of the site. VOC parameter MTBE was also found in MW308. No exceedances of PHC, BTEX or PAHs were found in the groundwater in this area of concern.

Soil contamination in the final area of concern, the former salt storage area in the vicinity of MW302, is consistent with previous investigations with high concentrations of SAR, EC and chloride. Metal and PAH impacts have previously been identified in the soil this area in MW6, however, these parameters were below the respective guidelines/standards during this investigation indicating this contamination is not widespread in this area.

Groundwater impacts (exceeding the MOE Standards) in this area of concern include metals, chloride and free cyanide (MW302 only). These exceedances are consistent with previous investigations. PAHs (MW6) and BTEX (MW302) found during previous investigations were below the applicable guidelines/standards during this current investigation. The toluene concentration exceeding the CCME guideline and the total F1 and F2 PHC concentration exceeding the MOE standard were found in the groundwater sample collected from MW310.

Surface water collected in the vicinity of this West Wharf South show slightly elevated metals (zinc exceeding the MOE Provincial Water Quality Objectives; detection limit of cadmium, silver and chromium VI exceeded the respective guidelines/objectives). However, these concentrations area similar throughout each sample and the sample collected at the South Rail Spur indicating this is the actual quality of the water in this area and not specifically related to the area.

4. Detailed Site Specific Risk Assessment

Based on the findings of the previous and current investigation, a Detailed SSRA was conducted by WESA Inc. on behalf of GENIVAR to estimate the potential human health and ecological risks the impacts may pose. This SSRA was completed in accordance with the Federal Contaminated Sites Action Plan. The full SSRA document is provided in Appendix E of this report. A summary of the findings is provided below:

- Based on the previous and current investigations, it has been confirmed that concentrations of PHCs, VOCs, PAHs and several inorganic parameters exceed the CCME guidelines for industrial/commercial sites. These parameters are identified as contaminants of potential concern (COPCs) and were assessed further in the SSRA and screening level ecological risk assessment (SLERA).
- The SSRA examined the potential exposures and health risks to two types of receptors: a remediation worker and a commercial worker.
- The COPCs examined for human health include: arsenic, benzene, PHC Fractions 2 and 3 in soil and PHC Fractions 2, 3 and 4 in groundwater.
- The risks for the Remediation Worker were estimated to be higher than acceptable for arsenic in soil due to ingestion, dermal contact, and inhalation of particles, and for benzene due to inhalation of vapours that migrate to outdoor air. The risks are also unacceptable for PHC Fraction 2 in soil due to vapour inhalation, and for PHC Fractions 2 and 3 in groundwater due to dermal contact.
- The risks for the Commercial Worker were estimated to be higher than acceptable for arsenic in soil as a non-threshold toxicant due to ingestion and dermal contact, and as a threshold toxicant due to inhalation of particles. Unacceptable risks were estimated for benzene due to inhalation of vapours that originate in soil and migrate to outdoor air.
- The estimates reflected numerous conservative assumptions including the assumption that all exposures involved soil with the maximum measured concentrations of the COCs (contaminants of concern). The unacceptable risk estimates for arsenic ranged from approximately three times to one order of magnitude higher than acceptable for the individual pathways. If average concentrations had been used, the risks would be three times to an order of magnitude lower than have been estimated. A similar rationale can be applied to the risks for benzene which are two to 4.5 times greater than acceptable, and for PHCs whose risks are two to three times greater than acceptable.
- The screening level ecological risk assessment (SLERA) examined potential exposures and risks to five broad categories of receptors: plants, soil microorganisms, soil invertebrates, birds, and mammals. In addition, aquatic receptors were considered in the assessment of ground water quality.
- The COCs identified for the SLERA in soil are arsenic, HWE boron EC, SAR and PHC Fractions 2 and 3. The COCs in groundwater are sodium, chloride and PHC Fractions 2 and 3.

- Risks were estimated to be higher than acceptable for all of the inorganic COCs except hexavalent chromium at numerous locations. EC and SAR in soil, and sodium and chlorides account for approximately three-quarters of instances where ecological risks are estimated to be higher than acceptable.
- The SSRA and SLERA were combined to recommend property specific standards (PSS) for the COCs that can be used in place of the generic CCME SQG. Risk management measures are required in locations where concentrations in soil and groundwater exceed acceptable risk levels. These standards are listed in Section 7 of the SSRA report.

5. Recommendations: Remediation/Risk Management Options & Analysis

This section provides an outline of the remedial and risk management options developed and evaluated by GENIVAR to address contaminants deemed of concern to human and/or ecological health in the detailed risk assessment completed as part of this study.

5.1 Site Characteristics

The property operates as a wharf and is currently occupied by two commercial/industrial businesses - McNally Construction in the northwest corner, and KR Wind and Oshawa Stevedoring in the southwest portion of the property. The property is bound by Oshawa Harbour to the north and east and Lake Ontario to the south.

The site surface is covered with concrete, asphalt and sand and gravel. Asphalt covers the bulk of the site surface in the southern wing of the property. Asphalt or sand and gravel are present over the majority of the site surface in the north wing of the property.

A wharf wall, constructed of concrete, runs along the full length of the water side of the property. The wall is 80 cm in thickness. It extends at least 5 m below grade with about 3.5 m of the wall situated below the lake/harbour water surface.

The stratigraphy encountered in boreholes advanced by GENIVAR and others to date consists of fill material underlain by a number of soil layers to the maximum depth investigated (7.4 m). The fill which extends to depths ranging from 0.6 to 1.9 m below grade is made up of silty sand, sandy silt and sand and gravel. Soil layers underlying the fill include silty sand, sandy silt, peaty silt, peat, silt and sand.

The water table of the shallow groundwater unit has been encountered at depths ranging from 0.4 to 1.2 m below grade. Based on assessment work carried out by GENIVAR and others, groundwater flow is towards Lake Ontario and the Harbour.

Past environmental studies identified fuel terminal facilities (Petrocor and former Lake Terminal) as the sources of the petroleum hydrocarbon contamination identified in the subsurface in the northwestern portion of the property. These facilities border the subject site to the immediate west. The former storage of road salt and coal are reported to have occurred at the subject site. Others (DCS 2003 and Aquaterre 2009) indicate that the salinity impacts (sodium adsorption ratio and electrical conductivity in soil and chloride in groundwater) apparent in the subsurface are attributed to the former storage of road salt in the north part of the south wing of the subject property.

5.2 Contaminants of Concern and Exposure Pathways

5.2.1 Soil

Chemical testing identified a number of organic parameters (BTEX, PHC fractions and several PAHs) and several inorganic parameters (arsenic, selenium, hot water soluble boron, sodium adsorption ratio and electrical conductivity) in soil at concentrations above generic federal guidelines and/or provincial standards. Risk assessment considering site specific characteristics and active exposure pathways

identified a number of these parameters as posing an adverse exposure risk to human and ecological receptors. These parameters which are present at concentrations above Final Site Standards (FSSs) or Property Specific Standards (PSSs) are summarized along with active exposure pathways, as follows:

Human Health

Soil Contact: arsenic

Soil to Indoor Air: benzene, PHC F2

Ecological

Soil Contact (soil invertebrates and plants): arsenic, boron (hot water soluble), PHC F2, PHC F3, SAR and EC.

Soil Leachate to Surface Water (aquatic): PHC F2.

The distributions of the above COCs are illustrated along with inferred extents by others on adjacent property parcels on Figure 6. As illustrated, soil contaminated with PHCs and/or metals at concentrations above FSSs is present beneath the northern half of the north wing of the subject site. PHC contamination in this area appears to be an extension of like contamination apparent beneath the adjacent former Lakes Terminal.

Non-compliant levels of SAR in subsurface soil (>1.5 m) are widespread – it is present at levels above generic standards/guidelines at all borehole locations tested for this parameter. It does not exceed the generic CCME guideline or MOE standard in surface soil (<= 1.5 m) at any of the borehole locations (6) tested, included locations cited within or proximate to the road salt storage area. Because SAR meets the generic guideline in surface soil, adverse affects to plants and soil invertebrates are not anticipated.

All of the soil samples analyzed from the upper part of the soil profile did not exhibit EC levels above the federal guideline. EC levels in soil exceeded the federal guideline at depths in excess of 1.9 m at various borehole locations. Because surface soils meet the generic guideline, adverse affects to plants and soil invertebrates are not anticipated.

Leachate testing (VOCs, PCBs, PAHs, metals) on a representative composite sample from the site indicates that the soil at the site is non-hazardous under Ontario Regulation 558/347.

5.2.2 Groundwater

Based on the risk assessment, parameters present in groundwater at concentrations above the FSSs include chloride, sodium, PHC F2 and PHC F3. These parameters are deemed to pose a potential adverse risk to aquatic receptors via the groundwater to surface water transport pathway.

PHC F2 and F3 at concentrations above their respective PSSs are generally present on one or more monitoring events in groundwater acquired from monitoring wells positioned in the north half of the north property wing of the subject site (Figure 7). Sodium and chloride have been detected above their FSSs in groundwater from three well locations; MW09-04 located in the middle of the north property wing; and MW09-01 and MW302 both situated adjacent to the wharf wall on the north side of the south property wing. Sodium has also been detected above the FSS in groundwater from MW308 and MW-09-02 located in the north part of the north property wing.

In light of the above, groundwater mitigative measures to protect aquatic receptors are deemed necessary and thus considered in the remedial/risk management options developed for this site.

5.3 Options Considered by Others

5.3.1 Subject Site

Aquaterre evaluated several remedial/risk management options in their 2009 study. The options considered included capping, excavation and offsite disposal, and groundwater controls to address salinity related

impacts in groundwater. Based on their evaluation, Aquaterre selected a preferred approach for implementation at the site. The preferred approach included an asphalt cap over the areas of concern, excavation and offsite disposal of metals impacted soil, and groundwater controls including a sheet pile barrier wall and groundwater recovery and desalinization using reverse osmosis. The estimated cost of the preferred approach was quoted at about $4.8 million. Long term operation, monitoring and maintenance costs were not included in the estimate.

An important item that is considered in our evaluation is the fact that an existing groundwater barrier wall is in-place at the subject site – the concrete wharf wall which extends at least 3.5 m below the water table and runs along the full length of the water side of the property. This existing wall is exploited in our options evaluation.

5.3.2 Adjoining Properties

In 2009, Jacques Whitford Stantec Limited (JWSL) evaluated several remedial/risk management options to address contaminants deemed to pose an adverse risk to local receptors on property parcels bordering the subject site to the immediate west and north. The options considered included:

- Excavation and Offsite Disposal
- Capping with 0.5 m of Earth Material
- Capping with Asphalt; and
- Fencing

Of the options considered, JWSL selected Capping with Fencing as preferred, recommending that it be implemented on adjacent property parcels. The option includes the placement of security fence around the properties and the placement of low permeability earth caps with a minimum thickness of 0.5 m over areas of the property parcels with constituents present at concentrations above Property Specific Clean-up Objectives (PSCOs). This option is a risk management measure as it serves to cut-off soil contact exposure pathways for human and ecological receptors.

Receptor exposure by way of the groundwater transport pathway was mentioned but excluded from consideration as JWSL assumed the following:

- In the event that the contaminated soil is removed, COCs in groundwater would naturally attenuate; and
- In the event that caps are placed over impacted areas, exposure pathways for ecological and human receptors would be blocked.

JWSL mentions that *"for areas of groundwater where CoC concentrations are greater than the applicable non-potable groundwater standards, groundwater sampling should be undertaken following soil remediation to meet the PSCO to determine whether or not further groundwater remediation or implementation of risk management measures are necessary"*.

As outlined in the preceding section, this study identified a potential exposure risk to aquatic receptors via the groundwater to surface water pathway and soil leachate to groundwater pathway. Because these receptors are potentially at risk of exposure, groundwater mitigation to address contaminants in groundwater at concentrations above aquatic based objectives is considered necessary and, thus, included in this evaluation.

5.4 GOST Consultation

The Government of Canada "Guidance and Orientation for the Selection of Technologies" (GOST) website was consulted in this evaluation. The site-specific output from GOST is provided in Appendix D. As presented, GOST suggests that the following in-situ remedial technologies be considered for the subject site:

- phytoremediation of organic compounds;
- bioaugmentation;
- enhanced aerobic bioremediation; and
- anaerobic biostimulation.

These technologies have been carried forward for further consideration in Section 5.6 of this report.

GOST did not provide ex-situ treatment technologies for possible implementation at the subject site.

5.5 Remedial and Risk Management Options

For simplicity, contaminated soil and groundwater mitigation have been considered separately in this options analysis with preferred options for both media selected at the conclusion of the evaluation for implementation into the preferred mitigation strategy for the area in general. Specifically, the evaluation takes into account a wider area of abatement through consideration of JWSLs recommended risk management based approach for adjoining property parcels to the west and north, namely, the placement of an earth cap to cut-off soil contact exposure pathways for human and ecological receptors. Wider area of abatement is addressed in this evaluation through the consideration of groundwater mitigation to address potential adverse affects to aquatic receptors via the groundwater to surface water transport and aquatic based soil leachate to groundwater pathways.

The mitigation options considered include:

- In-situ Remediation
- Excavation with Offsite Disposal
- Excavation with Onsite Biotreatment
- Excavation with Soil Transfer and Offsite Disposal
- Asphalt Capping
- Asphalt Capping with Soil Transfer
- Groundwater Mitigation

Details of the options are provided in the following sections.

5.5.1 In-situ Remediation

Because a continual source of organic contaminants exist beneath property parcels situated up-gradient of the subject site, in-situ remediation utilizing technologies such as air sparging with soil vapour extraction, chemical oxidation, enhanced bioremediation, among others, are not considered further in this evaluation. Specifically, the site restoration approaches recommended by others on the adjoining properties leave organic contaminants in-place and thus the potential for site recontamination is possible. Ultimately, a wider area of abatement considering the entire impacted area holistically is required to complete an effective evaluation of potential in-situ based remedial technologies.

5.5.2 Excavation with Offsite Disposal

This option would involve the excavation and offsite disposal of non-hazardous soil contaminated with petroleum hydrocarbons and metals. The contaminated soil would be transported to a landfill licensed to accept the material. The excavation would be advanced to the extent necessary to achieve compliance with the FSSs derived for the site. Imported fill, chemically verified as compliant with provincial background standards, would be used to backfill the excavation. Due to the depth of the EC/SAR impacts (i.e. in subsurface soil) they were not included in this option.

Excavation dewatering and groundwater treatment will be required as part of this option. For the purposes of this assessment, it has been assumed that treatment will include particulate settling and treatment to

remove organics with the resulting treated effluent discharged to the sanitary sewer or returned to the groundwater formation via a subsurface injection gallery.

Regulatory approvals of the excavation dewatering and treated effluent release plan, and groundwater treatment process will be required by provincial regulators prior to proceeding with this option.

This option assumes excavation depths and aerial extents of 2 m and 3,150 m^2 and 1.5 m and 2,850 m^2 in the PHC and metals impacted areas situated in the north wing of the property. The total contaminated soil volume all areas combined is on the order of 10,575 m^3.

To prevent recontamination of the site from organic contaminants present in the subsurface on adjacent property parcels, an allowance for the installation of a continuous HDPE liner along the property boundary is included in this option. The liner would be installed in a trench excavated along the north, northwest and western property boundaries in the north wing of the subject site. The liner would extend from near grade to 5 m below grade from the wharf wall in the northeast corner to approximately 50 m south of the southern limit of known hydrocarbon impact on the west property limit. The length of the liner/trench is estimated at about 240 m.

The volume of groundwater requiring dewatering and treatment during the excavation and trenching campaign is estimated at up to 230 m^3. Daily flows are estimated at up to 11,000 Litres. This estimate assumes excavation in stages, an effective porosity of 0.25, a hydraulic conductivity of 1.4 x 10^{-6} m/sec (as estimated by others) and water heads ranging from 0.2 m to 1 m.

This option would result in the successful remediation of soil to meet FSSs within the limits of the subject site.

This option is carried forward for further evaluation.

5.5.3 Excavation with Onsite Biotreatment

Under this option petroleum hydrocarbon contaminated soil would be treated in an engineered bio-treatment facility complete with secondary containment and leachate collection/treatment system. This option may be viable on a large scale, i.e., for the treatment of petroleum hydrocarbon contaminated soil from all Harbour lands. It is not, however, viable for the subject site alone as the cost of the biotreatment facility would exceed the cost of contaminated soil disposal. Further, biotreatment will not result in the remediation of metals such as arsenic which are present in a portion of the petroleum hydrocarbon contaminated soil. For these reasons, this option has been eliminated from further consideration.

It may be worthwhile to consider this option on a larger scale for the restoration of the Oshawa Harbour lands as a whole. In addition, consideration could be given to re-locating metals contaminated soil from this site and others and/or left over as a residual of bio-treatment to the South Rail Spur where metals are present throughout the fill material and the preferred remedial approach consists of fill containment. Ultimately, a harbour wide approach may be advantageous as it could result in the restoration of some of the property parcels to meet risk based objectives with no long term risk management measures necessary. Further, it may result in a more sustainable and cost effective approach as a whole, through the implementation of treatment and recycling of soil, relocation of metals contamination to one area, along with other approaches and considerations that may be derived from looking at the larger picture.

5.5.4 Asphalt Capping

This option is a risk management measure which would result in the cut-off of the soil contact exposure pathway for human and ecological receptors. Exposure cut off would be attained through the placement of asphalt caps over the site surface in regions of the site where soil exhibits PHCs and metals above FSSs. In addition, regions of the site where EC/SAR are apparent in subsurface soil (>1.5 m) at levels above FSSs, risk management measures which will prevent adverse risks to plants and soil invertebrates include:

- Maintaining the sand and gravel cover layer (0 to 1.8 m below grade) atop the EC/SAR impacted subsurface zone in the area of BH307;

- Maintaining the existing asphalt cap over the subsurface region with EC/SAR impacts in the south wing of the property;
- Maintaining existing land use within the SAR/EC impacted areas with no vegetation planting or placement of organic topsoil permitted in these areas without further risk analysis; and
- If future excavation is required, a soil management plan will need to be developed that will ensure that subsurface soil with EC/SAR impacts is not transferred into the upper surface soil horizon during future excavation and backfilling operations.

The proposed cap areas are illustrated along with the EC/SAR protection areas on Figure 6.

The estimated areal extent of the caps is on the order of 6,000 m^2.

This option includes a long term monitoring and maintenance program for the cap. The program assumes annual inspections of cap integrity over a 30 year period. It also assumes re-surfacing/paving of the cap area on three occasions, at year 10, 20 and 30.

This option is carried forward for further evaluation.

5.5.5 Excavation with Soil Transfer and Offsite Disposal

This option would involve the excavation and offsite disposal of non-hazardous soil contaminated with petroleum hydrocarbons and the transfer of soil contaminated with inorganics (only) to the South Rail Spur property for subsequent placement within the containment facility proposed at this property. The PHC contaminated soil would be transported to a landfill licensed to accept the material. The excavations would be advanced to the extent necessary to achieve compliance with PSCOs derived for the site. Imported fill, chemically verified as compliant with provincial background standards, would be used to backfill the excavation.

Excavation dewatering and groundwater treatment will be required as part of this option. For the purposes of this assessment, it has been assumed that treatment will include particulate settling and treatment to remove organics with the resulting treated effluent discharged to the sanitary sewer or returned to the groundwater formation via a subsurface injection gallery.

Regulatory approvals of the excavation dewatering and treated effluent release plan, and groundwater treatment process will be required by provincial regulators prior to proceeding with this option.

The volume of soil designated for offsite disposal is estimated at 9,650 m^3. This volume is composed of contaminated soil from the PHC impacted area (7,700 m^3) and PAH/EC impacted area (1,950 m^3) situated in the north wing and south wing of the subject property, respectively. The volume of metals contaminated soil slotted for transfer to the containment facility at the South Rail Spur is estimated at about 4,800 m^3.

To prevent recontamination of the site from organic contaminants present in the subsurface on adjacent property parcels, an allowance for the installation of a continuous HDPE liner along the property boundary is included in this option. The liner would be installed in a trench excavated along the north, northwest and western property boundaries in the north wing of the subject site. The liner would extend from near grade to 5 m below grade from the wharf wall in the northeast corner to approximately 50 m south of the southern limit of known hydrocarbon impact on the west property limit. The length of the liner/trench is estimated at about 240 m.

The volume of groundwater requiring dewatering and treatment during the excavation and trenching campaign is estimated at up to 230 m^3. Daily flows are estimated at up to 11,000 Litres. This estimate assumes excavation in stages, an effective porosity of 0.25, a hydraulic conductivity of 1.4×10^{-6} m/sec (as estimated by others) and water heads ranging from 0.2 m to 1 m.

This option would result in the successful remediation of soil to meet PSCOs within the limits of the subject site.

This option is carried forward for further evaluation.

5.5.6 Capping with Soil Transfer

This option would involve the excavation and removal of soil contaminated with inorganics with the soil relocated to the South Rail Spur property for subsequent placement within containment cell suggested for that property. Asphalt caps would be placed over the site surface in regions of the site where subsurface soils exhibit PHCs and PAHs above PCSOs. This option is deemed a risk management measure as PHC and PAH contaminated soil would remain in-place with the caps serving to cut-off the soil contact exposure pathway for human and ecological receptors. The estimated areal extent of the asphalt cap is on the order of 6,200 m^2. The estimated volume of soil contaminated with inorganics which would be transferred under this option is on the order of 4,800 m^3.

This option includes a long term monitoring and maintenance program for the cap. The program assumes annual inspections of cap integrity over a 30 year period. It also assumes re-surfacing/paving of the cap area on three occasions, at year 10, 20 and 30.

Excavation dewatering will required as part of this option. The volume of groundwater requiring dewatering and treatment during the excavation campaign is estimated at up to 5 m^3. Due to the volume anticipated we have assumed groundwater extraction and disposal at an appropriately licensed facility by way of vacuum truck.

This option is carried forward for further evaluation.

5.5.7 Groundwater Mitigation

This option exploits the existing concrete wharf wall as a barrier to shallow groundwater flow and dissolved plume transport to surface water. The wall extends along the full length of the water side of the property, is on the order of 80 cm thick, and is at least 5 m deep. Its base is positioned at least 3.5 m below the static water table. Dissolved constituents at concentrations above FSSs are illustrated along with the proposed groundwater barrier wall on Figure 7.

Within the regions of the plumes, groundwater flow was towards the Harbour or groundwater barrier wall on March 12, 2010. As a result, the plumes were effectively contained on this monitoring date. Because of the apparent plume containment, the need for an extension of the barrier wall along the beach area at the south limit of the south wing of the property was not considered necessary. It is important to note, however, that groundwater flow and plume migration trends should be monitored over time to ensure that the containment condition remains active. This has been taken into consideration in this evaluation by way of the long term groundwater monitoring program and groundwater flow and contaminant transport model that form part of this option.

This option is a risk management measure as it serves to cut-off aquatic receptor exposure by way of the groundwater to surface water transport pathway. Use of the existing wharf wall as groundwater/dissolved plume barrier is deemed valid, due to the following reasons:

- Surface water quality data collected as part of this study, suggests that the wharf wall is effectively containing the chloride plume that resides on the north side of south property wing. Specifically, chloride concentrations in surface water samples (46,200 to 65,600 ug/L) are one order of magnitude lower than the aquatic protection value (180,000 ug/L) established in MOE 2009 and three orders of magnitude lower that the maximum chloride concentration detected in the plume (33,300,000 ug/L).
- Chloride and petroleum hydrocarbon fractions in groundwater extracted from sentinel wells [4 – including one multi-level well nest (2)] situated adjacent to the wharf wall, down-gradient of chloride and PHC plumes situated in the north property wing, have not been detected to date at concentrations in excess of PSCOs or aquatic life based component standards.

To ensure long term containment and to validate continued use of the wall as a long term groundwater/plume containment barrier, we have allowed for the following:

- Barrier Wall Integrity Assessment (water side);

- Long Term Groundwater Monitoring Program; and
- Development of a 3D Groundwater Flow and Contaminant Transport Model.

The barrier wall integrity assessment would involve an underwater assessment of the water side of the wall to determine if cracks or openings are present which could result in plume release to surface water. A contingency measure for rectification of this potential issue would be to install, on the water side of the wall, an HDPE liner complete with protective UV cover along affected wall sections and/or along the full length of the water side of the wall for added protection. The need for this measure would be decided based on the results of the integrity assessment.

The long term groundwater monitoring program would serve to maintain an inventory of groundwater conditions and aid in establishing whether additional groundwater mitigation may be necessary in the future. For the purposes of this evaluation we have allowed for a 10 year program. The program would include quarterly monitoring complete with a monitored natural attenuation (mNA) assessment in Year 1, semi-annual monitoring in year 2 and annual monitoring thereafter. The program allows for the monitoring and groundwater sampling from 9 wells, including sentinel well nests (2) positioned down-gradient of known sources. It also allows for the acquisition of two surface water samples, down-gradient of known source areas, per monitoring event. Lab analysis would include petroleum hydrocarbon fractions 1 to 4 and chloride on all events and mNA parameters in groundwater for the year 1 events. At the conclusion of the 10 year program, the data collected would be interpreted to determine whether continued monitoring is necessary.

The three dimensional groundwater flow and contaminant transport model would be used to simulate plume migration over time (laterally and vertically). It would ultimately be used to validate that the existing wall configuration is an effective measure for plume containment and/or establish if additional mitigative measures are necessary to contain the plumes.

5.6 Options Evaluation

Options carried forward for further evaluation are as follows:

- Excavation with Offsite Disposal
- Excavation with Soil Transfer and Offsite Disposal
- Asphalt Capping with Groundwater Mitigation
- Asphalt Capping with Soil Transfer and Groundwater Mitigation

These options are assessed with respect to the evaluation factors listed below:

- Effectiveness in meeting property specific clean-up objectives;
- Effectiveness in reducing or managing adverse risks of exposure;
- Ease of Implementation;
- Regulatory Compliance and Acceptance;
- Community Acceptance;
- Remedial/Risk Management Timeframe;
- Net Present Worth Costs (full life cycle inclusive);
- Advantages; and
- Disadvantages

Estimated costs for the options are provided in Tables F1 to F6 in Appendix F.

Based on the evaluation results presented in Table F6, Capping with Groundwater Mitigation was selected as the preferred approach. It was selected due to the following reasons:

- It is an effective risk management measure which cuts off active exposure pathways;
- It integrates well with the risk management approaches recommended by others on adjacent property parcels (i.e. capping);

- The groundwater mitigation approach addresses groundwater contaminants originating from both the subject site and adjoining property parcels over the long term;
- Groundwater dewatering and treatment is not required;
- Permits and approvals are not required; and
- It is the lowest cost option, estimated at $918,000.

5.6.1 Remedial Action Plan

The components of the remedial action plan or preferred approach, Capping with Groundwater Mitigation, are detailed in Sections 5.5.5 and 5.5.6 as presented in these sections, the RAP includes:

- Asphalt caps constructed atop the site surface in the areas of the site where petroleum hydrocarbons and metals are present at concentrations in excess of FSSs;
- Use of existing sand and gravel cover and asphalt paved areas as a precautionary measure to protect ecological receptors (plants and soil invertebrates) from exposure to subsurface SAR and EC;
- Maintaining existing land use within SAR/EC impacted areas with no vegetation planting or placement of organic topsoil permitted in these areas without further risk analysis;
- The implementation of control measures in the form of a soil management plan to prevent the transfer of subsurface soil impacted with EC/SAR to the surface soil horizon during future excavation and backfilling operations.
- Use of the existing wharf wall as a barrier wall to shallow groundwater flow and dissolved plume migration to adjacent water bodies;
- A groundwater flow and contaminant transport model to validate the effectiveness of the existing groundwater barrier wall and/or establish if additional groundwater mitigative measures are necessary to prevent ingress of dissolved contaminants to surface water at concentrations in excess of FSSs;
- A long term monitoring and maintenance program for the asphalt caps; and
- A long term groundwater monitoring program.

. In the event that the HDPE liner or portions thereof are deemed necessary on the water side of the wall, a detailed installation plan complete with protective measures would likely need to be developed for review and approval by the Department of Fisheries and Oceans (DFO).

6. Limitations

This report is furnished as privileged and confidential to the PWGSC and Transport Canada. Release to any other company, concern, or individual is solely the responsibility of the addressee. GENIVAR Consultants LP (GENIVAR) reserves the right to amend and/or supplement this report in the event additional information, documentation or evidence becomes available.

The information and conclusions contained in this report are based upon work undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Any uses that a third party makes of this report, or any reliance on decisions made based on it, are the responsibility of such third parties. GENIVAR accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made, or actions taken, based on this report.

Conclusions presented in this report should not be construed as legal advice and represent the best technical judgement of GENIVAR staff. The conclusions are based on the site conditions observed by GENIVAR at the time the work was performed at the specific testing and/or sampling locations, and can only be extrapolated to an undefined limited area around these locations. The extent of the limited area depends on the soil and

groundwater conditions, as well as the history of the site reflecting natural, construction and other activities. In addition, analysis has been carried out for a limited number of chemical parameters, and it should not be inferred that other chemical species are not present. Due to the nature of the investigation and the limited data available, GENIVAR cannot warrant against undiscovered environmental liabilities or adverse impacts off site.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions and recommendations provided herein.

7. Qualifications of Assessors

Dr. Muin Husain is a Practice Leader of GENIVAR Consultants LP and has over 17 years of research, consulting and regulatory experience in environmental sciences. He has been extensively involved with both compliance driven and voluntary site assessment and remediation of contaminated sites. He has been involved in the audits and remediation of complex contaminated sites and the management of hazardous materials and wastes. Muin also acts as an independent third party reviewer for Ontario Power Generation environmental site assessment/remediation work. In addition, he has been involved with more than 50 Phase I and II ESA Audits all across the Province of Ontario.

Muin has worked in contaminated sites associated with petroleum dispensing operations, oil field sites and industrial sites. He has investigated soil and ground water contamination from industrial solvents (LNAPLs and DNAPLs) and metals. Muin has testified as an expert witness in courts and in public meetings regarding ground water contamination issues.

Muin brings in extensive experience in Ministry of the Environment regulation and approval system and stakeholder interaction (including the public, environmental groups, conservation authorities, the Niagara Escarpment commission and various other government agencies). His recent experience involves working as a Site Remediation Specialist for the Central Audit Team of the Ministry of the Environment and a lead member of the Province's Brownfield initiative.

John is an environmental scientist with 9 years of technical and project management experience in Phase 1 and 2 environmental site assessments (ESA's), site remediation, groundwater monitoring programs, underground storage tank removals, and landfill compliance monitoring. John has worked as project coordinator and has worked on over 40 Phase I ESA's for Public Works. He has also worked as project manager and scientist on several sites for a large industrial client for PCB, metals, SVOC and VOC contamination to soil, groundwater and surface water. John has also conducted landfill compliance reporting for over 20 municipal landfills across Ontario. Mr. Edwards also has experience with ArcView GIS, MapInfo, GiNT and has 40 hour OSHA and WHMIS training.

8. References

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Ontario Ministry of the Environment. *Provincial Water Quality Objectives (PWQO) Appendix A Table 2 - Table of PWQOs and Interim PWQOs* - 1994, reprinted 1999

Ontario Ministry of the Environment. *Guidance on Sampling and Analytical Methods for Use at Contaminated Sites in Ontario,* May 1996.

Ontario Ministry of the Environment. *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act.* March 2004.

Figures

Legend

Highway

Road

Site Location Map

Oshawa Harbour

0 0.2 0.4 0.8 1.2 km

1:40,000

MA-10-006-00-MA

March 2010

Fig. 1

Public Works and Government Services Canada

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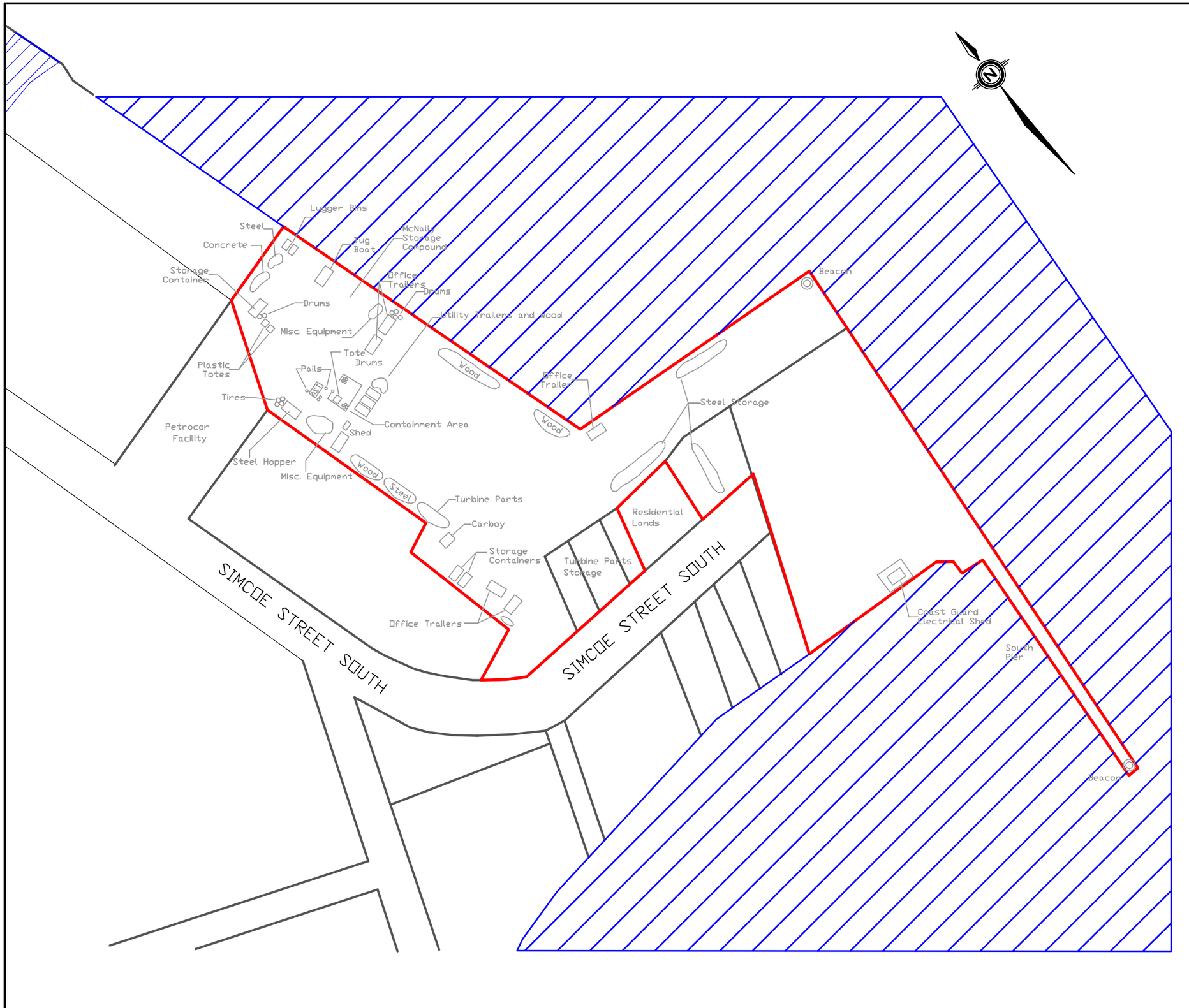

Legend

Approximate Study Area

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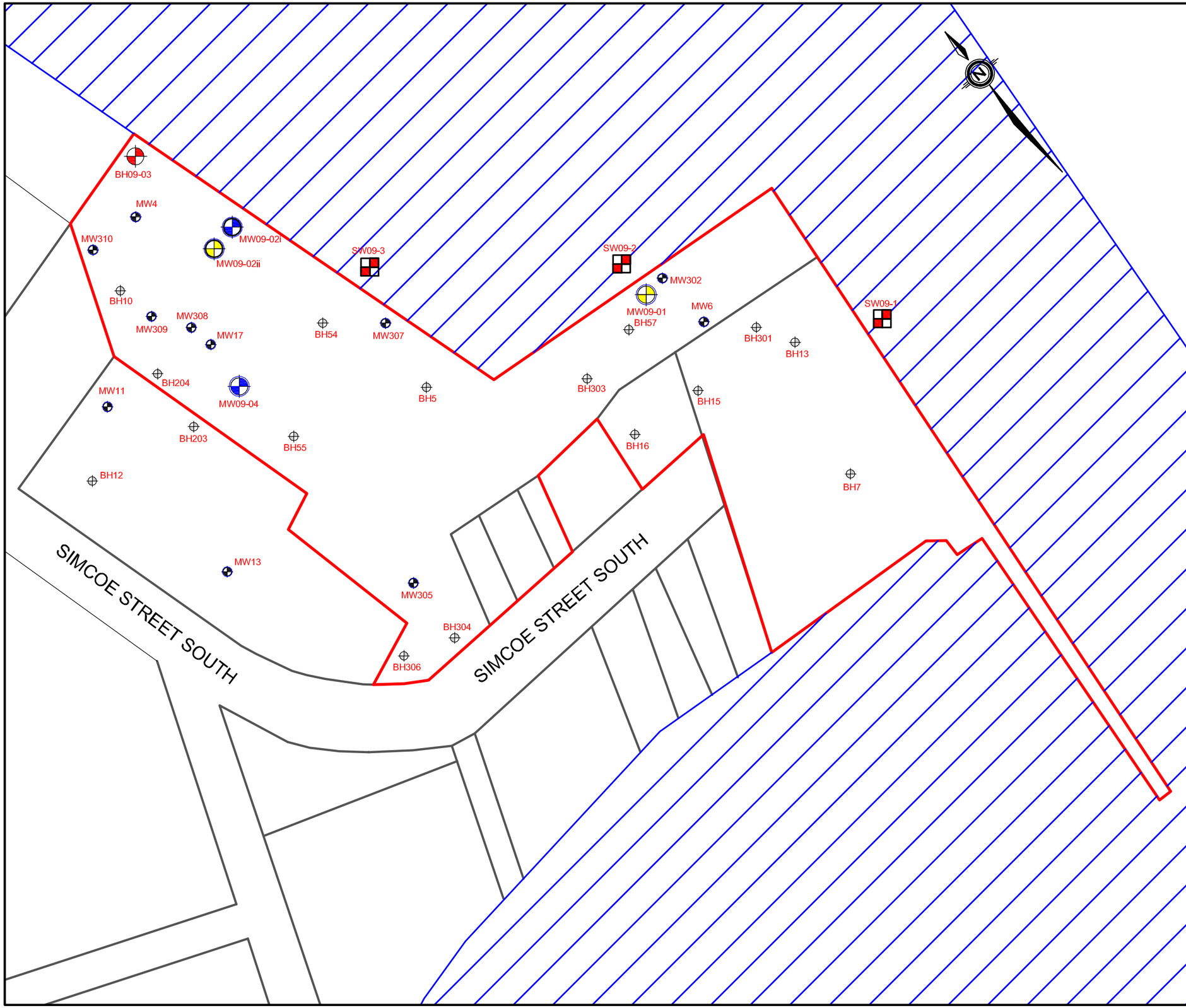
Figure 2

Oshawa Harbour Lands West Wharf

Site Plan



Legend

- Former Borehole Location
- Existing Monitoring Well Location
- Approximate Study Area
- Deep Monitoring Well Location
- Shallow Monitoring Well Location
- Surface Water Sample Location
- Borehole Location

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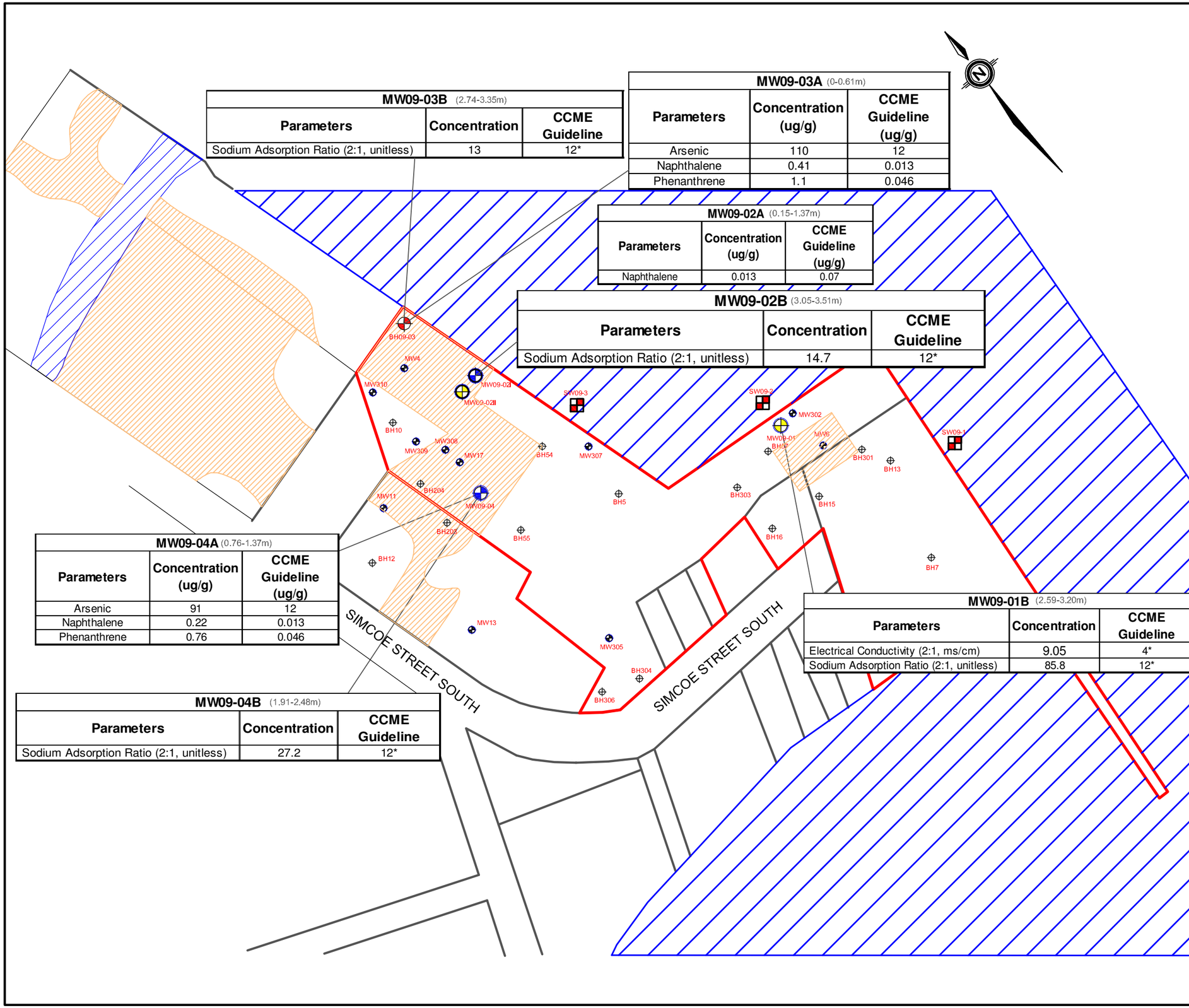
Figure 3

Oshawa Harbour Lands
West Wharf

Sample Location Plan



MW09-03B (2.74-3.35m)		
Parameters	Concentration	CCME Guideline
Sodium Adsorption Ratio (2:1, unitless)	13	12*

MW09-03A (0-0.61m)		
Parameters	Concentration (ug/g)	CCME Guideline (ug/g)
Arsenic	110	12
Naphthalene	0.41	0.013
Phenanthrene	1.1	0.046

MW09-02A (0.15-1.37m)		
Parameters	Concentration (ug/g)	CCME Guideline (ug/g)
Naphthalene	0.013	0.07

MW09-02B (3.05-3.51m)		
Parameters	Concentration	CCME Guideline
Sodium Adsorption Ratio (2:1, unitless)	14.7	12*

MW09-04A (0.76-1.37m)		
Parameters	Concentration (ug/g)	CCME Guideline (ug/g)
Arsenic	91	12
Naphthalene	0.22	0.013
Phenanthrene	0.76	0.046

MW09-04B (1.91-2.48m)		
Parameters	Concentration	CCME Guideline
Sodium Adsorption Ratio (2:1, unitless)	27.2	12*

MW09-01B (2.59-3.20m)		
Parameters	Concentration	CCME Guideline
Electrical Conductivity (2:1, ms/cm)	9.05	4*
Sodium Adsorption Ratio (2:1, unitless)	85.8	12*

Legend

- Former Borehole Location
- Existing Monitoring Well Location
- Approximate Study Area
- Soil Region Exceeding Property Specific Clean-up Objectives
- Deep Monitoring Well Location
- Shallow Monitoring Well Location
- Surface Water Sample Location
- Borehole Location

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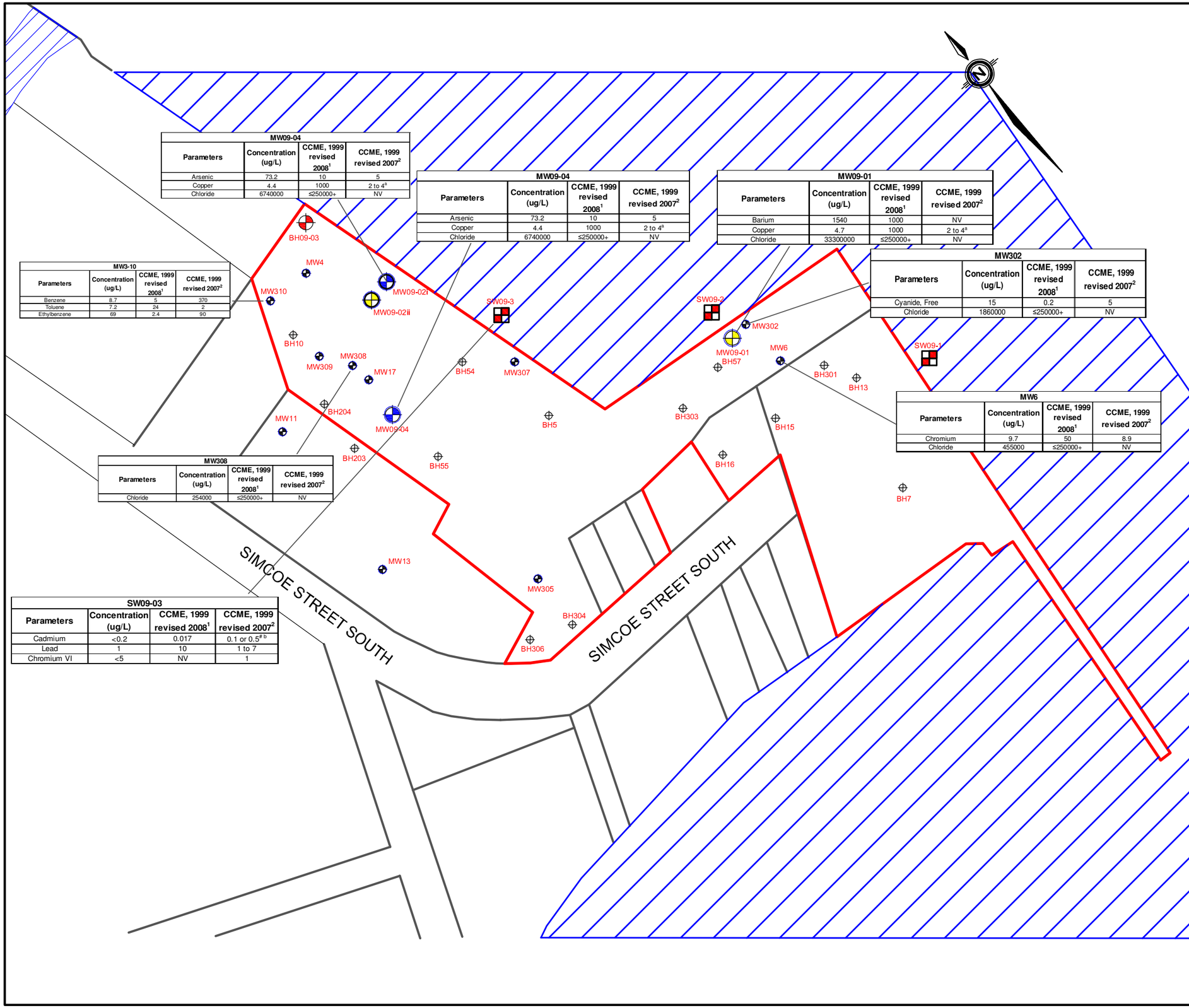
Figure 4

Oshawa Harbour Lands
West Wharf

Extent of COC and Soil Exceedances



MW09-04			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Arsenic	73.2	10	5
Copper	4.4	1000	2 to 4[a]
Chloride	6740000	≤250000+	NV

MW09-04			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Arsenic	73.2	10	5
Copper	4.4	1000	2 to 4[a]
Chloride	6740000	≤250000+	NV

MW09-01			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Barium	1540	1000	NV
Copper	4.7	1000	2 to 4[a]
Chloride	33300000	≤250000+	NV

MW3-10			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Benzene	8.7	5	370
Toluene	7.2	24	2
Ethylbenzene	69	2.4	90

MW302			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Cyanide, Free	15	0.2	5
Chloride	1860000	≤250000+	NV

MW6			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Chromium	9.7	50	8.9
Chloride	455000	≤250000+	NV

MW308			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Chloride	254000	≤250000+	NV

SW09-03			
Parameters	Concentration (ug/L)	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]
Cadmium	<0.2	0.017	0.1 or 0.5[# b]
Lead	1	10	1 to 7
Chromium VI	<5	NV	1

Legend

- Former Borehole Location
- Existing Monitoring Well Location
- Approximate Study Area
- Deep Monitoring Well Location
- Shallow Monitoring Well Location
- Surface Water Sample Location
- Borehole Location

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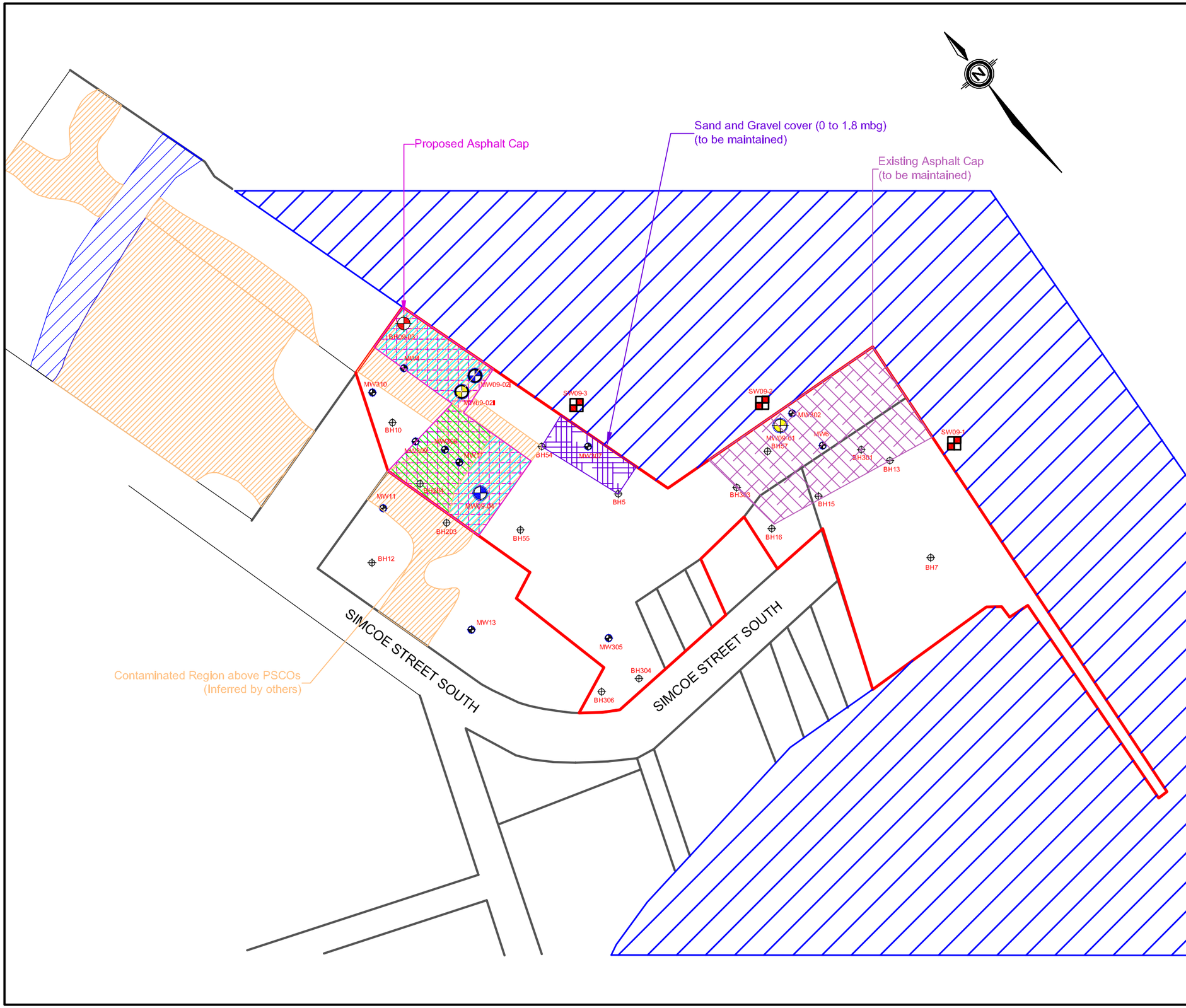
Scale: NTS

Figure 5

Oshawa Harbour Lands
West Wharf

Groundwater/Surface Water Exceedances



Legend

- Former Borehole Location
- Existing Monitoring Well Location
- Approximate Study Area
- Soil Region Exceeding Property Specific clean-up Objectives (determined by others)
- Deep Monitoring Well Location
- Shallow Monitoring Well Location
- Surface Water Sample Location
- Borehole Location
- Soil with metals above PSSs
- Soil with PHCs above PSSs
- Existing Asphalt cap
- Sand and Gravel cover
- Proposed Asphalt cap

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OCTOBER 2010

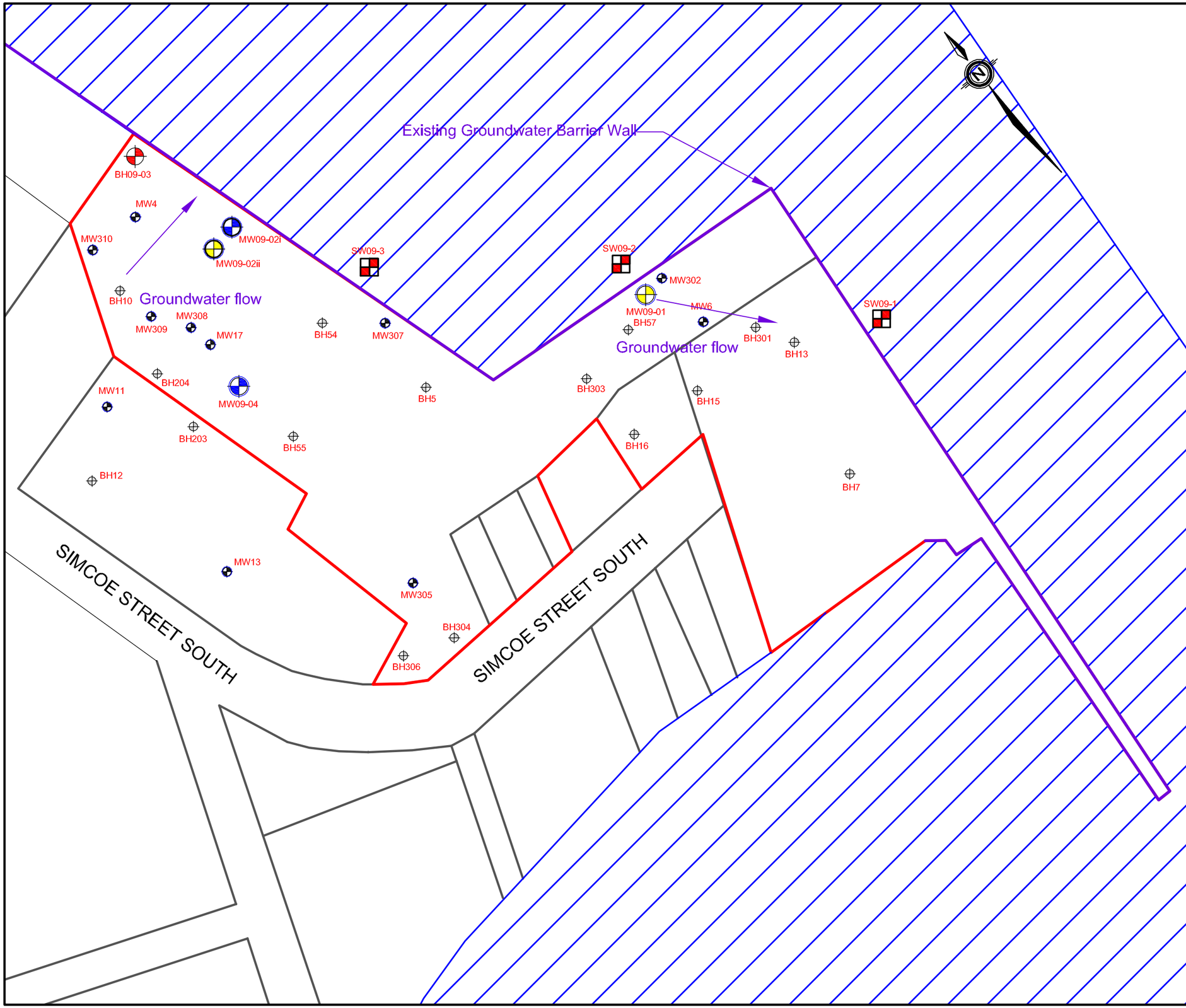
Project No.: MA-10-006-00-MA

Scale: NTS

Figure 6

Oshawa Harbour Lands
West Wharf

Risk Managment Measure:
Soil



Legend

- Former Borehole Location
- Existing Monitoring Well Location
- Approximate Study Area
- Deep Monitoring Well Location
- Shallow Monitoring Well Location
- Surface Water Sample Location
- Borehole Location

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OCTOBER 2010

Project No.: MA-10-006-00-MA

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Figure 7

Oshawa Harbour Lands
West Wharf

Risk Management Measures: Groundwater

Appendix A

Borehole Logs

Table A1 - GPS Coordinates for Borehole Locations

	17 M	
	Northing	Easting
MW09-01	674763	4859315
MW09-02i	674577	4859344
MW09-02ii	674572	4859332
BH09-03	674534	4859373
MW09-04	674581	4859267

BOREHOLE NUMBER MW09-01

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CLIENT Public Works and Government Services of Canada
PROJECT NAME Oshawa Harbour
PROJECT NUMBER MA-10-006-00-MA
PROJECT LOCATION Oshawa
DATE STARTED 3/4/10 **COMPLETED** 3/4/10
GROUND ELEVATION 100.775 m **HOLE SIZE** 0.2
DRILLING CONTRACTOR Atcost Drilling
GROUND WATER LEVELS:
DRILLING METHOD CME115 Hollow Stem
AT TIME OF DRILLING ---
LOGGED BY T.Swift **CHECKED BY** John Edwards
AT END OF DRILLING 1.39 m / Elev 99.39 m
NOTES
180hrs AFTER DRILLING 1.26 m / Elev 99.52 m

DEPTH (m)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	ENVIRONMENTAL DATA	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	8-28-50 (78)	Vapour = 0.6		0.08 **ASPHALT** 100.70 **FILL** Brown gravelly sand fill, wet, compact, mild odour	Casing Top Elev: 100.623 (ft) Casing Type: Flush Mount
	SS 2	3-4-19-15 (23)	Vapour = 0		Sample MW09-01A taken from 0.08 m to 0.61 m	
			Vapour = 0		1.52 99.26	
2	SS 3	1-3-2-2 (5)			**SAND** Dark grey sand, some silt, saturated, loose	
			Vapour = 0		2.27 98.51	
	SS 4	1-1-1-1 (2)			**SILT AND SAND** Dark grey silt and sand, occasional gravel, moist, very loose, strong odour, black staining Sample MW09-01B taken from 2.58 m to 3.18 m	
			Vapour = 0		3.04 97.74	
	SS 5	6-1-3-4 (4)			**SAND** Grey sand, trace silt, some shell fragments to 3.79 m, saturated, loose to very loose	
			Vapour = 0			
4	SS 6	1-3-5-6 (8)				
			Vapour = 0			
	SS 7	0-1-5-6 (6)				
	SS 8	0-2-4-6 (6)	Vapour = 0			
6						
	SS 9	1-2-3-3 (5)	Vapour = 0			
	SS 10	3-4-6-9 (10)	Vapour = 0			
					7.58 93.20	
8	SS 11	1-1-1-3/0.10	Vapour = 0		**SILT** Brown peat with silt, moist, very loose	
					8.18 92.60	

Bottom of hole at 8.18 m.

BOREHOLE NUMBER MW09-02i

GENIVAR

CLIENT Public Works and Government Services of Canada
PROJECT NAME Oshawa Harbour
PROJECT NUMBER MA-10-006-00-MA
PROJECT LOCATION Oshawa
DATE STARTED 3/4/10 **COMPLETED** 3/4/10
GROUND ELEVATION 101.019 m **HOLE SIZE** 0.2
DRILLING CONTRACTOR Atcost Drilling
GROUND WATER LEVELS:
DRILLING METHOD CME115 Hollow Stem
AT TIME OF DRILLING ---
LOGGED BY T.Swift **CHECKED BY** John Edwards
AT END OF DRILLING 6.25 m / Elev 94.77 m
NOTES
180hrs AFTER DRILLING 1.80 m / Elev 99.22 m

DEPTH (m)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	ENVIRONMENTAL DATA	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	2-4-6-5 (10)	Vapour = 0		**FILL** Coarse gravel fill. Becoming brown sand fill, some gravel, wet, loose, orange and black staining (0.76 / 100.26)	Casing Top Elev: 100.969 (ft) Casing Type: Flush Mount
	SS 2	2-2-3-4 (5)	Vapour = 0		Sample MW09-02A taken from 0.15 m to 1.36 m	
2	SS 3	1-3-5-8 (8)	Vapour = 0		**SILTY SAND** Brown silty sand, occasional gravel, wet turning saturated at 3.04 m, loose, black staining from 2.27 m to 3.49 m. Becoming grey below 1.52 m	
	SS 4	1-1-2-2 (3)	Vapour = 0			
	SS 5	0-1-1-2 (2)	Vapour = 0		Sample MW09-02B taken from 3.05 m to 3.49 m (3.23 / 97.79)	
					SILT Grey silt, some sand, some clay, WTPL, very loose (3.49 / 97.53)	
4	SS 6	0-1-2-2 (3)	Vapour = 0		**PEAT** Brown peat with silt and organics, some shell fragments, moist, very loose (3.94 / 97.08)	
					SILT Grey silt, some sand, wet, very loose (4.70 / 96.32)	
	SS 7	0-1-1-1 (2)	Vapour = 0		**SAND** Grey sand, some to trace silt, some gravel from 6.82 m to 7.58 m, saturated, very loose to compact	
6	SS 8	3-0-1-1 (1)	Vapour = 0 Vapour = 0			
	SS 9	0-1-1-2 (2)	Vapour = 0			
	SS 10	5-6-6-7 (12)	Vapour = 0		(7.58 / 93.44)	
8	SS 11	6-11-13-19 (24)			**CLAYEY SILT** Grey clayey silt, some fine sand, DTPL, very stiff (8.33 / 92.69)	

Bottom of hole at 8.33 m.

BOREHOLE NUMBER MW09-2ii

GENIVAR

CLIENT Public Works and Government Services of Canada
PROJECT NAME Oshawa Harbour
PROJECT NUMBER MA-10-006-00-MA
PROJECT LOCATION Oshawa
DATE STARTED 3/4/10 **COMPLETED** 3/4/10
GROUND ELEVATION 101.073 m **HOLE SIZE** 0.2
DRILLING CONTRACTOR Atcost Drilling
GROUND WATER LEVELS:
DRILLING METHOD CME115 Hollow Stem
AT TIME OF DRILLING ---
LOGGED BY T.Swift **CHECKED BY** John Edwards
AT END OF DRILLING 3.86 m / Elev 97.21 m
NOTES
180hrs AFTER DRILLING 1.46 m / Elev 99.61 m

DEPTH (m)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	ENVIRONMENTAL DATA	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
						Casing Top Elev: 101.073 (ft) Casing Type: Flush Mount
					FILL Coarse gravel fill Becoming brown sand fill, some gravel, wet, loose, orange and black staining 0.76 / 100.31	
					SILTY SAND Brown silty sand, occasional gravel, wet turning saturated at 3.04 m, loose, black staining from 2.27 m to 3.49 m Becoming grey below 1.52 m	
2						
					3.23 / 97.84	
					SILT Grey silt, some sand, some clay, WTPL, very loose 3.49 / 97.58	
					PEAT Brown peat with silt and organics, some shell fragments, moist, very loose 3.94 / 97.13	

Bottom of hole at 3.94 m.

BOREHOLE NUMBER BH09-03

GENIVAR

CLIENT Public Works and Government Services of Canada
PROJECT NAME Oshawa Harbour
PROJECT NUMBER MA-10-006-00-MA
PROJECT LOCATION Oshawa
DATE STARTED 3/5/10 **COMPLETED** 3/5/10
GROUND ELEVATION ____ **HOLE SIZE** 0.2
DRILLING CONTRACTOR Atcost Drilling
GROUND WATER LEVELS:
DRILLING METHOD CME115 Hollow Stem
AT TIME OF DRILLING ---
LOGGED BY John Edwards **CHECKED BY** John Edwards
AT END OF DRILLING ---
NOTES ____
AFTER DRILLING ---

DEPTH (m)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	ENVIRONMENTAL DATA	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	20-19-21-21 (40)			**FILL** Brown turning grey at 0.76 m sandy silt fill, some clay, trace gravel, moist, loose to compact, no odour, black staining from 0.3 m to 0.76 m	
	SS 2	3-4-6-7 (10)	Vapour = 0		Sample BH09-03A taken from 0 m to 0.61 m	
			Vapour = 0			
2	SS 3	2-1-2-2 (3)				
			Vapour = 0			
	SS 4	0-1-1-1 (2)			Becoming dark grey silty sand fill, trace gravel, saturated, very loose below 2.3 m. Sample BH09-03B taken from 2.73 m to 3.33 m	
			Vapour = 0			
	SS 5	1-1-1-1 (2)			**PEAT** Brown peat with silt and organics, moist, very loose	
			Vapour = 0	3.79		
4	SS 6	1-1-2-2/0.13			**SAND** Dark grey sand, saturated, very loose	
			Vapour = 0	4.39	Bottom of hole at 4.39 m.	

BOREHOLE NUMBER MW09-04

GENIVAR

CLIENT Public Works and Government Services of Canada
PROJECT NAME Oshawa Harbour
PROJECT NUMBER MA-10-006-00-MA
PROJECT LOCATION Oshawa
DATE STARTED 3/4/10 **COMPLETED** 3/4/10
GROUND ELEVATION 101.164 m **HOLE SIZE** 0.2
DRILLING CONTRACTOR Atcost Drilling
GROUND WATER LEVELS:
DRILLING METHOD CME115 Hollow Stem
AT TIME OF DRILLING ---
LOGGED BY T.Swift **CHECKED BY** John Edwards
AT END OF DRILLING 0.55 m / Elev 100.61 m
NOTES
180hrs AFTER DRILLING 0.73 m / Elev 100.43 m

DEPTH (m)	SAMPLE TYPE NUMBER	BLOW COUNTS (N VALUE)	ENVIRONMENTAL DATA	GRAPHIC LOG	MATERIAL DESCRIPTION	WELL DIAGRAM
	SS 1	36-50 (86)	Vapour = 0		**FILL** Brown gravelly sand, some silt, moist, compact, black staining to 1.52 m	Casing Top Elev: 101.071 (ft) Casing Type: Flush Mount
					Sample MW09-04A taken from 0.76 m to 1.36 m	
	SS 2	5-9-19-10 (28)	Vapour = 0			
	SS 3	3-4-4-7 (8)	Vapour = 0		1.89 / 99.27	
2					**SAND** Grey sand, some silt, saturated, loose, black staining to 2.27 m	
	SS 4	1-1-3-7 (4)	Vapour = 0		2.48 / 98.68	
					Sample MW09-04B taken from 1.89 m to 2.47 m	
	SS 5	2-3-3-4 (6)	Vapour = 0		**SILT** Grey silt, some sand, some clay, moist, very loose to loose	
			Vapour = 0		3.79 / 97.37	
4	SS 6	1-3-5-7 (8)			**PEAT** Brown peat with silt and organics, moist, loose	
	SS 7	1-2-4-4/0.13	Vapour = 0		5.15 / 96.01	

Bottom of hole at 5.15 m.

Appendix B

Chemical Analysis Summary Tables

Table 1: Soil Metal Analysis Result - West Wharf

Parameters	CCME, 1999 revised 2007[1]	O. Reg. 153 Table 1 All Other Types of Property Uses[2]	O. Reg. 153 Table 3 Commercial/ Industrial/ Community Property Uses[3]	Units	RDL	MW09-01A[4]	MW09-01B[4]	MW09-01 SS3	MW09-02A[4]	BHX1 (MW09-02A Dup)[4]	MW09-02B[4]	MW09-03A[4]	BH09-03B[4]	MW09-03 SS2	MW09-04A[5]	MW09-04B[5]
Antimony	40*	1.0	40	ug/g	0.8	<0.8	<0.8	-	<0.8	<0.8	<0.8	<0.8	<0.8	-	1.5	<0.8
Arsenic	12	17	40	ug/g	1	3	4	-	3	3	3	***110***	3	-	***91***	8
Barium	500	210	1500	ug/g	2	36	108	-	64	67	83	79	81	-	202	40
Beryllium	8*	1.2	1.2	ug/g	0.5	<0.5	0.6	-	<0.5	<0.5	<0.5	0.9	<0.5	-	***2.8***	<0.5
Boron	NV	NV	NV	ug/g	5	6	8	-	8	8	7	22	9	-	16	8
Boron (Hot Water Extractable)	NV	NV	2	ug/g	0.10	0.19	0.43	-	1.46	1.55	0.5	1.57	1.5	-	4.17	2.17
Cadmium	10	1.0	12	ug/g	0.5	<0.5	<0.5	-	<0.5	<0.5	<0.5	<0.5	<0.5	-	<0.5	<0.5
Chromium	64	71	750	ug/g	2	10	31	-	18	25	26	12	28	-	15	9
Cobalt	300*	21	80	ug/g	0.5	3	7.2	-	3.6	4.2	4.9	7.7	4.7	-	7.9	4.7
Copper	63	85	225	ug/g	1	9	15	-	8	8	11	16	12	-	38	12
Lead	140	120	1000	ug/g	1	13	12	-	6	6	8	9	9	-	21	17
Molybdenum	40*	2.5	40	ug/g	0.5	0.6	0.6	-	<0.5	<0.5	<0.5	1.1	<0.5	-	8.5	0.7
Nickel	50	43	150	ug/g	1	8	14	-	7	8	10	18	9	-	20	12
Selenium	2.9+	1.9	10	ug/g	0.4	<0.4	0.7	-	0.6	0.5	<0.4	***2.2***	0.6	-	2.7	0.7
Silver	40*	0.42	40	ug/g	0.2	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2
Thallium	1	2.5	32	ug/g	0.4	<0.4	<0.4	-	<0.4	<0.4	<0.4	<0.4	<0.4	-	0.7	<0.4
Uranium	33	NV	NV	ug/g	0.5	0.5	0.9	-	0.6	0.8	0.8	0.7	0.8	-	1.5	0.6
Vanadium	130	91	200	ug/g	1	11	30	-	17	17	23	20	22	-	30	11
Zinc	360	160	600	ug/g	5	53	56	-	27	30	40	46	40	-	36	50
Chromium, Hexavalent	0.4	2.5	8	ug/g	0.2	<0.2	<0.2	-	<0.2	<0.2	<0.2	<0.2	<0.2	-	<0.2	<0.2
Cyanide, Free	0.9	0.12	100	ug/g	0.05	<0.05	<0.05	-	<0.05	<0.05	<0.05	<0.05	<0.05	-	<0.05	<0.05
Mercury	6.6	0.23	10	ug/g	0.01	0.02	0.054	-	0.03	0.03	0.04	0.069	0.058	-	0.353	0.052
Electrical Conductivity (2:1)	4*	0.57	1.4	ug/g	0.002	0.179	***9.05***	-	***0.7***	***0.763***	***2.52***	***2.94***	***1.71***	-	***2.32***	0.251
Sodium Adsorption Ratio (2:1)	12*	2.4	12	mS/cm	N/A	0.491	***85.8***	-	1.49	1.38	***14.7***	***2.52***	***13***	-	11.2	***27.2***
pH, 2:1 CaCl2 Extraction	6 to 8*	5 to 9	5 to 9	N/A		7.84	7.6	-	7.22	7.27	7.29	7.33	7.3	-	7.73	7.62
Chloride (2:1)	NV	330	NV	ug/g	2	16	***5310***	-	16	21	***1010***	140	***504***	-	978	1160
Nitrate + Nitrite	NV	61	NV	ug/g	1	<1	<10	-	<1	<1	<1	<1	<1	-	<1	<1
Total Organic Carbon	NV	NV	NV	%	0.15	-	-	0.93	-	-	-	-	-	2.1	-	-

NOTES

Applicable Soil Criteria

[1] CCME - Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2007) as listed in Table 1 and Table 2 for Commercial Land Use

[2] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 Ful Depth Background Site Condition, March 2004

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004

[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

* Interim remediation criteria for soil that have not yet been replaced by Canadian Soil Quality Guideline

[+] Updated 2008

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

Italicized **and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

Highlighted values has detection limit exceeding the guideline/standard

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Table 2: Soil VOC Analysis Result - West Wharf

Parameters	CCME 1999 revised 2008[1]	O. Reg. 153 Table 1 All Other Types of Property Uses[2]	O. Reg. 153 Table 3 Commercial/ Industrial/ Community Property Uses[3]	Units	RDL	MW09-02A[4]	BHX1 (MW09-02A Dup)[4]	MW09-02B[4]	MW09-03A[4]	RDL	BH09-03B[4]	RDL	MW09-04A[5]	MW09-04B[5]
Volitale														
Dichlorodifluoromethane	NV	NV	NV	µg/g	0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.010	0.005	<0.005	<0.005
Chloromethane	NV	NV	NV	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Vinyl Chloride	NV	0.003	0.003	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Bromomethane	NV	0.003	0.061	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Chloroethane	NV	NV	NV	µg/g	0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.010	0.005	<0.005	<0.005
Trichlorofluoromethane	NV	NV	NV	µg/g	0.004	<0.004	<0.004	<0.004	<0.004	0.008	<0.008	0.004	<0.004	<0.004
Acetone	NV	NV	3.8	µg/g	0.130	<0.130	<0.130	<0.130	0.22	0.26	<0.260	0.130	<0.130	<0.130
1,1-Dichloroethylene	50	0.002	0.0024	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Methylene Chloride	NV	0.003	140	µg/g	0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003	<0.003
TRANS-1,2-Dichloroethylene	50	0.003	4.1	µg/g	0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003	<0.003
Methyl tert-butyl Ether	NV	NV	120	µg/g	0.004	<0.004	<0.004	<0.004	<0.004	0.008	<0.008	0.004	<0.004	<0.004
1,1-Dichloroethane	50	0.002	22	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Methyl Ethyl Ketone	NV	NV	38	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	0.2	<0.20	0.10	<0.10	<0.10
CIS 1,2-Dichloroethylene	50	NV	2.3	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Chloroform	50	0.006	0.79	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,2- Dichloroethane	50	0.002	0.022	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,1,1-Trichloroethane	50	0.009	26	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Carbon Tetrachloride	NV	0.002	0.1	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Benzene	0.03	0.002	5.3	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,2-Dichloropropane	50	0.002	0.019	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Trichloroethylene	0.01	0.004	1.1	µg/g	0.004	<0.004	<0.004	<0.004	<0.004	0.008	<0.008	0.004	<0.004	<0.004
Bromodichloromethane	NV	NV	25	µg/g	0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003	<0.003
CIS-1,3-Dichloropropene	NV	NV	NV	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Methyl Isobutyl Ketone	NV	NV	58	µg/g	0.10	<0.10	<0.10	<0.10	<0.10	0.2	<0.20	0.10	<0.10	<0.10
TRANS-1,3-Dichloropropene	NV	NV	NV	µg/g	0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003	<0.003
1,1,2-Trichloroethane	NV	0.002	3.1	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Toluene	NV	0.002	34	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
2-Hexanone	NV	NV	NV	µg/g	0.470	<0.470	<0.470	<0.470	<0.470	0.94	<0.940	0.470	<0.470	<0.470
Dibromochloromethane	NV	0.003	18	µg/g	0.003	<0.003	<0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003	<0.003
Ethylene Dibromide	NV	0.004	0.0056	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Tetrachloroethylene	NV	0.002	0.45	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,1,1,2-Tetrachloroethane	NV	NV	0.019	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Chlorobenzene	10*	0.002	8	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Ethylbenzene	NV	0.002	290	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
m & p-Xylene	NV	NV	NV	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Bromoform	NV	0.002	2.3	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Styrene	50*	0.002	1.2	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,1,2,2- Tetrachloroethane	50	0.004	0.037	µg/g	0.004	<0.004	<0.004	<0.004	<0.004	0.008	<0.008	0.004	<0.004	<0.004
o-Xylene	NV	NV	NV	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,3-Dichlorobenzene	10*	0.002	30	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,4-Dichlorobenzene	10*	0.002	30	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,2-Dichlorobenzene	10*	0.002	30	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,2,4-Trichlorobenzene	10	NV	30	µg/g	0.007	<0.007	<0.007	<0.007	<0.007	0.014	<0.014	0.007	<0.007	<0.007
Xylene Mixture (Total)	NV	0.002	34	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
1,3-Dichloropropene (Cis + Trans)	NV	0.003	0.0066	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
n-Hexane	NV	NV	NV	µg/g	0.005	<0.005	<0.005	<0.005	<0.005	0.01	<0.010	0.005	<0.005	<0.005

NOTES

Applicable Soil Criteria

[1] CCME - Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2007) as listed in Table 1 and Table 2 for Commercial Land Use

[2] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 Ful Depth Background Site Condition, March 2004

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater Condition) for Commercial/Industrial/Community Property Uses, March 2004

[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

* - Interim remediation criteria for soil that has not yet been replaced by Canadian Soil Quality Guidelines.

** Soil Quality Guideline for Human Health - 10^{-6} Incremental Lifetime Cancer Risk (ILCR) Total Potency Equivalents is 0.6 mg/kg, updated 2008

RDL - Reportable Detection Limit

NC - Not calculated

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

Highlighted values has detection limit exceeding the guideline/standard

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Table 3: Soil PHC and BTEX Analysis Result - West Wharf

Parameters	CCME/CWS, 1999 revised 2007[1]	O. Reg. 153 Table 1 All Other Types of Property Uses[2]	O. Reg. 153 Table 3 Commercial/ Industrial/Community Property Uses[3]	Units	RDL	MW09-01A[4]	MW09-01B[4]	MW09-02A[4]	BHX1 (MW09-02A Dup)[4]	MW09-02B[4]	MW09-03A[4]	RDL	BH09-03B[4]	RDL	MW09-04A[5]	MW09-04B[5]
Petroleum Hydrocarbons																
Benzene	0.030	0.002	5.3	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Toluene	0.37	0.002	34	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Ethylbenzene	0.082	0.002	290	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
Xylenes (Total)	11	0.002	34	µg/g	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002	<0.002
F1 (C6-C10)	320	NV	230	ug/g	5	<5	<5	<5	<5	<5	<5	10	<10	5	<5	<5
F2 (C10-C16)	260	NV	150	ug/g	10	<10	<10	<10	<10	<10	53	20	<20	10	<10	<10
F3 (C16-C34)	1700	NV	1700	ug/g	50	<50	<50	<50	<50	<50	370	100	320	50	<50	<50
F4 (C34-C50)	3300	NV	3300	ug/g	50	<50	<50	<50	<50	<50	130	100	<100	50	<50	<50

NOTES

Applicable Soil Criteria

[1] CCME - Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2007) as listed in Table 1 and Table 2 for Commercial Land Use

[1] CWS - Canadian Wide Standard Tier 1 levels for surface soil - Commercial Land Use (PHCs)

[2] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 Ful Depth Background Site Condition, March 2004

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004

[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

* - Interim remediation criteria for soil that has not yet been replaced by Canadian Soil Quality Guidelines.

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

Table 4: Soil PAH Analysis Result - West Wharf

Parameters	CCME 1999 revised 2008[1]	O. Reg. 153 Table 1 All Other Types of Property Uses[2]	O. Reg. 153 Table 3 Commercial/ Industrial/Community Property Uses[3]	Units	RDL	MW09-02A[4]	BHX1 (MW09-02A Dup)[4]	MW09-02B[4]	MW09-03A[4]	RDL	BH09-03B[4]	RDL	MW09-04A[5]	MW09-04B[5]
Polyaromatic Hydrocarbons														
Naphthalene	0.013	0.09	40	µg/g	0.03	**0.07**	<0.03	<0.03	**0.41**	0.06	<0.06	0.03	**0.22**	<0.03
Acenaphthylene	320	0.08	840	µg/g	0.02	<0.02	<0.02	<0.02	0.02	0.04	<0.04	0.02	<0.02	<0.02
Acenaphthene	0.28	0.07	1300	µg/g	0.03	<0.03	<0.03	<0.03	0.05	0.06	<0.06	0.03	<0.03	<0.03
Fluorene	0.25	0.12	350	µg/g	0.02	<0.02	<0.02	<0.02	0.11	0.04	<0.04	0.02	<0.02	<0.02
Phenanthrene	0.046	0.69	40	µg/g	0.02	0.04	<0.02	<0.02	**1.1**	0.04	<0.04	0.02	**0.76**	0.03
Anthracene	32	0.16	28	µg/g	0.02	<0.02	<0.02	<0.02	0.12	0.04	<0.04	0.02	<0.02	<0.02
Fluoranthene	180	1.1	40	µg/g	0.02	0.02	<0.02	<0.02	0.15	0.04	<0.04	0.02	0.12	<0.02
Pyrene	NC	1.0	250	µg/g	0.02	0.02	<0.02	<0.02	0.25	0.04	<0.04	0.02	0.15	<0.02
Benzo(a)anthracene	NC	0.74	40	µg/g	0.02	<0.02	<0.02	<0.02	0.13	0.04	<0.04	0.02	0.08	<0.02
Chrysene	NC	0.69	19	µg/g	0.02	0.03	<0.02	<0.02	0.21	0.04	<0.04	0.02	0.19	0.02
Benzo(b)fluoranthene	NC	0.47	19	µg/g	0.02	<0.02	<0.02	<0.02	0.06	0.04	<0.04	0.02	0.05	<0.02
Benzo(k)fluoranthene	NC	0.48	19	µg/g	0.02	<0.02	<0.02	<0.02	0.02	0.04	<0.04	0.02	<0.02	<0.02
Benzo(a)pyrene	72	0.49	1.9	µg/g	0.02	<0.02	<0.02	<0.02	0.1	0.04	<0.04	0.02	0.04	<0.02
Indeno(1,2,3-cd)pyrene	NC	0.38	19	µg/g	0.02	<0.02	<0.02	<0.02	0.03	0.04	<0.04	0.02	<0.02	<0.02
Dibenz(a,h)anthracene	NC	0.16	1.9	µg/g	0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.04	0.02	<0.02	<0.02
Benzo(g,h,i)perylene	NC	0.68	40	µg/g	0.02	<0.02	<0.02	<0.02	0.08	0.04	<0.04	0.02	0.04	<0.02
2-and 1-methyl Naphthalene	NC	NV	280	µg/g	0.05	0.09	<0.05	<0.05	1.6	0.1	<0.10	0.05	1.1	<0.05

NOTES

Applicable Soil Criteria

[1] CCME - Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health (1999, updated 2007) as listed in Table 1 and Table 2 for Commercial Use

[2] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 Full Depth Background Site Condition, March 2004

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 Non Potable Groundwater Condition, March 2004

[4] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[5] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

* - Interim remediation criteria for soil that has not yet been replaced by Canadian Soil Quality Guidelines.

Soil Quality Guidelines for Carcinogenic and Other PAHs for Protection of Freshwater Life (SQG_{FL}), updated 2010

Soil Quality Guidelines for Carcinogenic and Other PAHs for Envrionment (SQG_{E}) and Soil Contact (SQG_{SC}), updated 2010

RDL - Reportable Detection Limit

NC - Not calculated

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

Highlighted values has detection limit exceeding the guideline/standard

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Table 5: TCLP Analysis

Parameters	Hazardous Waste	Registrable Waste	RDL	Unit	West Whart (South)	West Whart (North)
Inorganics						
Fluoride	150	15	0.05	mg/L	0.1	0.19
Free Cyanide	20	2	0.05	mg/L	<0.05	<0.05
Nitrate and Nitrite	1000	100	0.7	mg/L	<0.70	<0.70
Metals						
Arsenic	2.5	0.25	0.010	mg/L	0.075	<0.010
Barium	100	10	0.100	mg/L	2.04	0.747
Boron	500	50	0.050	mg/L	0.063	0.051
Cadmium	0.5	0.05	0.010	mg/L	<0.010	<0.010
Chromium	5	0.5	0.010	mg/L	<0.010	<0.010
Lead	5	0.5	0.010	mg/L	<0.010	<0.010
Mercury	0.1	0.01	0.005	mg/L	<0.005	<0.005
Selenium	1	0.1	0.010	mg/L	<0.010	<0.010
Silver	5	0.5	0.010	mg/L	<0.010	<0.010
Uranium	10	1	0.050	mg/L	<0.050	<0.050
Volatiles						
Benzene	0.5	0.05	0.02	mg/L	<0.020	<0.020
Carbon Tetrachloride	0.5	0.05	0.02	mg/L	<0.020	<0.020
Chlorobenzene	8	0.8	0.01	mg/L	<0.010	<0.010
Chloroform	10	1	0.02	mg/L	<0.020	<0.020
1,2-Dichlorobenzene	20	2	0.01	mg/L	<0.010	<0.010
1,4-Dichlorobenzene	0.5	0.05	0.01	mg/L	<0.010	<0.010
1,2-Dichloroethane	0.5	0.05	0.02	mg/L	<0.020	<0.020
1,1 Dichloroethene	1.4	0.14	0.02	mg/L	<0.020	<0.020
Dichloromethane	5	0.5	0.03	mg/L	<0.030	<0.030
Methyl Ethyl Ketone	200	20	0.09	mg/L	<0.090	<0.090
Tetrachloroethene	3	0.3	0.01	mg/L	<0.010	<0.010
Trichloroethene	5	0.5	0.02	mg/L	<0.020	<0.020
Vinyl Chloride	0.2	0.02	0.03	mg/L	<0.030	<0.030
Semi Volatiles						
Pyridine	5.0	0.5	0.010	mg/L	<0.010	<0.010
Cresols	200	20	0.012	mg/L	<0.012	<0.012
Ortho-Cresol	200	20	0.004	mg/L	<0.004	<0.004
Meta & Para-Cresol	200	20	0.008	mg/L	<0.008	<0.008
Hexachloroethane	3.0	0.3	0.004	mg/L	<0.004	<0.004
Nitrobenzene	2.0	0.2	0.004	mg/L	<0.004	<0.004
Hexachlorobutadiene	0.5	0.05	0.004	mg/L	<0.004	<0.004
2,4,6-Trichlorophenol	0.5	0.05	0.05	mg/L	<0.05	<0.05
2,4,5-Trichlorophenol	400	40	0.004	mg/L	<0.004	<0.004
2,4-Dinitrotoluene	0.13	0.013	0.004	mg/L	<0.004	<0.004
2,3,4,6-Tetrachlorophenol	10.0	1	0.004	mg/L	<0.004	<0.004
Hexachlorobenzene	0.13	0.013	0.004	mg/L	<0.004	<0.004
Dinoseb	1.0	0.1	0.004	mg/L	<0.004	<0.004
Benzo(a)pyrene	0.001	0.0001	0.001	mg/L	<0.001	<0.001
Polychlorinated Biphenyls						
PCB	0.3	0.03	0.005	mg/L	<0.005	<0.005

MOE O.Reg. 558 under the Environmental Protection Act, Schedule 4.
RDL - Reportable Detection Limit

Table 6: Groundwater Metal Analysis Result - West Wharf

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1 All Property Uses[3]	O. Reg. 153 Table 3 All Property Uses[4]	Units	RDL	MW09-01[5]	MW09-2i[5]	MW09-100 (MW09-02i Dup)[5]	MW09-2ii[5]	RDL	MW09-04[6]	RDL	MW302[5]	MW308[6]	MW6[5]	MW310[6]
Metals and Inorganics																	
Antimony	6	NV	6.0	16,000	ug/L	0.5	2.8	<0.5	<0.5	<0.5	0.5	0.7	0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	10	5	25	480	ug/L	1.0	3.3	4.5	4.4	<1.0	1.0	**73.2**	1.0	3.6	1.7	1.8	3.3
Barium	1000	NV	NV	23,000	ug/L	2.0	1540	90.9	91.6	40.7	2.0	102	2.0	122	97.6	157	91.2
Beryllium	NV	NV	4.0	53	ug/L	0.5	<0.5	<0.5	<0.5	<0.5	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5
Boron	5000	NV	200	50,000	ug/L	10.0	17.1	190	182	59.1	10.0	1230	10.0	48.2	145	97.9	89.1
Cadmium	5	0.017	0.5	11	ug/L	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
Chromium	50	8.9	8.9	2000	ug/L	2.0	2.5	<2.0	<2.0	<2.0	2.0	2	2.0	4.3	5.2	***9.7***	2.1
Cobalt	NV	NV	0.9	100	ug/L	0.5	***4.2***	***1***	0.8	0.7	0.5	15.8	0.5	***1***	2.7	0.7	2.1
Copper	1000	2 to 4[a]	2.5	23	ug/L	1.0	***4.7***	1.4	1.1	2.4	1.0	**4.4**	1.0	1.8	1.4	1.5	1.1
Lead	10	1 to 7[b]	1	32	ug/L	0.5	<0.5	***1.2***	<0.5	<0.5	0.5	0.5	0.5	<0.5	<0.5	<0.5	<0.5
Molybdenum	NV	73	40	7300	ug/L	0.5	1.7	<0.5	<0.5	0.9	0.5	15.1	0.5	1.8	1.1	0.8	1
Nickel	NV	25 to 150[c]	25	1600	ug/L	1.0	<1.0	<1.0	<1.0	3.3	1.0	21.2	1.0	2.7	3.2	3.2	5.4
Selenium	10	1	5.0	50	ug/L	1.0	<1.0	<1.0	**2**	**2**	1.0	**3.6**	1.0	<1.0	**1.5**	**2.4**	<1.0
Silver	NV	0.1	0.25	1.2	ug/L	0.2	<0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2
Thallium	1	NV	0.5	400	ug/L	0.3	<0.3	<0.3	<0.3	<0.3	0.3	<0.3	0.3	<0.3	<0.3	<0.3	<0.3
Uranium	20*	NV	NV	NV	ug/L	0.5	0.8	<0.5	<0.5	0.9	0.5	1	0.5	0.6	1.5	<0.5	1.4
Vanadium	130	NV	6.0	200	ug/L	0.4	<0.4	2.9	3.5	<0.4	0.4	0.5	0.4	2.8	0.4	2.3	0.6
Zinc	5000	30	20	1100	ug/L	5.0	15.9	<5.0	<5.0	<5.0	5.0	16.5	5.0	7.2	6.2	<5.0	<5.0
Mercury	0.001	0.026	0.02	0.12	ug/L	0.02	<0.02	<0.02	<0.02	<0.02	0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02
Chromium VI	NV	1	10	110	ug/L	5	<5	<5	<5	<5	5	<5	5	<5	<5	<5	<5
Cyanide, Free	0.2	5	5.0	52	ug/L	2	<2	<2	<2	<2	2	<2	2	***15***	<2	2	<2
Sodium	NV	NV	NV	NV	ug/L	50	17800000	1100000	1100000	67400	50	8240000	50	1040000	234000	350000	54200
Chloride	≤250000+	NV	NV	NV	ug/L	2000	**33300000**	**1650000**	**1600000**	66200	1000	**6740000**	100	**1860000**	**254000**	**455000**	20300
Nitrate as N	45000	13000	NV	NV	ug/L	1000	<1000	<50	<50	940	500	<500	50	<50	<50	<50	<50
Nitrite as N	NV	60	NV	2000	ug/L	1000	<1000	<50	<50	<50	500	<500	50	<50	<50	<50	<50
Electrical Conductivity	NV	NV	NV	NA	uS/cm	2	72500	6390	6290	1650	2	20600	2	5700	2560	3740	1070
pH	6.5 to 8.5 +	NV	NV	NA	NA	NA	7.15	7.76	7.73	7.89	NA	7.51	NA	7.97	7.7	7.91	7.59
Other																	
Total Suspended Solids	NV	NV	NV	NV	mg/L	10	16800	5020	3820	378	10	7420	10	6840	1800	1640	1210

NOTES

Applicable Soil Criteria

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines

[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004

[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004

[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

* Interim Maximum Acceptable Concentration (IMAC)

\+ Aesthetic Objectives (AO) applied when no MAC available.

[a] Hardness as $CaCO^3$ at 0 - 120 mg/L , guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L , guideline = 3 ug/L; CaCO3 at >180 mg/L , guideline = 4 ug/L

[b] Hardness as $CaCO^3$ at 0 - 60 mg/L , guideline = 1 ug/L; CaCO3 at 60 - 120 mg/L , guideline = 2 ug/L; CaCO3 at 120 - 180 mg/L , guideline = 4 ug/L; CaCO3 at >180 mg/L , guideline = 7 ug/L

[b] Hardness as $CaCO^3$ at 0 - 60 mg/L , guideline = 25 ug/L; CaCO3 at 60 - 120 mg/L , guideline = 65 ug/L; CaCO3 at 120 - 180 mg/L , guideline = 110 ug/L; CaCO3 at >180 mg/L , guideline = 150 ug/L

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

RDL Exceeded CCME Guideline

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Table 7: Groundwater VOC Analysis Result - West Wharf

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1 All Property Uses[3]	O. Reg. 153 Table 3 All Property Uses[4]	Units	RDL	MW09-2i[5]	MW09-100 (MW09-02i Dup)[5]	RDL	MW09-2ii[5]	RDL	MW09-04[6]	RDL	MW308[6]	MW310[6]
Volatile Organic Compounds															
Dichlorodifluoromethane	NV	NV	NV	NV	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Chloromethane	NV	NV	NV	NV	µg/L	0.8	<0.80	<0.80	0.40	<0.40	0.8	<0.80	0.8	<0.80	<0.80
Vinyl Chloride	2	NV	0.5	0.5	µg/L	0.34	<0.34	<0.34	0.17	<0.17	0.34	<0.34	0.34	<0.34	<0.34
Bromomethane	NV	NV	0.9	3.7	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Chloroethane	NV	NV	NV	NV	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Trichlorofluoromethane	NV	NV	NV	NV	µg/L	0.8	<0.80	<0.80	0.40	<0.40	0.8	<0.80	0.8	<0.80	<0.80
Acetone	NV	NV	NV	3300	µg/L	2	<2.0	<2.0	1.0	<1.0	2	<2.0	2	<2.0	<2.0
1,1 Dichloroethene	NV	NV	0.66	0.66	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
Methylene Chloride	NV	98.1	50	50,000	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
trans- 1,2-dichloroethylene	NV	100-	100	100	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Methyl tert-butyl ether	15	10000	200	50,000	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	23	<0.40
1,1-Dichloroethane	5	NV	70	9000	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
Methyl Ethyl Ketone	NV	NV	350	50,000	µg/L	2	<2.0	<2.0	1.0	<1.0	2	<2.0	2	<2.0	<2.0
cis-1,2-Dichloroethylene	NV	100-	70	70	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Chloroform	NV	NV	0.5	430	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
1,2 - Dichloroethane	5	100	5.0	17	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
1,1,1-Trichloroethane	NV	NV	10	200	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
Carbon Tetrachloride	5	13.3	0.5	17	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Benzene	5	370	5.0	1,900	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	8.7
1,2-Dichloropropane	NV	NV	0.7	3.8	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Trichloroethylene	NV	21	20	50	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Bromodichloromethane	16	NV	5.0	50,000	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
cis-1,3-Dichloropropene	NV	NV	NV	NV	ug/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Methyl Isobutyl Ketone	NV	NV	NV	50,000	µg/L	2	<2.0	<2.0	1.0	<1.0	2	<2.0	2	<2.0	<2.0
trans-1,3-Dichloropropene	NV	NV	NV	NV	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
1,1,2-Trichloroethane	NV	NV	5	16,000	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Toluene	24	2	0.8	5,900	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	**7.2**
2-Hexanone	NV	NV	NV	NV	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
Dibromochloromethane	NV	NV	0.5	50,000	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
Ethylene Dibromide	NV	NV	1.0	3.3	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
Tetrachloroethene	5	111	5.0	5	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	<0.40
1,1,1,2-Tetrachloroethane	NV	NV	5.0	6	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
Chlorobenzene	NV	1.3	15	500	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
Ethylbenzene	2.4	90	2.4	28,000	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	69
m & p-Xylene	NV	NV	NV	5,600	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	17
Bromoform	NV	NV	5.0	840	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
Styrene	NV	72	4.0	940	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
1,1,2,2-Tetrachloroethane	NV	NV	1.0	22	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
o-Xylene	NV	NV	NV	5,600	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	2.4
1,3-Dichlorobenzene	NV	150	2.5	7,600	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
1,4-Dichlorobenzene	5	26	1.0	7,600	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
1,2-Dichlorobenzene	200	0.7	2.5	7,600	µg/L	0.2	<0.20	<0.20	0.10	<0.10	0.2	<0.20	0.2	<0.20	<0.20
1,2,4-Trichlorobenzene	NV	24	0.5	500	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
1,3-Dichloropropene (Cis + Trans)	NV	NV	1.4	3.8	µg/L	0.6	<0.60	<0.60	0.30	<0.30	0.6	<0.60	0.6	<0.60	<0.60
Xylenes (Total)	300	NV	72	5,600	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	19
n-Hexane	NV	NV	NV	NV	µg/L	0.4	<0.40	<0.40	0.20	<0.20	0.4	<0.40	0.4	<0.40	1.5

NOTES

Applicable Soil Criteria

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines

[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004

[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004

[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

GENIVAR

Table 8: Groundwater PHC and BTEX Analysis Result - West Wharf

Parameters	CCME, 1999 revised 2007[1]	CCME, 1999 revised 2008[2]	O. Reg. 153 Table 1 All Property Uses[3]	O. Reg. 153 Table 3 All Property Uses[4]	Units	RDL	MW09-01[5]	RDL	MW09-2i[5]	MW09-100 (MW09-02i Dup)[5]	RDL	MW09-2ii[5]	MW09-04[6]	RDL	MW302[5]	RDL	MW308[6]	MW310[6]	RDL	MW6[5]
Petroleum Hydrocarbons																				
Benzene	5	370	5	1900	ug/L	0.2	<0.2	0.4	<0.40	<0.40	0.2	<0.20	<0.40	0.2	<0.2	0.4	<0.40	8.7	0.2	<0.2
Toluene	24	2	0.8	5900	ug/L	0.2	<0.2	0.4	<0.40	<0.40	0.2	<0.20	<0.40	0.2	<0.2	0.4	<0.40	**7.2**	0.2	<0.2
Ethylbenzene	2.4	90	2.4	28000	ug/L	0.1	<0.1	0.2	<0.20	<0.20	0.1	<0.10	<0.20	0.1	<0.1	0.2	<0.20	69	0.1	<0.1
Xylenes (total)	300	NV	72	5600	ug/L	0.2	<0.2	0.4	<0.40	<0.40	0.2	<0.20	<0.40	0.2	<0.2	0.4	<0.40	19	0.2	<0.2
F1 (C6-C10)	NV	NV	NV	1000[a]	ug/L	25	<25	25	<25	<25	25	<25	<25	25	<25	25	27	**610**	25	<25
F2 (C10-C16)	NV	NV	NV		ug/L	100	<100	100	<100	<100	100	<100	<100	100	<100	100	<100	**430**	100	<100
F3 (C16-C34)	NV	NV	NV	1000[a]	ug/L	100	<100	100	<100	<100	100	<100	<100	100	<100	100	<100	500	100	<100
F4 (C34-C50)	NV	NV	NV		ug/L	100	<100	100	<100	<100	100	<100	<100	100	<100	100	<100	<100	100	<100

NOTES

Applicable Soil Criteria

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines

[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004

[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004

[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

[a] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 2 for All property uses, March 2004

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

Table 9: Groundwater PAH Analysis Result - West Wharf

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2009[2]	O. Reg. 153 Table 1 All Types of Property Uses[3]	O. Reg. 153 Table 3 All Types of Property Uses[4]	Units	RDL	MW09-2i[5]	MW09-100 (MW09-02i Dup)[5]	MW09-2ii[5]	MW09-04	MW308[6]	MW310[6]
Polyaromatic Hydrocarbons												
Naphthalene	NV	1.1	7.0	5900	µg/L	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Acenaphthylene	NV	NV	1.0	2000	µg/L	0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11
Acenaphthene	NV	5.8	1.0	1700	µg/L	0.10	<0.10	<0.10	<0.10	<0.10	1.6	0.51
Fluorene	NV	3	1.0	290	µg/L	0.09	<0.09	<0.09	<0.09	<0.09	2	0.55
Phenanthrene	NV	0.4	1.0	63	µg/L	0.10	<0.10	<0.10	0.22	<0.10	<0.10	<0.10
Anthracene	NV	0.012	0.05	12	µg/L	0.07	<0.07	<0.07	<0.07	<0.07	<0.07	<0.07
Fluoranthene	NV	0.04	1.0	130	µg/L	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Pyrene	NV	0.025	0.05	40	µg/L	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Benzo(a)anthracene	NV	0.018	0.1	5	µg/L	0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Chrysene	NV	NV	0.05	3	µg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)fluoranthene	NV	NV	0.05	7	µg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(k)fluoranthene	NV	NV	0.05	0.4	µg/L	0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Benzo(a)pyrene	0.01	0.015	0.005	1.9	ug/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	NV	NV	0.1	0.27	µg/L	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Dibenzo(a,h)anthracene	NV	NV	0.1	0.25	µg/L	0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
Benzo(g,h,i)perylene	NV	NV	0.10	0.2	µg/L	0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
2-and 1-methyl Napthalene	NV	NV	2.5	13000	µg/L	0.20	<0.20	<0.20	<0.20	<0.20	0.2	7.6

NOTES

Applicable Soil Criteria

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines

[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2009

[3] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 1 for All property uses, March 2004

[4] MOE Standards in Ontario Regulation 153/04 under the Environmental Protection Act as proposed in Table 3 (Non-Potable Groundwater) for All property uses, March 2004

[5] MOE Table 1 Standards apply as the sample location is within 30 m of the water body

[6] MOE Table 3 Standards apply as the sample location is beyond 30 m of the water body

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed applicable O.Reg. 153/04 Standards**

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Table 10: Surfacewater Metal Analysis Result

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	Provincial Water Quality Objectives[3]	RDL	Units	SW09-02 (West Wharf)	SW09-03 (West Wharf)	SW09-04 (West Wharf)
Metals and Inorganics								
Antimony	6	NV	20	0.5	ug/L	<0.5	<0.5	<0.5
Arsenic	10	5	100	1.0	ug/L	<1.0	<1.0	<1.0
Barium	1000	NV	NV	2.0	ug/L	39.6	38.9	33.6
Beryllium	NV	NV	11 or 1100[# a]	0.5	ug/L	<0.5	<0.5	<0.5
Boron	5000	NV	200[#]	10.0	ug/L	17.6	14.6	17
Cadmium	5	0.017	0.1 or 0.5[# b]	0.2	ug/L	***<0.2***	***<0.2***	***<0.2***
Chromium	50	8.9	8.9	2.0	ug/L	<2.0	<2.0	<2.0
Cobalt	NV	NV	0.9	0.5	ug/L	<0.5	<0.5	<0.5
Copper	1000	2 to 4	1 or 5[# c]	1.0	ug/L	1.6	1.6	1.3
Lead	10	1 to 7	5, 10 , 20 or 25[# d]	0.5	ug/L	0.9	1	1
Molybdenum	NV	73	40	0.5	ug/L	0.7	0.7	0.9
Nickel	NV	25 to 150	25	1.0	ug/L	1.2	1.6	1.8
Selenium	10	1	100	1.0	ug/L	<1.0	<1.0	<1.0
Silver	NV	0.1	0.1	0.2	ug/L	**<0.2**	**<0.2**	**<0.2**
Thallium	1	NV	0.3[#]	0.3	ug/L	<0.3	<0.3	<0.3
Uranium	20*	NV	5[#]	0.5	ug/L	0.7	0.6	0.6
Vanadium	130	NV	6	0.4	ug/L	1	0.9	0.4
Zinc	5000	30	20[#]	5.0	ug/L	***20.5***	19.2	6.3
Chromium VI	NV	1	1	5	ug/L	**<5**	**<5**	**<5**
Sodium	NV	NV	NV	50	ug/L	34600	34900	26600
Chloride	≤250000+	NV	NV	100	ug/L	64300	65600	56500
Nitrate as N	45000	13000	NV	1000	ug/L	1090	1190	817
Nitrite as N	NV	60	NV	1000	ug/L	<50	<50	<50
Electrical Conductivity	NV	NV	NV	2	uS/cm	509	511	4790
pH	6.5 to 8.5 +	NV	6.5 to 8.5	NA	NA	8.32	8.33	8.35

NOTES

Applicable Soil Criteria

[1] CCME - Community Water Supplies referring to the Guidelines for Canadian Drinking Water Quality Summary (2008) as listed in Table 4 for Health-based and aesthetic guidelines

[2] CCME - Canadian Water Quality Guidelines for the Protection of Aquatic Life - Updated 2007

[3] MOE Provincial Water Quality Objectives (PWQO) Appendix A Table 2 - Table of PWQOs and Interim PWQOs - 1994, reprinted 1999

* Interim Maximum Acceptable Concentration (IMAC)

\+ Aesthetic Objectives (AO) applied when no MAC available.

[#] Interim PWQO

[a] Hardness as $CaCO^3$ at <75 mg/L , PWQO = 11 ug/L; CaCO3 at >75 mg/L , PWQO = 1100 ug/L

[b] Hardness as $CaCO^3$ at 0-100 mg/L , PWQO = 0.1 ug/L; CaCO3 at >100 mg/L , PWQO = 0.5 ug/L

[c] Hardness as $CaCO^3$ at 0-20 mg/L , PWQO = 1 ug/L; CaCO3 at >20 mg/L , PWQO = 5 ug/L

[d] Alkalinity as $CaCO^3$ at <20 mg/L, PWQO = 5 ug/L; CaCO3 at 20 to 40 mg/L, PWQO = 10 ug/L; CaCO3 at 40 to 80 mg/L, PWQO = 20 ug/L; CaCO3 at >80 mg/L, PWQO = 25 ug/L

RDL - Reportable Detection Limit

NV - No Value

Bolded and Highlighted Values Exceed CCME Guidelines

***Italicized* and Bolded Values Exceed PWQO**

GENIVAR

Sample ID	Units	Detection Limit	MW09-02A	BHX1 (MW09-02A Dup)	5x RDL	Acceptable range	Diff / Max diff	RPD
Petroleum Hydrocarbons								
Benzene	ug/g	0.002	<0.002	<0.002	0.01	50.00%		
Toluene	ug/g	0.002	<0.002	<0.002	0.01	50.00%		
Ethylbenzene	ug/g	0.002	<0.002	<0.002	0.01	50.00%		
Xylenes (total)	ug/g	0.002	<0.002	<0.002	0.01	50.00%		
F1 (C6-C10)	ug/g	5	<5	<5	25	50.00%		
F2 (C10-C16)	ug/g	10	<10	<10	50	50.00%		
F3 (C16-C34)	ug/g	50	<50	<50	250	50.00%		
F4 (C34-C50)	ug/g	50	<50	<50	250	50.00%		
Metals and Inorganics								
Antimony	µg/g	0.8	<0.8	<0.8	4	50.00%		
Arsenic	µg/g	1	3	3	5	4	0	
Barium	µg/g	2	64	67	10	50.00%		5%
Beryllium	µg/g	0.5	<0.5	<0.5	2.5	50.00%		
Boron	µg/g	5	8	8	25	20	0	
Boron (Hot Water Extractable)	µg/g	0.10	1.46	1.55	0.5	50.00%		6%
Cadmium	µg/g	0.5	<0.5	<0.5	2.5	50.00%		
Chromium	µg/g	2	18	25	10	50.00%		33%
Cobalt	µg/g	0.5	3.6	4.2	2.5	50.00%		15%
Copper	µg/g	1	8	8	5	50.00%		0%
Lead	µg/g	1	6	6	5	50.00%		0%
Molybdenum	µg/g	0.5	<0.5	<0.5	2.5	50.00%		
Nickel	µg/g	1	7	8	5	50.00%		13%
Selenium	µg/g	0.4	0.6	0.5	2	1.6	0.1	
Silver	µg/g	0.2	<0.2	<0.2	1	50.00%		
Thallium	µg/g	0.4	<0.4	<0.4	2	50.00%		
Uranium	µg/g	0.5	0.6	0.8	2.5	2	0.2	
Vanadium	µg/g	1	17	17	5	50.00%		0%
Zinc	µg/g	5	27	30	25	50.00%		11%
Chromium, Hexavalent	µg/g	0.2	<0.2	<0.2	1	50.00%		
Cyanide, Free	mS/cm	0.05	<0.05	<0.05	0.25	50.00%		
Mercury	N/A	0.01	0.03	0.03	0.05	0.04	0	
Electrical Conductivity (2:1)	N/A	0.002	***0.7***	***0.763***	0.01	50.00%		9%
Sodium Adsorption Ratio (2:1)	µg/g	N/A	1.49	1.38		50.00%		8%
pH, 2:1 CaCl2 Extraction	µg/g	N/A	7.22	7.27		50.00%		1%
Chloride (2:1)	µg/g	2	16	21	10	50.00%		27%
Nitrate + Nitrite	µg/g	1	<1	<1	5	50.00%		
Volatile Organic Compounds								
Dichlorodifluoromethane	µg/g	0.005	<0.005	<0.005	0.025	50.00%		
Chloromethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Vinyl Chloride	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Bromomethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Chloroethane	µg/g	0.005	<0.005	<0.005	0.025	50.00%		
Trichlorofluoromethane	µg/g	0.004	<0.004	<0.004	0.02	50.00%		
Acetone	µg/g	0.130	<0.130	<0.130	0.65	50.00%		
1,1-Dichloroethylene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Methylene Chloride	µg/g	0.003	<0.003	<0.003	0.015	50.00%		
TRANS-1,2-Dichloroethylene	µg/g	0.003	<0.003	<0.003	0.015	50.00%		
Methyl tert-butyl Ether	µg/g	0.004	<0.004	<0.004	0.02	50.00%		
1,1-Dichloroethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Methyl Ethyl Ketone	µg/g	0.10	<0.10	<0.10	0.5	50.00%		
CIS 1,2-Dichloroethylene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Chloroform	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,2- Dichloroethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,1,1-Trichloroethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Carbon Tetrachloride	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Benzene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,2-Dichloropropane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Trichloroethylene	µg/g	0.004	<0.004	<0.004	0.02	50.00%		
Bromodichloromethane	µg/g	0.003	<0.003	<0.003	0.015	50.00%		
CIS-1,3-Dichloropropene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		

Methyl Isobutyl Ketone	µg/g	0.10	<0.10	<0.10	0.5	50.00%		
TRANS-1,3-Dichloropropene	µg/g	0.003	<0.003	<0.003	0.015	50.00%		
1,1,2-Trichloroethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Toluene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
2-Hexanone	µg/g	0.470	<0.470	<0.470	2.35	50.00%		
Dibromochloromethane	µg/g	0.003	<0.003	<0.003	0.015	50.00%		
Ethylene Dibromide	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Tetrachloroethylene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,1,1,2-Tetrachloroethane	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Chlorobenzene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Ethylbenzene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
m & p-Xylene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Bromoform	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
Styrene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,1,2,2- Tetrachloroethane	µg/g	0.004	<0.004	<0.004	0.02	50.00%		
o-Xylene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,3-Dichlorobenzene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,4-Dichlorobenzene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,2-Dichlorobenzene	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,2,4-Trichlorobenzene	µg/g	0.007	<0.007	<0.007	0.035	50.00%		
Xylene Mixture (Total)	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
1,3-Dichloropropene (Cis + Trans)	µg/g	0.002	<0.002	<0.002	0.01	50.00%		
n-Hexane	µg/g	0.005	<0.005	<0.005	0.025	50.00%		
Polycyclic Aromatic Hydrocarbon								
Naphthalene	µg/g	0.03	0.07	<0.03	0.15	0.12	0.07	
Acenaphthylene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Acenaphthene	µg/g	0.03	<0.03	<0.03	0.15	50.00%		
Fluorene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Phenanthrene	µg/g	0.02	0.04	<0.02	0.1	0.08	0.04	
Anthracene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Fluoranthene	µg/g	0.02	0.02	<0.02	0.1	0.08	0.02	
Pyrene	µg/g	0.02	0.02	<0.02	0.1	0.08	0.02	
Benzo(a)anthracene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Chrysene	µg/g	0.02	0.03	<0.02	0.1	0.08	0.03	
Benzo(b)fluoranthene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Benzo(k)fluoranthene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Benzo(a)pyrene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Indeno(1,2,3-cd)pyrene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Dibenz(a,h)anthracene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
Benzo(g,h,i)perylene	µg/g	0.02	<0.02	<0.02	0.1	50.00%		
2-and 1-methyl Naphthalene	µg/g	0.05	0.09	<0.05	0.25	0.2	0.09	

Sample ID	Units	Detection Limit	MW09-2i	MW09-100 (MW09-02i Dup)	5x RDL	Acceptable range	Diff	RPD
Petroleum Hydrocarbons								
Benzene	ug/L	0.4	<0.40	<0.40	2	30.00%		
Toluene	ug/L	0.4	<0.40	<0.40	2	30.00%		
Ethylbenzene	ug/L	0.2	<0.20	<0.20	1	30.00%		
Xylenes (total)	ug/L	0.4	<0.40	<0.40	2	30.00%		
F1 (C6-C10)	ug/L	25	<25	<25	125	30.00%		
F2 (C10-C16)	ug/L	100	<100	<100	500	30.00%		
F3 (C16-C34)	ug/L	100	<100	<100	500	30.00%		
F4 (C34-C50)	ug/L	100	<100	<100	500	30.00%		
Metals and Inorganics								
Antimony	ug/L	0.5	<0.5	<0.5	2.5	30.00%		
Arsenic	ug/L	1.0	4.5	4.4	5	2	0.1	
Barium	ug/L	2.0	90.9	91.6	10	30.00%		1%
Beryllium	ug/L	0.5	<0.5	<0.5	2.5	30.00%		
Boron	ug/L	10.0	190	182	50	30.00%	8	4%
Cadmium	ug/L	0.2	<0.2	<0.2	1	30.00%		
Chromium	ug/L	2.0	<2.0	<2.0	10	0.3		
Cobalt	ug/L	0.5	1	0.8	2.5	1	0.2	22%
Copper	ug/L	1.0	1.4	1.1	5	2	0.3	24%
Lead	ug/L	0.5	1.2	<0.5	2.5	1	≤1.2	
Molybdenum	ug/L	0.5	<0.5	<0.5	2.5	30.00%		
Nickel	ug/L	1.0	<1.0	<1.0	5	30.00%		
Selenium	ug/L	1.0	<1.0	2	5	30.00%		
Silver	ug/L	0.2	<0.2	<0.2	1	30.00%		
Thallium	ug/L	0.3	<0.3	<0.3	1.5	30.00%		
Uranium	ug/L	0.5	<0.5	<0.5	2.5	30.00%		
Vanadium	ug/L	0.4	2.9	3.5	2	30.00%	0.6	19%
Zinc	ug/L	5.0	<5.0	<5.0	25	30.00%		
Mercury	ug/L	0.02	<0.02	<0.02	0.1	30.00%		
Chromium VI	ug/L	5	<5	<5	25	30.00%		
Cyanide, Free	ug/L	2	<2	<2	10	30.00%		
Sodium	ug/L	50	1100000	1100000	250	30.00%	0	0%
Chloride	ug/L	100	1650000	1600000	500	30.00%		3%
Nitrate as N	ug/L	50	<50	<50	250	30.00%		
Nitrite as N	ug/L	50	<50	<50	250	30.00%		
Electrical Conductivity	uS/cm	2	6390	6290	10	30.00%		2%
pH		NA	7.76	7.73		30.00%	0.03	0%
Volatile Organic Compounds								
Dichlorodifluoromethane	µg/L	0.4	<0.40	<0.40	2	30.00%		
Chloromethane	µg/L	0.8	<0.80	<0.80	4	30.00%		
Vinyl Chloride	µg/L	0.34	<0.34	<0.34	1.7	30.00%		
Bromomethane	µg/L	0.4	<0.40	<0.40	2	30.00%		
Chloroethane	µg/L	0.4	<0.40	<0.40	2	30.00%		
Trichlorofluoromethane	µg/L	0.8	<0.80	<0.80	4	30.00%		
Acetone	µg/L	2	<2.0	<2.0	10	30.00%		
1,1 Dichloroethene	µg/L	0.6	<0.60	<0.60	3	30.00%		
Methylene Chloride	µg/L	0.6	<0.60	<0.60	3	30.00%		
trans- 1,2-dichloroethylene	µg/L	0.4	<0.40	<0.40	2	30.00%		
Methyl tert-butyl ether	µg/L	0.4	<0.40	<0.40	2	30.00%		
1,1-Dichloroethane	µg/L	0.6	<0.60	<0.60	3	30.00%		
Methyl Ethyl Ketone	µg/L	2	<2.0	<2.0	10	30.00%		
cis-1,2-Dichloroethylene	µg/L	0.4	<0.40	<0.40	2	30.00%		
Chloroform	µg/L	0.4	<0.40	<0.40	2	30.00%		

1,2 - Dichloroethane	µg/L	0.4	<0.40	<0.40	2	30.00%		
1,1,1-Trichloroethane	µg/L	0.6	<0.60	<0.60	3	30.00%		
Carbon Tetrachloride	µg/L	0.4	<0.40	<0.40	2	30.00%		
Benzene	µg/L	0.4	<0.40	<0.40	2	30.00%		
1,2-Dichloropropane	µg/L	0.4	<0.40	<0.40	2	30.00%		
Trichloroethylene	µg/L	0.4	<0.40	<0.40	2	30.00%		
Bromodichloromethane	ug/L	0.4	<0.40	<0.40	2	30.00%		
cis-1,3-Dichloropropene	µg/L	0.4	<0.40	<0.40	2	30.00%		
Methyl Isobutyl Ketone	µg/L	2	<2.0	<2.0	10	30.00%		
trans-1,3-Dichloropropene	µg/L	0.6	<0.60	<0.60	3	30.00%		
1,1,2-Trichloroethane	µg/L	0.4	<0.40	<0.40	2	30.00%		
Toluene	µg/L	0.4	<0.40	<0.40	2	30.00%		
2-Hexanone	µg/L	0.6	<0.60	<0.60	3	30.00%		
Dibromochloromethane	µg/L	0.2	<0.20	<0.20	1	30.00%		
Ethylene Dibromide	µg/L	0.4	<0.40	<0.40	2	30.00%		
Tetrachloroethene	µg/L	0.4	<0.40	<0.40	2	30.00%		
1,1,1,2-Tetrachloroethane	µg/L	0.2	<0.20	<0.20	1	30.00%		
Chlorobenzene	µg/L	0.2	<0.20	<0.20	1	30.00%		
Ethylbenzene	µg/L	0.2	<0.20	<0.20	1	30.00%		
m & p-Xylene	µg/L	0.4	<0.40	<0.40	2	30.00%		
Bromoform	µg/L	0.2	<0.20	<0.20	1	30.00%		
Styrene	µg/L	0.2	<0.20	<0.20	1	30.00%		
1,1,2,2-Tetrachloroethane	µg/L	0.2	<0.20	<0.20	1	30.00%		
o-Xylene	µg/L	0.2	<0.20	<0.20	1	30.00%		
1,3-Dichlorobenzene	µg/L	0.2	<0.20	<0.20	1	30.00%		
1,4-Dichlorobenzene	µg/L	0.2	<0.20	<0.20	1	30.00%		
1,2-Dichlorobenzene	µg/L	0.2	<0.20	<0.20	1	30.00%		
1,2,4-Trichlorobenzene	µg/L	0.6	<0.60	<0.60	3	30.00%		
1,3-Dichloropropene (Cis + Trans)	µg/L	0.6	<0.60	<0.60	3	30.00%		
Xylenes (Total)	µg/L	0.4	<0.40	<0.40	2	30.00%		
n-Hexane	µg/L	0.4	<0.40	<0.40	2	30.00%		
Polycyclic Aromatic Hydrocarbons								
Naphthalene	µg/L	0.12	<0.12	<0.12	0.6	30.00%		
Acenaphthylene	µg/L	0.11	<0.11	<0.11	0.55	30.00%		
Acenaphthene	µg/L	0.10	<0.10	<0.10	0.5	30.00%		
Fluorene	µg/L	0.09	<0.09	<0.09	0.45	30.00%		
Phenanthrene	µg/L	0.10	<0.10	<0.10	0.5	30.00%		
Anthracene	µg/L	0.07	<0.07	<0.07	0.35	30.00%		
Fluoranthene	µg/L	0.12	<0.12	<0.12	0.6	30.00%		
Pyrene	µg/L	0.12	<0.12	<0.12	0.6	30.00%		
Benzo(a)anthracene	µg/L	0.08	<0.08	<0.08	0.4	30.00%		
Chrysene	µg/L	0.05	<0.05	<0.05	0.25	30.00%		
Benzo(b)fluoranthene	µg/L	0.05	<0.05	<0.05	0.25	30.00%		
Benzo(k)fluoranthene	µg/L	0.06	<0.06	<0.06	0.3	30.00%		
Benzo(a)pyrene	µg/L	0.01	<0.01	<0.01	0.05	30.00%		
Indeno(1,2,3-cd)pyrene	µg/L	0.03	<0.03	<0.03	0.15	30.00%		
Dibenzo(a,h)anthracene	µg/L	0.09	<0.09	<0.09	0.45	30.00%		
Benzo(g,h,i)perylene	µg/L	0.06	<0.06	<0.06	0.3	30.00%		
2-and 1-methyl Napthalene	µg/L	0.20	<0.20	<0.20	1	30.00%		

Appendix C

Laboratory Certificates of Analysis and Chain of Custody Forms

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Certificate of Analysis

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 Metals & Inorganics in Soil - Table 1

DATE SAMPLED: Mar 03, 2010 | **DATE RECEIVED: Mar 05, 2010** | **DATE REPORTED: Mar 11, 2010** | **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-05A 1680873	MW09-05B 1680878	BHX 1680882	BH09-06A 1680886	BH09-06B 1680890	MW09-07A 1680895	MW09-07B 1680897	MW09-01A 1680899
Antimony	µg/g	1.0	0.8	**28.8**	<0.8	**16.8**	<0.8	<0.8	**6.8**	**3.0**	<0.8
Arsenic	µg/g	17	1	14	2	10	2	2	4	7	3
Barium	µg/g	210	2	**604**	48	**399**	76	37	88	**304**	36
Beryllium	µg/g	1.2	0.5	0.6	<0.5	0.6	<0.5	<0.5	<0.5	0.7	<0.5
Boron	µg/g		5	10	<5	10	9	<5	6	13	6
Boron (Hot Water Extractable)	µg/g		0.10	1.14	0.78	0.80	0.14	0.23	1.39	0.72	0.19
Cadmium	µg/g	1.0	0.5	**4.8**	<0.5	**3.9**	<0.5	<0.5	1.0	**17.1**	<0.5
Chromium	µg/g	71	2	54	69	44	16	**111**	**136**	**1220**	10
Cobalt	µg/g	21	0.5	9.1	2.2	8.3	5.3	2.2	3.7	7.6	3.0
Copper	µg/g	85	1	**256**	10	**135**	12	10	22	**367**	9
Lead	µg/g	120	1	**1160**	29	**627**	21	43	**302**	**202**	13
Molybdenum	µg/g	2.5	0.5	2.0	<0.5	1.6	<0.5	<0.5	<0.5	1.8	0.6
Nickel	µg/g	43	1	**212**	23	**131**	12	43	**170**	**90**	8
Selenium	µg/g	1.9	0.4	1.0	<0.4	0.9	<0.4	0.4	0.4	0.9	<0.4
Silver	µg/g	0.42	0.2	**0.6**	<0.2	**0.5**	<0.2	<0.2	0.2	**8.9**	<0.2
Thallium	µg/g	2.5	0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	ug/g		0.5	0.6	<0.5	0.6	0.5	<0.5	0.6	1.7	0.5
Vanadium	µg/g	91	1	29	9	32	24	10	17	33	11
Zinc	µg/g	160	5	**817**	75	**546**	46	96	**172**	**2300**	53
Chromium, Hexavalent	µg/g	2.5	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide, Free	µg/g	0.12	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	µg/g	0.23	0.01	**0.251**	0.034	0.228	0.026	0.045	0.069	**1.46**	0.020
Electrical Conductivity (2:1)	mS/cm	0.57	0.002	**0.642**	0.299	0.404	0.168	0.231	0.380	**2.28**	0.179
Sodium Adsorption Ratio (2:1)	N/A	2.4	N/A	0.115	0.147	0.099	0.150	0.904	0.868	1.48	0.491
pH, 2:1 CaCl2 Extraction	pH Units			7.29	7.25	7.41	7.64	7.27	7.10	6.94	7.84
Chloride (2:1)	µg/g	330	2	6	2	7	5	25	25	93	16
Nitrate + Nitrite	µg/g	61	1	10	<1	9	<1	<1	<1	<1	<1

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Certificate of Analysis

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 Metals & Inorganics in Soil - Table 1

DATE SAMPLED: Mar 03, 2010 | **DATE RECEIVED: Mar 05, 2010** | **DATE REPORTED: Mar 11, 2010** | **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-01B 1680901	RDL	MW09-04A 1680903	MW09-04B 1680907	MW09-02A 1680911	MW09-02B 1680915	BH09-03A 1680919	BH09-03B 1680923
Antimony	µg/g	1.0	0.8	<0.8	0.8	**1.5**	<0.8	<0.8	<0.8	<0.8	<0.8
Arsenic	µg/g	17	1	4	1	**91**	8	3	3	**110**	3
Barium	µg/g	210	2	108	2	202	40	64	83	79	81
Beryllium	µg/g	1.2	0.5	0.6	0.5	**2.8**	<0.5	<0.5	<0.5	0.9	<0.5
Boron	µg/g		5	8	5	16	8	8	7	22	9
Boron (Hot Water Extractable)	µg/g		0.10	0.43	0.10	4.17	2.17	1.46	0.50	1.57	1.50
Cadmium	µg/g	1.0	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium	µg/g	71	2	31	2	15	9	18	26	12	28
Cobalt	µg/g	21	0.5	7.2	0.5	7.9	4.7	3.6	4.9	7.7	4.7
Copper	µg/g	85	1	15	1	38	12	8	11	16	12
Lead	µg/g	120	1	12	1	21	17	6	8	9	9
Molybdenum	µg/g	2.5	0.5	0.6	0.5	**8.5**	0.7	<0.5	<0.5	1.1	<0.5
Nickel	µg/g	43	1	14	1	20	12	7	10	18	9
Selenium	µg/g	1.9	0.4	0.7	0.4	**2.7**	0.7	0.6	<0.4	**2.2**	0.6
Silver	µg/g	0.42	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/g	2.5	0.4	<0.4	0.4	0.7	<0.4	<0.4	<0.4	<0.4	<0.4
Uranium	ug/g		0.5	0.9	0.5	1.5	0.6	0.6	0.8	0.7	0.8
Vanadium	µg/g	91	1	30	1	30	11	17	23	20	22
Zinc	µg/g	160	5	56	5	36	50	27	40	46	40
Chromium, Hexavalent	µg/g	2.5	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cyanide, Free	µg/g	0.12	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Mercury	µg/g	0.23	0.01	0.054	0.01	**0.353**	0.052	0.030	0.040	0.069	0.058
Electrical Conductivity (2:1)	mS/cm	0.57	0.002	**9.05**	0.002	**2.32**	**2.51**	**0.700**	**2.52**	**2.94**	**1.71**
Sodium Adsorption Ratio (2:1)	N/A	2.4	N/A	**85.8**	N/A	**11.2**	**27.2**	1.49	**14.7**	**2.52**	**13.0**
pH, 2:1 CaCl2 Extraction	pH Units			7.60		7.73	7.62	7.22	7.29	7.33	7.30
Chloride (2:1)	µg/g	330	20	**5310**	2	**978**	**1160**	16	**1010**	140	**504**
Nitrate + Nitrite	µg/g	61	10	<10	1	<1	<1	<1	<1	<1	<1

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Certificate of Analysis

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 Metals & Inorganics in Soil - Table 1

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	BHX1 1680927
Antimony	µg/g	1.0	0.8	<0.8
Arsenic	µg/g	17	1	3
Barium	µg/g	210	2	67
Beryllium	µg/g	1.2	0.5	<0.5
Boron	µg/g		5	8
Boron (Hot Water Extractable)	µg/g		0.10	1.55
Cadmium	µg/g	1.0	0.5	<0.5
Chromium	µg/g	71	2	25
Cobalt	µg/g	21	0.5	4.2
Copper	µg/g	85	1	8
Lead	µg/g	120	1	6
Molybdenum	µg/g	2.5	0.5	<0.5
Nickel	µg/g	43	1	8
Selenium	µg/g	1.9	0.4	0.5
Silver	µg/g	0.42	0.2	<0.2
Thallium	µg/g	2.5	0.4	<0.4
Uranium	ug/g		0.5	0.8
Vanadium	µg/g	91	1	17
Zinc	µg/g	160	5	30
Chromium, Hexavalent	µg/g	2.5	0.2	<0.2
Cyanide, Free	µg/g	0.12	0.05	<0.05
Mercury	µg/g	0.23	0.01	0.030
Electrical Conductivity (2:1)	mS/cm	0.57	0.002	**0.763**
Sodium Adsorption Ratio (2:1)	N/A	2.4	N/A	1.38
pH, 2:1 CaCl2 Extraction	pH Units			7.27
Chloride (2:1)	µg/g	330	2	21
Nitrate + Nitrite	µg/g	61	1	<1

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All)

1680873-1680927 EC, SAR, Chloride & Nitrate/Nitrite were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil).
pH was determined on the extract obtained from the 2:1 leaching procedure (2 parts 0.01M CaCl2:1 part soil).

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 558 Metals and Inorganics

DATE SAMPLED: Mar 03, 2010 | **DATE RECEIVED: Mar 05, 2010** | **DATE REPORTED: Mar 11, 2010** | **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-07B 1680897
Arsenic Leachate	mg/L	2.5	0.010	<0.010
Barium Leachate	mg/L	100	0.100	0.897
Boron Leachate	mg/L	500	0.050	0.095
Cadmium Leachate	mg/L	0.5	0.010	0.060
Chromium Leachate	mg/L	5.0	0.010	0.027
Lead Leachate	mg/L	5.0	0.010	0.064
Mercury Leachate	mg/L	0.1	0.005	<0.005
Selenium Leachate	mg/L	1.0	0.010	<0.010
Silver Leachate	mg/L	5.0	0.010	<0.010
Uranium Leachate	mg/L	10.0	0.050	<0.050
Fluoride Leachate	mg/L	150	0.05	0.17
Cyanide Leachate	mg/L	20.0	0.05	<0.05
(Nitrate + Nitrite) as N Leachate	mg/L	1000	0.70	<0.70

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Regulation 558

Certified By:

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

(P & T) BTEX - Soil (GC/MS)

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-07A 1680895	MW09-07B 1680897	MW09-01A 1680899	MW09-01B 1680901
Benzene	µg/g	0.002	0.002	<0.002	**0.003**	<0.002	<0.002
Toluene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002
Ethylbenzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002
m & p-Xylene	µg/g		0.002	<0.002	<0.002	<0.002	<0.002
o-Xylene	µg/g		0.002	<0.002	<0.002	<0.002	<0.002
Xylenes (Total)	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002
Moisture Content	%		0.01	20.5	40.0	7.9	34.1
Surrogate	**Unit**	**Acceptable Limits**					
Toluene-d8	% Recovery	60-130		105	78	91	98
4-Bromofluorobenzene	% Recovery	70-130		97	108	115	98

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All)

1680895-1680901 Results are based on the dry weight of the soil.

Certified By: Jordy Takewchi

AGAT Laboratories

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Volatile Organic Compounds in Soil

DATE SAMPLED: Mar 03, 2010 | **DATE RECEIVED: Mar 05, 2010** | **DATE REPORTED: Mar 11, 2010** | **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-05A 1680873	MW09-05B 1680878	BHX 1680882	BH09-06A 1680886	BH09-06B 1680890	MW09-04A 1680903	MW09-04B 1680907	MW09-02A 1680911
Dichlorodifluoromethane	µg/g		0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Chloromethane	µg/g		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Vinyl Chloride	µg/g	0.003	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Bromomethane	µg/g	0.003	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chloroethane	µg/g		0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Trichlorofluoromethane	µg/g		0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Acetone	µg/g		0.130	<0.130	<0.130	<0.130	<0.130	<0.130	<0.130	<0.130	<0.130
1,1-Dichloroethylene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Methylene Chloride	µg/g	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
TRANS-1,2-Dichloroethylene	µg/g	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Methyl tert-butyl Ether	µg/g		0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
1,1-Dichloroethane	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Methyl Ethyl Ketone	µg/g		0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
CIS 1,2-Dichloroethylene	µg/g		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chloroform	µg/g	0.006	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,2- Dichloroethane	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,1,1-Trichloroethane	µg/g	0.009	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Carbon Tetrachloride	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Benzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,2-Dichloropropane	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Trichloroethylene	µg/g	0.004	0.004	<0.004	<0.004	**0.006**	<0.004	<0.004	<0.004	<0.004	<0.004
Bromodichloromethane	µg/g		0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
CIS-1,3-Dichloropropene	µg/g		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Methyl Isobutyl Ketone	µg/g		0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
TRANS-1,3-Dichloropropene	µg/g		0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
1,1,2-Trichloroethane	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Toluene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
2-Hexanone	µg/g		0.470	<0.470	<0.470	<0.470	<0.470	<0.470	<0.470	<0.470	<0.470
Dibromochloromethane	µg/g	0.003	0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003
Ethylene Dibromide	µg/g	0.004	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Tetrachloroethylene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,1,1,2-Tetrachloroethane	µg/g		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Chlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002

Certified By: Jordy Takewchi

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Certificate of Analysis

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Volatile Organic Compounds in Soil

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-05A 1680873	MW09-05B 1680878	BHX 1680882	BH09-06A 1680886	BH09-06B 1680890	MW09-04A 1680903	MW09-04B 1680907	MW09-02A 1680911
Ethylbenzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
m & p-Xylene	µg/g		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Bromoform	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Styrene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,1,2,2- Tetrachloroethane	µg/g	0.004	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004
o-Xylene	µg/g		0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,3-Dichlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,4-Dichlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,2-Dichlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,2,4-Trichlorobenzene	µg/g		0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007	<0.007
Xylene Mixture (Total)	µg/g	0.002	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
1,3-Dichloropropene (Cis + Trans)	µg/g	0.003	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
n-Hexane	µg/g		0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Moisture Content	%		0.1	14.4	22.5	21.0	20.8	23.9	19.7	19.1	28.9
Surrogate	**Unit**	**Acceptable Limits**									
Toluene-d8	% Recovery	60-130		104	105	105	103	105	118	105	106
4-Bromofluorobenzene	% Recovery	70-130		86	81	83	86	84	84	83	84

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Volatile Organic Compounds in Soil

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-02B 1680915	BH09-03A 1680919	RDL	BH09-03B 1680923	RDL	BHX1 1680927
Dichlorodifluoromethane	µg/g		0.005	<0.005	<0.005	0.010	<0.010	0.005	<0.005
Chloromethane	µg/g		0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Vinyl Chloride	µg/g	0.003	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Bromomethane	µg/g	0.003	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Chloroethane	µg/g		0.005	<0.005	<0.005	0.010	<0.010	0.005	<0.005
Trichlorofluoromethane	µg/g		0.004	<0.004	<0.004	0.008	<0.008	0.004	<0.004
Acetone	µg/g		0.130	<0.130	0.22	0.260	<0.260	0.130	<0.130
1,1-Dichloroethylene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Methylene Chloride	µg/g	0.003	0.003	<0.003	<0.003	**0.006**	<0.006	0.003	<0.003
TRANS-1,2-Dichloroethylene	µg/g	0.003	0.003	<0.003	<0.003	**0.006**	<0.006	0.003	<0.003
Methyl tert-butyl Ether	µg/g		0.004	<0.004	<0.004	0.008	<0.008	0.004	<0.004
1,1-Dichloroethane	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Methyl Ethyl Ketone	µg/g		0.10	<0.10	<0.10	0.20	<0.20	0.10	<0.10
CIS 1,2-Dichloroethylene	µg/g		0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Chloroform	µg/g	0.006	0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
1,2- Dichloroethane	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,1,1-Trichloroethane	µg/g	0.009	0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Carbon Tetrachloride	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Benzene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,2-Dichloropropane	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Trichloroethylene	µg/g	0.004	0.004	<0.004	<0.004	**0.008**	<0.008	0.004	<0.004
Bromodichloromethane	µg/g		0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003
CIS-1,3-Dichloropropene	µg/g		0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Methyl Isobutyl Ketone	µg/g		0.10	<0.10	<0.10	0.20	<0.20	0.10	<0.10
TRANS-1,3-Dichloropropene	µg/g		0.003	<0.003	<0.003	0.006	<0.006	0.003	<0.003
1,1,2-Trichloroethane	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Toluene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
2-Hexanone	µg/g		0.470	<0.470	<0.470	0.940	<0.940	0.470	<0.470
Dibromochloromethane	µg/g	0.003	0.003	<0.003	<0.003	**0.006**	<0.006	0.003	<0.003
Ethylene Dibromide	µg/g	0.004	0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Tetrachloroethylene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,1,1,2-Tetrachloroethane	µg/g		0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Chlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002

Certified By: Jordy Takewski

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Volatile Organic Compounds in Soil

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-02B 1680915	BH09-03A 1680919	RDL	BH09-03B 1680923	RDL	BHX1 1680927
Ethylbenzene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
m & p-Xylene	µg/g		0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
Bromoform	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
Styrene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,1,2,2- Tetrachloroethane	µg/g	0.004	0.004	<0.004	<0.004	**0.008**	<0.008	0.004	<0.004
o-Xylene	µg/g		0.002	<0.002	<0.002	0.004	<0.004	0.002	<0.002
1,3-Dichlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,4-Dichlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,2-Dichlorobenzene	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,2,4-Trichlorobenzene	µg/g		0.007	<0.007	<0.007	0.014	<0.014	0.007	<0.007
Xylene Mixture (Total)	µg/g	0.002	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
1,3-Dichloropropene (Cis + Trans)	µg/g	0.003	0.002	<0.002	<0.002	**0.004**	<0.004	0.002	<0.002
n-Hexane	µg/g		0.005	<0.005	<0.005	0.010	<0.010	0.005	<0.005
Moisture Content	%		0.1	28.6	19.9	0.1	53.4	0.1	26.5
Surrogate	**Unit**	**Acceptable Limits**							
Toluene-d8	% Recovery	60-130		111	106		96		108
4-Bromofluorobenzene	% Recovery	70-130		80	83		92		84

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All)

1680873-1680919 Results are based on the dry weight of the soil.

1680923 Results are based on the dry weight of the soil.
Due to the high moisture content of the sample the reporting detection limit has been raised.

1680927 Results are based on the dry weight of the soil.

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 - Petroleum Hydrocarbons F1 - F4 (C6 - C50) in Soil (-BTEX)

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-07A 1680895	MW09-07B 1680897	MW09-01A 1680899	MW09-01B 1680901
C6 - C10 (F1)	µg/g		5	<5	12	<5	<5
C6 - C10 (F1 minus BTEX)	µg/g		5	<5	12	<5	<5
C>10 - C16 (F2)	µg/g		10	21	140	<10	<10
C>16 - C34 (F3)	µg/g		50	910	4100	<50	<50
C>34 - C50 (F4)	µg/g		50	250	660	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA
Moisture Content	%		0.1	20.5	40.0	7.9	34.1

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

1680895-1680901 Results are based on sample dry weight.
The C6-C10 fraction is calculated using toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
Total C6 - C50 results are corrected for BTEX and PAH contributions (when is available).
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.
Fractions 1-4 are quantified without the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.

Certified By: Jordy Takewchi

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Certificate of Analysis

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 - Petroleum Hydrocarbons F1 - F4 (C6 - C50) in Soil (PAHs Incl.)

DATE SAMPLED: Mar 03, 2010 **DATE RECEIVED: Mar 05, 2010** **DATE REPORTED: Mar 11, 2010** **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-05A 1680873	MW09-05B 1680878	BHX 1680882	BH09-06A 1680886	BH09-06B 1680890	MW09-04A 1680903	MW09-04B 1680907	MW09-02A 1680911
C6 - C10 (F1)	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
C6 - C10 (F1 minus BTEX)	µg/g		5	<5	<5	<5	<5	<5	<5	<5	<5
C>10 - C16 (F2)	µg/g		10	<10	<10	<10	<10	<10	<10	<10	<10
C>10 - C16 (F2 minus Naphthalene)	µg/g		10	<10	<10	<10	<10	<10	<10	<10	<10
C>16 - C34 (F3)	µg/g		50	250	63	420	<50	370	<50	<50	<50
C>16 - C34 (F3 minus PAHs)	µg/g		50	250	62	420	<50	370	<50	<50	<50
C>34 - C50 (F4)	µg/g		50	170	<50	170	58	100	<50	<50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	NA	NA	NA	NA	NA	NA
Moisture Content	%		0.1	14.4	22.5	21.0	20.8	23.9	19.7	19.1	28.9

Parameter	Unit	G / S	RDL	MW09-02B 1680915	BH09-03A 1680919	RDL	BH09-03B 1680923	RDL	BHX1 1680927
C6 - C10 (F1)	µg/g		5	<5	<5	10	<10	5	<5
C6 - C10 (F1 minus BTEX)	µg/g		5	<5	<5	10	<10	5	<5
C>10 - C16 (F2)	µg/g		10	<10	53	20	<20	10	<10
C>10 - C16 (F2 minus Naphthalene)	µg/g		10	<10	53	20	<20	10	<10
C>16 - C34 (F3)	µg/g		50	<50	370	100	320	50	<50
C>16 - C34 (F3 minus PAHs)	µg/g		50	<50	370	100	320	50	<50
C>34 - C50 (F4)	µg/g		50	<50	130	100	<100	50	<50
Gravimetric Heavy Hydrocarbons	µg/g		50	NA	NA	100	NA	50	NA
Moisture Content	%		0.1	28.6	19.9	0.1	53.4	0.1	26.5

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 - Petroleum Hydrocarbons F1 - F4 (C6 - C50) in Soil (PAHs Incl.)

DATE SAMPLED: Mar 03, 2010	DATE RECEIVED: Mar 05, 2010	DATE REPORTED: Mar 11, 2010	SAMPLE TYPE: Soil

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All)

1680873-1680919
Results are based on sample dry weight.
The C6-C10 fraction is calculated using toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
Total C6 - C50 results are corrected for BTEX and PAH contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.

1680923
Results are based on sample dry weight.
Due to the high moisture content of the sample the reporting detection limit has been raised.
The C6-C10 fraction is calculated using toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
Total C6 - C50 results are corrected for BTEX and PAH contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.

1680927
Results are based on sample dry weight.
The C6-C10 fraction is calculated using toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and n-C34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16-C50 and are only determined if the chromatogram of the C34 - C50 hydrocarbons indicates that hydrocarbons >C50 are present.
Total C6 - C50 results are corrected for BTEX and PAH contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 + nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.

Certified By: Jordy Takewchi

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Certificate of Analysis

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 PAHs in Soil

DATE SAMPLED: Mar 03, 2010 | **DATE RECEIVED: Mar 05, 2010** | **DATE REPORTED: Mar 11, 2010** | **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-05A 1680873	MW09-05B 1680878	BHX 1680882	BH09-06A 1680886	BH09-06B 1680890	MW09-04A 1680903	MW09-04B 1680907	MW09-02A 1680911
Naphthalene	µg/g	0.09	0.03	0.09	0.07	**0.14**	0.03	0.05	**0.22**	<0.03	0.07
Acenaphthylene	µg/g	0.08	0.02	0.08	0.03	0.07	0.02	0.02	<0.02	<0.02	<0.02
Acenaphthene	µg/g	0.07	0.03	<0.03	0.04	0.05	<0.03	<0.03	<0.03	<0.03	<0.03
Fluorene	µg/g	0.12	0.02	0.04	0.03	0.07	<0.02	0.02	<0.02	<0.02	<0.02
Phenanthrene	µg/g	0.69	0.02	0.32	0.13	0.63	0.03	0.14	**0.76**	0.03	0.04
Anthracene	µg/g	0.16	0.02	0.09	0.04	0.15	<0.02	0.03	<0.02	<0.02	<0.02
Fluoranthene	µg/g	1.1	0.02	0.48	0.22	0.82	0.06	0.19	0.12	<0.02	0.02
Pyrene	µg/g	1.0	0.02	0.42	0.24	0.71	0.06	0.16	0.15	<0.02	0.02
Benzo(a)anthracene	µg/g	0.74	0.02	0.25	0.10	0.39	0.03	0.09	0.08	<0.02	<0.02
Chrysene	µg/g	0.69	0.02	0.27	0.11	0.43	0.04	0.10	0.19	0.02	0.03
Benzo(b)fluoranthene	µg/g	0.47	0.02	0.22	0.07	0.31	0.04	0.07	0.05	<0.02	<0.02
Benzo(k)fluoranthene	µg/g	0.48	0.02	0.10	0.03	0.14	0.02	0.03	<0.02	<0.02	<0.02
Benzo(a)pyrene	µg/g	0.49	0.02	0.30	0.11	0.40	0.06	0.10	0.04	<0.02	<0.02
Indeno(1,2,3-cd)pyrene	µg/g	0.38	0.02	0.19	0.05	0.23	0.04	0.05	<0.02	<0.02	<0.02
Dibenz(a,h)anthracene	µg/g	0.16	0.02	0.04	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	<0.02
Benzo(g,h,i)perylene	µg/g	0.68	0.02	0.27	0.06	0.29	0.05	0.07	0.04	<0.02	<0.02
2-and 1-methyl Naphthalene	µg/g		0.05	0.10	0.12	0.13	<0.05	0.09	1.1	<0.05	0.09
Surrogate	**Unit**	**Acceptable Limits**									
Chrysene-d12	%	60-130		91	91	96	85	87	104	81	82

Certified By: Jordy Takewski

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AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 PAHs in Soil

DATE SAMPLED: Mar 03, 2010 | **DATE RECEIVED: Mar 05, 2010** | **DATE REPORTED: Mar 11, 2010** | **SAMPLE TYPE: Soil**

Parameter	Unit	G / S	RDL	MW09-02B 1680915	BH09-03A 1680919	RDL	BH09-03B 1680923	RDL	BHX1 1680927
Naphthalene	µg/g	0.09	0.03	<0.03	**0.41**	0.06	<0.06	0.03	<0.03
Acenaphthylene	µg/g	0.08	0.02	<0.02	0.02	0.04	<0.04	0.02	<0.02
Acenaphthene	µg/g	0.07	0.03	<0.03	0.05	0.06	<0.06	0.03	<0.03
Fluorene	µg/g	0.12	0.02	<0.02	0.11	0.04	<0.04	0.02	<0.02
Phenanthrene	µg/g	0.69	0.02	<0.02	**1.1**	0.04	<0.04	0.02	<0.02
Anthracene	µg/g	0.16	0.02	<0.02	0.12	0.04	<0.04	0.02	<0.02
Fluoranthene	µg/g	1.1	0.02	<0.02	0.15	0.04	<0.04	0.02	<0.02
Pyrene	µg/g	1.0	0.02	<0.02	0.25	0.04	<0.04	0.02	<0.02
Benzo(a)anthracene	µg/g	0.74	0.02	<0.02	0.13	0.04	<0.04	0.02	<0.02
Chrysene	µg/g	0.69	0.02	<0.02	0.21	0.04	<0.04	0.02	<0.02
Benzo(b)fluoranthene	µg/g	0.47	0.02	<0.02	0.06	0.04	<0.04	0.02	<0.02
Benzo(k)fluoranthene	µg/g	0.48	0.02	<0.02	0.02	0.04	<0.04	0.02	<0.02
Benzo(a)pyrene	µg/g	0.49	0.02	<0.02	0.10	0.04	<0.04	0.02	<0.02
Indeno(1,2,3-cd)pyrene	µg/g	0.38	0.02	<0.02	0.03	0.04	<0.04	0.02	<0.02
Dibenz(a,h)anthracene	µg/g	0.16	0.02	<0.02	<0.02	0.04	<0.04	0.02	<0.02
Benzo(g,h,i)perylene	µg/g	0.68	0.02	<0.02	0.08	0.04	<0.04	0.02	<0.02
2-and 1-methyl Naphthalene	µg/g		0.05	<0.05	1.6	0.10	<0.10	0.05	<0.05
Surrogate	**Unit**	**Acceptable Limits**							
Chrysene-d12	%	60-130		91	103		90		89

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All)

1680873-1680919 Results are based on the dry weight of the soil.

1680923 Results are based on the dry weight of the soil.
Due to the high moisture content of the sample the reporting detection limit has been raised.

1680927 Results are based on the dry weight of the soil.

Certified By: Jordy Takewchi

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Guideline Violation

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Antimony	1.0	28.8
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Barium	210	604
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Cadmium	1.0	4.8
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Copper	85	256
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	0.642
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Lead	120	1160
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Mercury	0.23	0.251
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Nickel	43	212
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Silver	0.42	0.6
1680873	MW09-05A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Zinc	160	817
1680882	BHX	T1(All)	O. Reg 153 - Volatile Organic Compounds in Soil	Trichloroethylene	0.004	0.006
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Antimony	1.0	16.8
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Barium	210	399
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Cadmium	1.0	3.9
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Copper	85	135
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Lead	120	627
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Nickel	43	131
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Silver	0.42	0.5
1680882	BHX	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Zinc	160	546
1680882	BHX	T1(All)	O. Reg. 153 PAHs in Soil	Naphthalene	0.09	0.14
1680890	BH09-06B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chromium	71	111
1680895	MW09-07A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Antimony	1.0	6.8
1680895	MW09-07A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chromium	71	136
1680895	MW09-07A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Lead	120	302
1680895	MW09-07A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Nickel	43	170
1680895	MW09-07A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Zinc	160	172
1680897	MW09-07B	T1(All)	(P & T) BTEX - Soil (GC/MS)	Benzene	0.002	0.003
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Antimony	1.0	3.0
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Barium	210	304
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Cadmium	1.0	17.1
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chromium	71	1220
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Copper	85	367
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	2.28
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Lead	120	202
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Mercury	0.23	1.46
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Nickel	43	90
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Silver	0.42	8.9
1680897	MW09-07B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Zinc	160	2300
1680901	MW09-01B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chloride (2:1)	330	5310
1680901	MW09-01B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	9.05
1680901	MW09-01B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Sodium Adsorption Ratio (2:1)	2.4	85.8
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Antimony	1.0	1.5
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Arsenic	17	91

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Guideline Violation

AGAT WORK ORDER: 10T389881

PROJECT NO: MA-10-006-00-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Beryllium	1.2	2.8
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chloride (2:1)	330	978
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	2.32
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Mercury	0.23	0.353
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Molybdenum	2.5	8.5
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Selenium	1.9	2.7
1680903	MW09-04A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Sodium Adsorption Ratio (2:1)	2.4	11.2
1680903	MW09-04A	T1(All)	O. Reg. 153 PAHs in Soil	Naphthalene	0.09	0.22
1680903	MW09-04A	T1(All)	O. Reg. 153 PAHs in Soil	Phenanthrene	0.69	0.76
1680907	MW09-04B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chloride (2:1)	330	1160
1680907	MW09-04B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	2.51
1680907	MW09-04B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Sodium Adsorption Ratio (2:1)	2.4	27.2
1680911	MW09-02A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	0.700
1680915	MW09-02B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chloride (2:1)	330	1010
1680915	MW09-02B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	2.52
1680915	MW09-02B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Sodium Adsorption Ratio (2:1)	2.4	14.7
1680919	BH09-03A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Arsenic	17	110
1680919	BH09-03A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	2.94
1680919	BH09-03A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Selenium	1.9	2.2
1680919	BH09-03A	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Sodium Adsorption Ratio (2:1)	2.4	2.52
1680919	BH09-03A	T1(All)	O. Reg. 153 PAHs in Soil	Naphthalene	0.09	0.41
1680919	BH09-03A	T1(All)	O. Reg. 153 PAHs in Soil	Phenanthrene	0.69	1.1
1680923	BH09-03B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Chloride (2:1)	330	504
1680923	BH09-03B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	1.71
1680923	BH09-03B	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Sodium Adsorption Ratio (2:1)	2.4	13.0
1680927	BHX1	T1(All)	O. Reg. 153 Metals & Inorganics in Soil - Table 1	Electrical Conductivity (2:1)	0.57	0.763

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AGAT WORK ORDER: 10T390487

PROJECT NO: MA1000600MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 558 Metals and Inorganics

DATE SAMPLED: Mar 03, 2010 | DATE RECEIVED: Mar 09, 2010 | DATE REPORTED: Mar 12, 2010 | SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	South Spur 1684672	West Whart (South) 1684673	West Whart (North) 1684674
Arsenic Leachate	mg/L	2.5	0.010	<0.010	0.075	<0.010
Barium Leachate	mg/L	100	0.100	1.00	2.04	0.747
Boron Leachate	mg/L	500	0.050	0.062	0.063	0.051
Cadmium Leachate	mg/L	0.5	0.010	<0.010	<0.010	<0.010
Chromium Leachate	mg/L	5.0	0.010	<0.010	<0.010	<0.010
Lead Leachate	mg/L	5.0	0.010	0.010	<0.010	<0.010
Mercury Leachate	mg/L	0.1	0.005	<0.005	<0.005	<0.005
Selenium Leachate	mg/L	1.0	0.010	<0.010	<0.010	<0.010
Silver Leachate	mg/L	5.0	0.010	<0.010	<0.010	<0.010
Uranium Leachate	mg/L	10.0	0.050	<0.050	<0.050	<0.050
Fluoride Leachate	mg/L	150	0.05	0.13	0.10	0.19
Cyanide Leachate	mg/L	20.0	0.05	<0.05	<0.05	<0.05
(Nitrate + Nitrite) as N Leachate	mg/L	1000	0.70	<0.70	<0.70	<0.70

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Regulation 558

Certified By:

AGAT Laboratories

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AGAT WORK ORDER: 10T390487

PROJECT NO: MA1000600MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

Soil Analysis - Total Organic Carbon (W-B Wet Oxidation)

DATE SAMPLED: Mar 04, 2010 | DATE RECEIVED: Mar 09, 2010 | DATE REPORTED: Mar 12, 2010 | SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	MW09-01 SS3 1684668	MW09-03 SS2 1684670	MW09-05 SS1 1684671
Total Organic Carbon	%		0.15	0.93	2.10	1.66

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:

AGAT Laboratories

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AGAT WORK ORDER: 10T390487

PROJECT NO: MA1000600MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

ON Regulation 558 PCBs

DATE SAMPLED: Mar 03, 2010 | DATE RECEIVED: Mar 09, 2010 | DATE REPORTED: Mar 12, 2010 | SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	South Spur 1684672	West Whart (South) 1684673	West Whart (North) 1684674
Polychlorinated Biphenyls	mg/L	0.3	0.005	<0.005	<0.005	<0.005

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Regulation 558

1684672-1684674 The soil sample was leached using the Regulation 558 procedure. Analysis was performed on the leachate.

Certified By: Jordy Takewchi

AGAT Laboratories

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Certificate of Analysis

AGAT WORK ORDER: 10T390487

PROJECT NO: MA1000600MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

ON Regulation 558 SVOCs

DATE SAMPLED: Mar 03, 2010 | DATE RECEIVED: Mar 09, 2010 | DATE REPORTED: Mar 12, 2010 | SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	South Spur 1684672	West Whart (South) 1684673	West Whart (North) 1684674
Pyridine	mg/L	5.0	0.010	<0.010	<0.010	<0.010
Cresols	mg/L	200	0.012	<0.012	<0.012	<0.012
Ortho-Cresol	mg/L	200	0.004	<0.004	<0.004	<0.004
Meta & Para-Cresol	mg/L	200	0.008	<0.008	<0.008	<0.008
Hexachloroethane	mg/L	3.0	0.004	<0.004	<0.004	<0.004
Nitrobenzene	mg/L	2.0	0.004	<0.004	<0.004	<0.004
Hexachlorobutadiene	mg/L	0.5	0.004	<0.004	<0.004	<0.004
2,4,6-Trichlorophenol	mg/L	0.5	0.05	<0.05	<0.05	<0.05
2,4,5-Trichlorophenol	mg/L	400	0.004	<0.004	<0.004	<0.004
2,4-Dinitrotoluene	mg/L	0.13	0.004	<0.004	<0.004	<0.004
2,3,4,6-Tetrachlorophenol	mg/L	10.0	0.004	<0.004	<0.004	<0.004
Hexachlorobenzene	mg/L	0.13	0.004	<0.004	<0.004	<0.004
Dinoseb	mg/L	1.0	0.004	<0.004	<0.004	<0.004
Benzo(a)pyrene	mg/L	0.001	0.001	<0.001	<0.001	<0.001

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Regulation 558

1684672 The sample was leached according to Regulation 558 protocol. Analysis was performed on the leachate.
Surrogate recovery for 2,4,6-Tribromophenol: 105 %.
Surrogate recovery for Chrysene-12: 104 %.
Results relate only to the items tested.

1684673 The sample was leached according to Regulation 558 protocol. Analysis was performed on the leachate.
Surrogate recovery for 2,4,6-Tribromophenol: 107 %.
Surrogate recovery for Chrysene-12: 102%.
Results relate only to the items tested.

1684674 The sample was leached according to Regulation 558 protocol. Analysis was performed on the leachate.
Surrogate recovery for 2,4,6-Tribromophenol: 110%.
Surrogate recovery for Chrysene-12: 106 %.
Results relate only to the items tested.

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T390487

PROJECT NO: MA1000600MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

ON Regulation 558 VOCs

DATE SAMPLED: Mar 03, 2010 | DATE RECEIVED: Mar 09, 2010 | DATE REPORTED: Mar 12, 2010 | SAMPLE TYPE: Soil

Parameter	Unit	G / S	RDL	South Spur 1684672	West Whart (South) 1684673	West Whart (North) 1684674
Vinyl Chloride	mg/L	0.2	0.030	<0.030	<0.030	<0.030
1,1 Dichloroethene	mg/L	1.4	0.020	<0.020	<0.020	<0.020
Dichloromethane	mg/L	5.0	0.030	<0.030	<0.030	<0.030
Methyl Ethyl Ketone	mg/L	200	0.090	<0.090	<0.090	<0.090
Chloroform	mg/L	10.0	0.020	<0.020	<0.020	<0.020
1,2-Dichloroethane	mg/L	0.5	0.020	<0.020	<0.020	<0.020
Carbon Tetrachloride	mg/L	0.5	0.020	<0.020	<0.020	<0.020
Benzene	mg/L	0.5	0.020	<0.020	<0.020	<0.020
Trichloroethene	mg/L	5.0	0.020	<0.020	<0.020	<0.020
Tetrachloroethene	mg/L	3.0	0.010	<0.010	<0.010	<0.010
Chlorobenzene	mg/L	8.0	0.010	<0.010	<0.010	<0.010
1,2-Dichlorobenzene	mg/L	20.0	0.010	<0.010	<0.010	<0.010
1,4-Dichlorobenzene	mg/L	0.5	0.010	<0.010	<0.010	<0.010
Surrogate	Unit	Acceptable Limits				
Toluene-d8	% Recovery	60-130		100	94	92

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to Reg. 558

1684672-1684674 Sample was prepared using Regulation 558 protocol and a zero headspace extractor.

Certified By: Jordy Takewchi

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 Petroleum Hydrocarbon F1 - F4 in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW21 1692221	MW58 1692295	MW24 1692300	MW33 1692309	MW22 1692320	MW36 1692364	MW09-01 1692405	MW302 1692424
Benzene	µg/L	5.0	0.2	<0.2	<0.2	0.25	<0.2	0.73	<0.2	<0.2	<0.2
Toluene	µg/L	0.8	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Ethylbenzene	µg/L	2.4	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Xylene Mixture (Total)	µg/L	72	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
C6 - C10 (F1)	µg/L		25	<25	<25	<25	<25	<25	<25	<25	<25
C6 - C10 (F1 minus BTEX)	µg/L		25	<25	<25	<25	<25	<25	<25	<25	<25
C>10 - C16 (F2)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C6 - C16 (F1 + F2)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>16 - C34 (F3)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>34 - C50 (F4)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>16 - C50 (F3 + F4)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
Gravimetric Heavy Hydrocarbons	µg/L		500	NA	NA	NA	NA	NA	NA	NA	NA

Parameter	Unit	G / S	RDL	MW6 1692449
Benzene	µg/L	5.0	0.2	<0.2
Toluene	µg/L	0.8	0.2	<0.2
Ethylbenzene	µg/L	2.4	0.1	<0.1
Xylene Mixture (Total)	µg/L	72	0.2	<0.2
C6 - C10 (F1)	µg/L		25	<25
C6 - C10 (F1 minus BTEX)	µg/L		25	<25
C>10 - C16 (F2)	µg/L		100	<100
C6 - C16 (F1 + F2)	µg/L		100	<100
C>16 - C34 (F3)	µg/L		100	<100
C>34 - C50 (F4)	µg/L		100	<100
C>16 - C50 (F3 + F4)	µg/L		100	<100
Gravimetric Heavy Hydrocarbons	µg/L		500	NA

Certified By: Jordy Takewski

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 Petroleum Hydrocarbon F1 - F4 in Water

DATE SAMPLED: Mar 12, 2010	DATE RECEIVED: Mar 16, 2010	DATE REPORTED: Mar 24, 2010	SAMPLE TYPE: Water

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All-GW)

1692221-1692449 The C6-C10 fraction is calculated using Toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and nC34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16 - C50 and are only determined if the chromatogram of the C34 - C50 Hydrocarbons indicated that hydrocarbons >C50 are present.
Total C6-C50 results are corrected for BTEX contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.
Fractions 1-4 are quantified with the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.
NA = Not Applicable

Certified By: Jordy Takewski

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 Petroleum Hydrocarbon F1 - F4 in Water (-BTEX)

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW09-07 1692395
C6 - C10 (F1)	µg/L		25	<25
C6 - C10 (F1 minus BTEX)	µg/L		25	<25
C>10 - C16 (F2)	µg/L		100	<100
C6 - C16 (F1 + F2)	µg/L		100	<100
C>16 - C34 (F3)	µg/L		100	<100
C>34 - C50 (F4)	µg/L		100	<100
C>16 - C50 (F3 + F4)	µg/L		100	<100
Gravimetric Heavy Hydrocarbons	µg/L		500	NA

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

1692395
The C6-C10 fraction is calculated using Toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and nC34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16 - C50 and are only determined if the chromatogram of the C34 - C50 Hydrocarbons indicated that hydrocarbons >C50 are present.
Total C6-C50 results are corrected for BTEX and PAH contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.
Fractions 1-4 are quantified without the contribution of PAHs. Under Ontario Regulation 153, results are considered valid without determining the PAH contribution if not requested by the client.

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 Petroleum Hydrocarbon F1 - F4 in Water (With PAHs)

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW27 1692355	MW09-05 1692372	MW09-00 1692382	MW09-04 1692551	MW308 1692572	MW09-2i 1692589	MW09-100 1692596	MW09-2ii 1692612
C6 - C10 (F1)	µg/L		25	<25	<25	<25	<25	27	<25	<25	<25
C6 - C10 (F1 minus BTEX)	µg/L		25	<25	<25	<25	<25	27	<25	<25	<25
C>10 - C16 (F2)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>10 - C16 (F2 minus Naphthalene)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C6 - C16 (F1 + F2)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>16 - C34 (F3)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>16 - C34 (F3 minus PAHs)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>34 - C50 (F4)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
C>16 - C50 (F3 + F4)	µg/L		100	<100	<100	<100	<100	<100	<100	<100	<100
Gravimetric Heavy Hydrocarbons	µg/L		500	NA	NA	NA	NA	NA	NA	NA	NA

Parameter	Unit	G / S	RDL	MW3-10 1692661
C6 - C10 (F1)	µg/L		25	610
C6 - C10 (F1 minus BTEX)	µg/L		25	610
C>10 - C16 (F2)	µg/L		100	430
C>10 - C16 (F2 minus Naphthalene)	µg/L		100	430
C6 - C16 (F1 + F2)	µg/L		100	1000
C>16 - C34 (F3)	µg/L		100	500
C>16 - C34 (F3 minus PAHs)	µg/L		100	500
C>34 - C50 (F4)	µg/L		100	<100
C>16 - C50 (F3 + F4)	µg/L		100	500
Gravimetric Heavy Hydrocarbons	µg/L		500	NA

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

1692355-1692661 The C6-C10 fraction is calculated using Toluene response factor.
The C10 - C16, C16 - C34, and C34 - C50 fractions are calculated using the average response factor for n-C10, n-C16, and nC34.
Gravimetric Heavy Hydrocarbons are not included in the Total C16 - C50 and are only determined if the chromatogram of the C34 - C50 Hydrocarbons indicated that hydrocarbons >C50 are present.
Total C6-C50 results are corrected for BTEX and PAH contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
nC10, nC16 and nC34 response factors are within 10% of their average.
C50 response factor is within 70% of nC10 + nC16 nC34 average.
Linearity is within 15%.
Extraction and holding times were met for this sample.

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 Petroleum Hydrocarbon F1 in Water (-BTEX)

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW34 1692342
C6 - C10 (F1)	µg/L		25	<25
C6 - C10 (F1 minus BTEX)	µg/L		25	<25

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

1692342
The C6-C10 fraction is calculated using Toluene response factor.
Total C6-C10 results are corrected for BTEX contributions.
This method complies with the Reference Method for the CWS PHC and is validated for use in the laboratory.
nC6 and nC10 response factors are within 30% of Toluene response factor.
Linearity is within 15%.
Extraction and holding times were met for this sample.

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 PAHs in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW27 1692355	MW09-05 1692372	MW09-00 1692382	MW09-04 1692551	MW308 1692572	MW09-2i 1692589	MW09-100 1692596	MW09-2ii 1692612
Naphthalene	µg/L	7.0	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Acenaphthylene	µg/L	1.0	0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11	<0.11
Acenaphthene	µg/L	1.0	0.10	<0.10	<0.10	<0.10	<0.10	1.6	<0.10	<0.10	<0.10
Fluorene	µg/L	1.0	0.09	<0.09	<0.09	<0.09	<0.09	2.0	<0.09	<0.09	<0.09
Phenanthrene	µg/L	1.0	0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.22
Anthracene	µg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Fluoranthene	µg/L	1.0	0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12	<0.12
Pyrene	µg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(a)anthracene	µg/L	0.1	0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08	<0.08
Chrysene	µg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(b)fluoranthene	µg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Benzo(k)fluoranthene	µg/L	0.05	0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
Benzo(a)pyrene	µg/L	0.005	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno(1,2,3-cd)pyrene	µg/L	0.1	0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03	<0.03
Dibenzo(a,h)anthracene	µg/L	0.1	0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09	<0.09
Benzo(g,h,i)perylene	µg/L	0.10	0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06	<0.06
2-and 1-methyl Napthalene	µg/L	2.5	0.20	<0.20	<0.20	<0.20	<0.20	0.20	<0.20	<0.20	<0.20
Surrogate	Unit	Acceptable Limits									
Chrysene-d12	%	60-130		115	106	111	105	108	105	109	109

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg. 153 PAHs in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW3-10 1692661
Naphthalene	µg/L	7.0	0.12	<0.12
Acenaphthylene	µg/L	1.0	0.11	<0.11
Acenaphthene	µg/L	1.0	0.10	0.51
Fluorene	µg/L	1.0	0.09	0.55
Phenanthrene	µg/L	1.0	0.10	<0.10
Anthracene	µg/L	0.05	0.05	<0.05
Fluoranthene	µg/L	1.0	0.12	<0.12
Pyrene	µg/L	0.05	0.05	<0.05
Benzo(a)anthracene	µg/L	0.1	0.08	<0.08
Chrysene	µg/L	0.05	0.05	<0.05
Benzo(b)fluoranthene	µg/L	0.05	0.05	<0.05
Benzo(k)fluoranthene	µg/L	0.05	0.06	<0.06
Benzo(a)pyrene	µg/L	0.005	0.01	<0.01
Indeno(1,2,3-cd)pyrene	µg/L	0.1	0.03	<0.03
Dibenzo(a,h)anthracene	µg/L	0.1	0.09	<0.09
Benzo(g,h,i)perylene	µg/L	0.10	0.06	<0.06
2-and 1-methyl Napthalene	µg/L	2.5	0.20	7.6
Surrogate	Unit	Acceptable Limits		
Chrysene-d12	%	60-130		112

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All-GW)

Certified By: Jordy Takewski

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Regulation 153 - Volatile Organic Compounds in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW34 1692342	MW27 1692355	RDL	MW09-05 1692372	MW09-00 1692382	RDL	MW09-07 1692395	MW09-04 1692551
Dichlorodifluoromethane	µg/L		0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Chloromethane	µg/L		0.80	<0.80	<0.80	0.40	<0.40	<0.40	0.80	<0.80	<0.80
Vinyl Chloride	µg/L	0.5	0.34	<0.34	<0.34	0.17	<0.17	<0.17	0.34	<0.34	<0.34
Bromomethane	µg/L	0.9	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Chloroethane	µg/L		0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Trichlorofluoromethane	µg/L		0.80	<0.80	<0.80	0.40	<0.40	<0.40	0.80	<0.80	<0.80
Acetone	µg/L		2.0	61	<2.0	1.0	<1.0	<1.0	2.0	<2.0	<2.0
1,1 Dichloroethylene	µg/L	0.66	0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
Methylene Chloride	µg/L	50	0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
trans- 1,2-dichloroethylene	µg/L	100	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Methyl tert-butyl ether	µg/L	200	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
1,1-Dichloroethane	µg/L	70	0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
Methyl Ethyl Ketone	µg/L	350	2.0	<2.0	<2.0	1.0	<1.0	<1.0	2.0	<2.0	<2.0
cis- 1,2-Dichloroethylene	µg/L	70	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Chloroform	µg/L	0.5	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
1,2 - Dichloroethane	µg/L	5.0	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
1,1,1-Trichloroethane	µg/L	10	0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
Carbon Tetrachloride	µg/L	0.5	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Benzene	µg/L	5.0	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	1.8	<0.40
1,2-Dichloropropane	µg/L	0.7	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Trichloroethylene	µg/L	20	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Bromodichloromethane	µg/L	5.0	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
cis-1,3-Dichloropropene	ug/L		0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Methyl Isobutyl Ketone	µg/L		2.0	<2.0	<2.0	1.0	<1.0	<1.0	2.0	<2.0	<2.0
trans-1,3-Dichloropropene	µg/L		0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
1,1,2-Trichloroethane	µg/L	5	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Toluene	µg/L	0.8	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
2-Hexanone	µg/L		0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
Dibromochloromethane	µg/L	0.5	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
Ethylene Dibromide	µg/L	1.0	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Tetrachloroethylene	µg/L	5.0	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
1,1,1,2-Tetrachloroethane	µg/L	5.0	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
Chlorobenzene	µg/L	15	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20

Certified By: Jordy Takewchi

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Regulation 153 - Volatile Organic Compounds in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW34 1692342	MW27 1692355	RDL	MW09-05 1692372	MW09-00 1692382	RDL	MW09-07 1692395	MW09-04 1692551
Ethylbenzene	µg/L	2.4	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
m & p-Xylene	µg/L		0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Bromoform	µg/L	5.0	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
Styrene	µg/L	4.0	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
1,1,2,2-Tetrachloroethane	µg/L	1.0	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
o-Xylene	µg/L		0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
1,3-Dichlorobenzene	µg/L	2.5	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
1,4-Dichlorobenzene	µg/L	1.0	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
1,2-Dichlorobenzene	µg/L	2.5	0.20	<0.20	<0.20	0.10	<0.10	<0.10	0.20	<0.20	<0.20
1,2,4-Trichlorobenzene	µg/L	0.5	0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
1,3-Dichloropropene (Cis + Trans)	µg/L	1.4	0.60	<0.60	<0.60	0.30	<0.30	<0.30	0.60	<0.60	<0.60
Xylene Mixture (Total)	µg/L	72	0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
n-Hexane	µg/L		0.40	<0.40	<0.40	0.20	<0.20	<0.20	0.40	<0.40	<0.40
Surrogate	Unit	Acceptable Limits									
Toluene-d8	% Recovery	60-130		98	95		91	90		94	98
4-Bromofluorobenzene	% Recovery	70-130		95	102		96	104		98	99

Certified By: Jordy Takewchi

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Regulation 153 - Volatile Organic Compounds in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW308 1692572	MW09-2i 1692589	MW09-100 1692596	RDL	MW09-2ii 1692612	RDL	MW3-10 1692661
Dichlorodifluoromethane	µg/L		0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Chloromethane	µg/L		0.80	<0.80	<0.80	<0.80	0.40	<0.40	0.80	<0.80
Vinyl Chloride	µg/L	0.5	0.34	<0.34	<0.34	<0.34	0.17	<0.17	0.34	<0.34
Bromomethane	µg/L	0.9	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Chloroethane	µg/L		0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Trichlorofluoromethane	µg/L		0.80	<0.80	<0.80	<0.80	0.40	<0.40	0.80	<0.80
Acetone	µg/L		2.0	<2.0	<2.0	<2.0	1.0	<1.0	2.0	<2.0
1,1 Dichloroethylene	µg/L	0.66	0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
Methylene Chloride	µg/L	50	0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
trans- 1,2-dichloroethylene	µg/L	100	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Methyl tert-butyl ether	µg/L	200	0.40	23	<0.40	<0.40	0.20	<0.20	0.40	<0.40
1,1-Dichloroethane	µg/L	70	0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
Methyl Ethyl Ketone	µg/L	350	2.0	<2.0	<2.0	<2.0	1.0	<1.0	2.0	<2.0
cis- 1,2-Dichloroethylene	µg/L	70	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Chloroform	µg/L	0.5	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
1,2 - Dichloroethane	µg/L	5.0	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
1,1,1-Trichloroethane	µg/L	10	0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
Carbon Tetrachloride	µg/L	0.5	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Benzene	µg/L	5.0	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	8.7
1,2-Dichloropropane	µg/L	0.7	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Trichloroethylene	µg/L	20	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Bromodichloromethane	µg/L	5.0	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
cis-1,3-Dichloropropene	ug/L		0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Methyl Isobutyl Ketone	µg/L		2.0	<2.0	<2.0	<2.0	1.0	<1.0	2.0	<2.0
trans-1,3-Dichloropropene	µg/L		0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
1,1,2-Trichloroethane	µg/L	5	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Toluene	µg/L	0.8	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	7.2
2-Hexanone	µg/L		0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
Dibromochloromethane	µg/L	0.5	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
Ethylene Dibromide	µg/L	1.0	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
Tetrachloroethylene	µg/L	5.0	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	<0.40
1,1,1,2-Tetrachloroethane	µg/L	5.0	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
Chlorobenzene	µg/L	15	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20

Certified By: Jordy Takewchi

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Regulation 153 - Volatile Organic Compounds in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW308 1692572	MW09-2i 1692589	MW09-100 1692596	RDL	MW09-2ii 1692612	RDL	MW3-10 1692661
Ethylbenzene	µg/L	2.4	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	69
m & p-Xylene	µg/L		0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	17
Bromoform	µg/L	5.0	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
Styrene	µg/L	4.0	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
1,1,2,2-Tetrachloroethane	µg/L	1.0	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
o-Xylene	µg/L		0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	2.4
1,3-Dichlorobenzene	µg/L	2.5	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
1,4-Dichlorobenzene	µg/L	1.0	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
1,2-Dichlorobenzene	µg/L	2.5	0.20	<0.20	<0.20	<0.20	0.10	<0.10	0.20	<0.20
1,2,4-Trichlorobenzene	µg/L	0.5	0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
1,3-Dichloropropene (Cis + Trans)	µg/L	1.4	0.60	<0.60	<0.60	<0.60	0.30	<0.30	0.60	<0.60
Xylene Mixture (Total)	µg/L	72	0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	19
n-Hexane	µg/L		0.40	<0.40	<0.40	<0.40	0.20	<0.20	0.40	1.5
Surrogate	Unit	Acceptable Limits								
Toluene-d8	% Recovery	60-130		88	91	90		91		113
4-Bromofluorobenzene	% Recovery	70-130		102	96	96		104		109

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All-GW)

1692342-1692355 Dilution factor=2
The sample was diluted Because it was foamy. The reporting detection limit has been corrected for the dilution factor used.

1692395-1692596 Dilution factor=2
The sample was diluted Because it was foamy. The reporting detection limit has been corrected for the dilution factor used.

1692612 Dilution factor=
The sample was diluted to keep the target compounds in the calibration range of the instrument and avoid contaminating the Purge and Trap system. The reporting detection limit has been corrected for the dilution factor used.

1692661 Dilution factor=2
The sample was diluted Because it was foamy. The reporting detection limit has been corrected for the dilution factor used.

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Metals & Inorganics in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW21 1692221	MW58 1692295	MW24 1692300	MW33 1692309	MW22 1692320	MW34 1692342	MW27 1692355	MW36 1692364
Antimony	µg/L	6.0	0.5	45.0	3.0	1.2	0.5	2.1	1.1	8.8	1.0
Arsenic	µg/L	25	1.0	1.2	1.0	3.5	1.2	10.0	2.8	3.0	8.2
Barium	µg/L		2.0	50.5	211	693	163	1610	106	185	145
Beryllium	µg/L	4.0	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/L	200	10.0	781	175	403	216	184	269	105	237
Cadmium	µg/L	0.5	0.2	1.5	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium	µg/L	8.9	2.0	2.0	2.7	7.4	9.4	9.5	11.4	18.3	13.5
Cobalt	µg/L	0.9	0.5	2.8	2.0	0.5	0.7	1.9	1.2	2.0	2.6
Copper	µg/L	2.5	1.0	7.7	2.3	1.4	1.6	1.2	2.2	2.0	2.1
Lead	µg/L	1	0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	1.3	0.7
Molybdenum	µg/L	40	0.5	5.0	4.7	0.9	0.6	35.1	1.5	1.1	1.6
Nickel	µg/L	25	1.0	209	24.2	11.5	15.9	98.4	35.7	226	62.5
Selenium	µg/L	5.0	1.0	10.2	1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Silver	µg/L	0.25	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/L	0.5	0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Uranium	µg/L		0.5	2.9	1.6	<0.5	<0.5	0.9	1.7	<0.5	<0.5
Vanadium	µg/L	6.0	0.4	<0.4	<0.4	<0.4	<0.4	0.5	<0.4	0.8	<0.4
Zinc	µg/L	20	5.0	622	78.3	8.5	9.9	9.6	19.1	184	8.8
Mercury	µg/L	0.02	0.02	No Sample	<0.02	<0.02	<0.02	<0.02	No Sample	<0.02	<0.02
Chromium VI	µg/L	10	5	<5	<5	<5	<5	<5	<5	<5	<5
Cyanide, Free	µg/L	5.0	2	No Sample	<2	<2	<2	<2	No Sample	No Sample	<2
Sodium	µg/L		50	67700	65000	48400	85700	63700	98200	78000	22900
Chloride	µg/L		100	55900	9780	8220	28600	19100	48300	56200	12700
Nitrate as N	µg/L		50	423	<50	<50	<50	<50	<50	<50	99
Nitrite as N	µg/L		50	<50	<50	<50	<50	<50	<50	<50	<50
Electrical Conductivity	uS/cm		2	2030	1330	1300	1740	1460	2670	2060	1680
pH	pH Units		NA	7.88	7.93	7.59	7.58	7.66	7.73	7.61	7.70

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AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Metals & Inorganics in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW09-05 1692372	MW09-00 1692382	MW09-07 1692395	RDL	MW09-01 1692405	RDL	MW302 1692424	MW6 1692449
Antimony	µg/L	6.0	0.5	<0.5	<0.5	<0.5	0.5	2.8	0.5	<0.5	<0.5
Arsenic	µg/L	25	1.0	1.5	1.5	2.1	1.0	3.3	1.0	3.6	1.8
Barium	µg/L		2.0	168	164	100	2.0	1540	2.0	122	157
Beryllium	µg/L	4.0	0.5	<0.5	<0.5	<0.5	0.5	<0.5	0.5	<0.5	<0.5
Boron	µg/L	200	10.0	290	250	215	10.0	17.1	10.0	48.2	97.9
Cadmium	µg/L	0.5	0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2
Chromium	µg/L	8.9	2.0	6.2	7.5	12.0	2.0	2.5	2.0	4.3	9.7
Cobalt	µg/L	0.9	0.5	0.5	0.6	1.5	0.5	4.2	0.5	1.0	0.7
Copper	µg/L	2.5	1.0	<1.0	<1.0	1.1	1.0	4.7	1.0	1.8	1.5
Lead	µg/L	1	0.5	<0.5	<0.5	1.0	0.5	<0.5	0.5	<0.5	<0.5
Molybdenum	µg/L	40	0.5	<0.5	<0.5	0.7	0.5	1.7	0.5	1.8	0.8
Nickel	µg/L	25	1.0	3.6	3.3	11.3	1.0	<1.0	1.0	2.7	3.2
Selenium	µg/L	5.0	1.0	<1.0	<1.0	3.2	1.0	<1.0	1.0	<1.0	2.4
Silver	µg/L	0.25	0.2	<0.2	<0.2	<0.2	0.2	<0.2	0.2	<0.2	<0.2
Thallium	µg/L	0.5	0.3	<0.3	<0.3	<0.3	0.3	<0.3	0.3	<0.3	<0.3
Uranium	µg/L		0.5	<0.5	<0.5	<0.5	0.5	0.8	0.5	0.6	<0.5
Vanadium	µg/L	6.0	0.4	<0.4	<0.4	<0.4	0.4	<0.4	0.4	2.8	2.3
Zinc	µg/L	20	5.0	<5.0	<5.0	6.9	5.0	15.9	5.0	7.2	<5.0
Mercury	µg/L	0.02	0.02	<0.02	<0.02	<0.02	0.02	<0.02	0.02	<0.02	<0.02
Chromium VI	µg/L	10	5	<5	<5	<5	5	<5	5	<5	<5
Cyanide, Free	µg/L	5.0	2	<2	<2	<2	2	<2	2	15	2
Sodium	µg/L		50	18000	18600	156000	50	17800000	50	1040000	350000
Chloride	µg/L		100	6460	6200	151000	2000	33300000	100	1860000	455000
Nitrate as N	µg/L		50	<50	<50	<50	1000	<1000	50	<50	<50
Nitrite as N	µg/L		50	<50	<50	<50	1000	<1000	50	<50	<50
Electrical Conductivity	uS/cm		2	1400	1400	2030	2	72500	2	5700	3740
pH	pH Units		NA	7.70	7.68	7.68	NA	7.15	NA	7.97	7.91

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Metals & Inorganics in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW09-04 1692551	RDL	MW308 1692572	MW09-2i 1692589	MW09-100 1692596	MW09-2ii 1692612	MW3-10 1692661	SW09-01 1692676
Antimony	µg/L	6.0	0.5	0.7	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Arsenic	µg/L	25	1.0	73.2	1.0	1.7	4.5	4.4	<1.0	3.3	<1.0
Barium	µg/L		2.0	102	2.0	97.6	90.9	91.6	40.7	91.2	28.8
Beryllium	µg/L	4.0	0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Boron	µg/L	200	10.0	1230	10.0	145	190	182	59.1	89.1	17.6
Cadmium	µg/L	0.5	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium	µg/L	8.9	2.0	2.0	2.0	5.2	<2.0	<2.0	<2.0	2.1	<2.0
Cobalt	µg/L	0.9	0.5	15.8	0.5	2.7	1.0	0.8	0.7	2.1	<0.5
Copper	µg/L	2.5	1.0	4.4	1.0	1.4	1.4	1.1	2.4	1.1	1.4
Lead	µg/L	1	0.5	0.5	0.5	<0.5	1.2	<0.5	<0.5	<0.5	0.6
Molybdenum	µg/L	40	0.5	15.1	0.5	1.1	<0.5	<0.5	0.9	1.0	0.9
Nickel	µg/L	25	1.0	21.2	1.0	3.2	<1.0	<1.0	3.3	5.4	1.1
Selenium	µg/L	5.0	1.0	3.6	1.0	1.5	<1.0	2.0	2.0	<1.0	<1.0
Silver	µg/L	0.25	0.2	<0.2	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thallium	µg/L	0.5	0.3	<0.3	0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
Uranium	µg/L		0.5	1.0	0.5	1.5	<0.5	<0.5	0.9	1.4	0.6
Vanadium	µg/L	6.0	0.4	0.5	0.4	0.4	2.9	3.5	<0.4	0.6	0.5
Zinc	µg/L	20	5.0	16.5	5.0	6.2	<5.0	<5.0	<5.0	<5.0	<5.0
Mercury	µg/L	0.02	0.02	<0.02	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	No Sample
Chromium VI	µg/L	10	5	<5	5	<5	<5	<5	<5	<5	<5
Cyanide, Free	µg/L	5.0	2	<2	2	<2	<2	<2	<2	<2	No Sample
Sodium	µg/L		50	8240000	50	234000	1100000	1100000	67400	54200	24100
Chloride	µg/L		1000	6740000	100	254000	1650000	1600000	66200	20300	46200
Nitrate as N	µg/L		500	<500	50	<50	<50	<50	940	<50	929
Nitrite as N	µg/L		500	<500	50	<50	<50	<50	<50	<50	<50
Electrical Conductivity	uS/cm		2	20600	2	2560	6390	6290	1650	1070	413
pH	pH Units		NA	7.51	NA	7.70	7.76	7.73	7.89	7.59	8.28

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

O. Reg 153 - Metals & Inorganics in Water

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	SW09-02 1692683	SW09-03 1692685	SW09-04 1692688
Antimony	µg/L	6.0	0.5	<0.5	<0.5	<0.5
Arsenic	µg/L	25	1.0	<1.0	<1.0	<1.0
Barium	µg/L		2.0	39.6	38.9	33.6
Beryllium	µg/L	4.0	0.5	<0.5	<0.5	<0.5
Boron	µg/L	200	10.0	17.6	14.6	17.0
Cadmium	µg/L	0.5	0.2	<0.2	<0.2	<0.2
Chromium	µg/L	8.9	2.0	<2.0	<2.0	<2.0
Cobalt	µg/L	0.9	0.5	<0.5	<0.5	<0.5
Copper	µg/L	2.5	1.0	1.6	1.6	1.3
Lead	µg/L	1	0.5	0.9	1.0	1.0
Molybdenum	µg/L	40	0.5	0.7	0.7	0.9
Nickel	µg/L	25	1.0	1.2	1.6	1.8
Selenium	µg/L	5.0	1.0	<1.0	<1.0	<1.0
Silver	µg/L	0.25	0.2	<0.2	<0.2	<0.2
Thallium	µg/L	0.5	0.3	<0.3	<0.3	<0.3
Uranium	µg/L		0.5	0.7	0.6	0.6
Vanadium	µg/L	6.0	0.4	1.0	0.9	0.4
Zinc	µg/L	20	5.0	20.5	19.2	6.3
Chromium VI	µg/L	10	5	<5	<5	<5
Sodium	µg/L		50	34600	34900	26600
Chloride	µg/L		100	64300	65600	56500
Nitrate as N	µg/L		50	1090	1190	817
Nitrite as N	µg/L		50	<50	<50	<50
Electrical Conductivity	uS/cm		2	509	511	4790
pH	pH Units		NA	8.32	8.33	8.35
Mercury	µg/L	0.02	0.02	No Sample	No Sample	No Sample
Cyanide, Free	µg/L	5.0	2	No Sample	No Sample	No Sample

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard: Refers to T1(All-GW)

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Certificate of Analysis

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

TSS (Water)

DATE SAMPLED: Mar 12, 2010 | DATE RECEIVED: Mar 16, 2010 | DATE REPORTED: Mar 24, 2010 | SAMPLE TYPE: Water

Parameter	Unit	G / S	RDL	MW21 1692221	MW58 1692295	MW24 1692300	MW33 1692309	MW22 1692320	MW34 1692342	MW27 1692355	MW36 1692364
Total Suspended Solids	mg/L		10	2850	1820	318	1340	782	234	3820	34600

Parameter	Unit	G / S	RDL	MW09-05 1692372	MW09-00 1692382	MW09-07 1692395	MW09-01 1692405	MW302 1692424	MW6 1692449	MW09-04 1692551	MW308 1692572
Total Suspended Solids	mg/L		10	5250	5720	446	16800	6840	1640	7420	1800

Parameter	Unit	G / S	RDL	MW09-2i 1692589	MW09-100 1692596	MW09-2ii 1692612	MW3-10 1692661
Total Suspended Solids	mg/L		10	5020	3820	378	1210

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

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Guideline Violation

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Antimony	6.0	45.0
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	781
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cadmium	0.5	1.5
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	2.8
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Copper	2.5	7.7
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Nickel	25	209
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Selenium	5.0	10.2
1692221	MW21	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Zinc	20	622
1692295	MW58	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	2.0
1692295	MW58	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Zinc	20	78.3
1692300	MW24	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	403
1692309	MW33	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	216
1692309	MW33	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	9.4
1692320	MW22	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	9.5
1692320	MW22	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	1.9
1692320	MW22	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Nickel	25	98.4
1692342	MW34	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	269
1692342	MW34	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	11.4
1692342	MW34	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	1.2
1692342	MW34	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Nickel	25	35.7
1692355	MW27	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Antimony	6.0	8.8
1692355	MW27	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	18.3
1692355	MW27	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	2.0
1692355	MW27	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Lead	1	1.3
1692355	MW27	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Nickel	25	226
1692355	MW27	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Zinc	20	184
1692364	MW36	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	237
1692364	MW36	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	13.5
1692364	MW36	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	2.6
1692364	MW36	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Nickel	25	62.5
1692372	MW09-05	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	290
1692382	MW09-00	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	250
1692395	MW09-07	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	215
1692395	MW09-07	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	12.0
1692395	MW09-07	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	1.5
1692405	MW09-01	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	4.2
1692405	MW09-01	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Copper	2.5	4.7
1692424	MW302	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	1.0
1692424	MW302	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cyanide, Free	5.0	15
1692449	MW6	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Chromium	8.9	9.7
1692551	MW09-04	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Arsenic	25	73.2
1692551	MW09-04	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Boron	200	1230
1692551	MW09-04	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	15.8

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Guideline Violation

AGAT WORK ORDER: 10T391800

PROJECT NO: MA-10-006-0O-MA

CLIENT NAME: GENIVAR ONTARIO INC.

ATTENTION TO: John Edwards

SAMPLEID	SAMPLE TITLE	GUIDELINE	ANALYSIS PACKAGE	PARAMETER	GUIDEVALUE	RESULT
1692551	MW09-04	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Copper	2.5	4.4
1692572	MW308	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	2.7
1692572	MW308	T1(All-GW)	O. Reg. 153 PAHs in Water	Acenaphthene	1.0	1.6
1692572	MW308	T1(All-GW)	O. Reg. 153 PAHs in Water	Fluorene	1.0	2.0
1692589	MW09-2i	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	1.0
1692589	MW09-2i	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Lead	1	1.2
1692661	MW3-10	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Cobalt	0.9	2.1
1692661	MW3-10	T1(All-GW)	O. Reg. 153 PAHs in Water	2-and 1-methyl Napthalene	2.5	7.6
1692661	MW3-10	T1(All-GW)	O. Regulation 153 - Volatile Organic Compounds in Water	Benzene	5.0	8.7
1692661	MW3-10	T1(All-GW)	O. Regulation 153 - Volatile Organic Compounds in Water	Ethylbenzene	2.4	69
1692661	MW3-10	T1(All-GW)	O. Regulation 153 - Volatile Organic Compounds in Water	Toluene	0.8	7.2
1692683	SW09-02	T1(All-GW)	O. Reg 153 - Metals & Inorganics in Water	Zinc	20	20.5

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consulting engineers

EMAIL

Email to :	John A. Edwards, B.A. EMPD	Email Address :	john.edwards@genivar.com
From :	Demetra Matthews	Date :	18 March 2010
Ref. No. :	10-033	Page 1 of 7	
Subject :	Laboratory Testing Genivar MA-10-006-00-MA		

Enclosed are the Grain Size Distribution Test Reports for testing carried out on six samples received in our office on 09 March 2010. Originals will follow by mail.

The table below provides soil permeability and bulk density of the following samples:

Samples	Depths (ft)	Soil Permeability (cm/s)	Bulk Density (tonnes/m^3)
MW 09-01	20 to 22	10^-2	unable to measure
MW 09-07	0 to 2	4 x 10^-6	2.02
MW 09-04	10 to 12	10^-7 or less	1.71

Regards.

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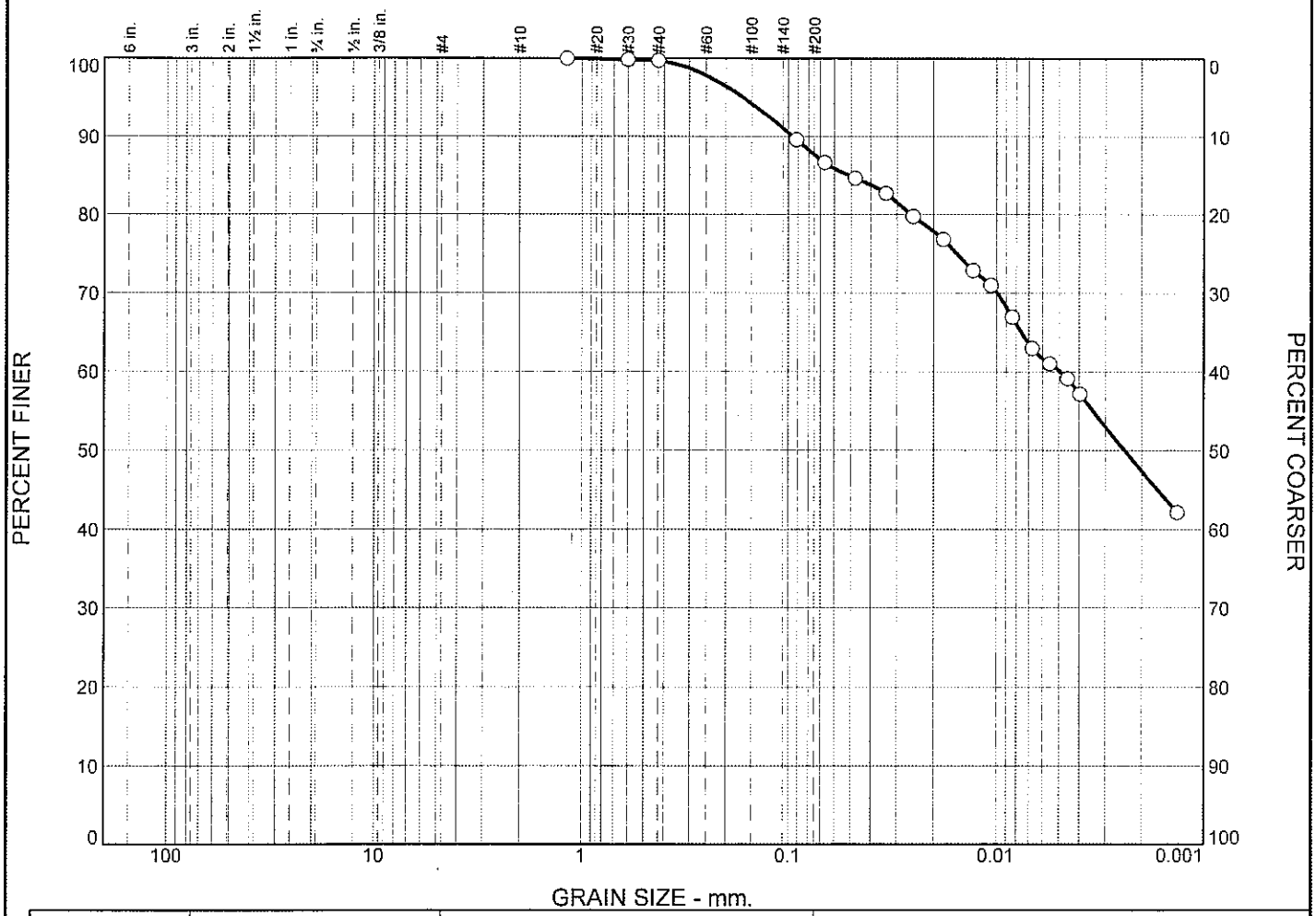
Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	0	12	41	47

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0504	0.0049	0.0024					

Material Description	USCS	AASHTO
○ SILT and CLAY, some fine sand		

Project No. 10-033 **Client:** Genivar
Project: # MA-10-006-00-MA

○ **Depth:** 15'-17' **Sample Number:** BH 09-06 SS3

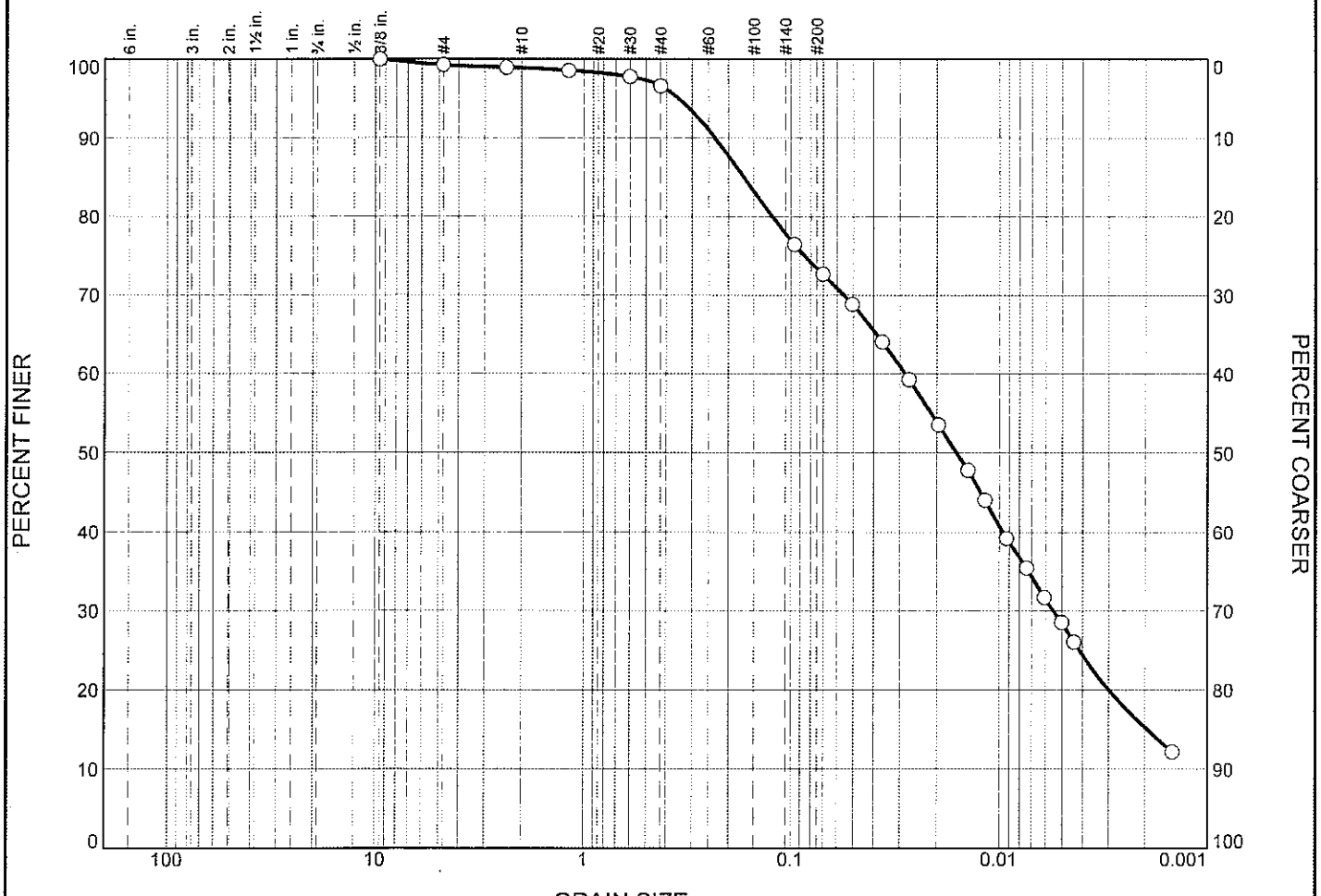
Remarks:

alston associates inc.
consulting engineers

Figure 1

Tested By: NW **Checked By:** NW

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	1	0	2	24	58	15

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.1679	0.0283	0.0160	0.0055	0.0020			

Material Description	USCS	AASHTO
○ SANDY SILT, some clay		

Project No. 10-033 **Client:** Genivar

Project: # MA-10-006-00-MA

○ **Depth:** 5'-7' **Sample Number:** BH 09-03 SS3

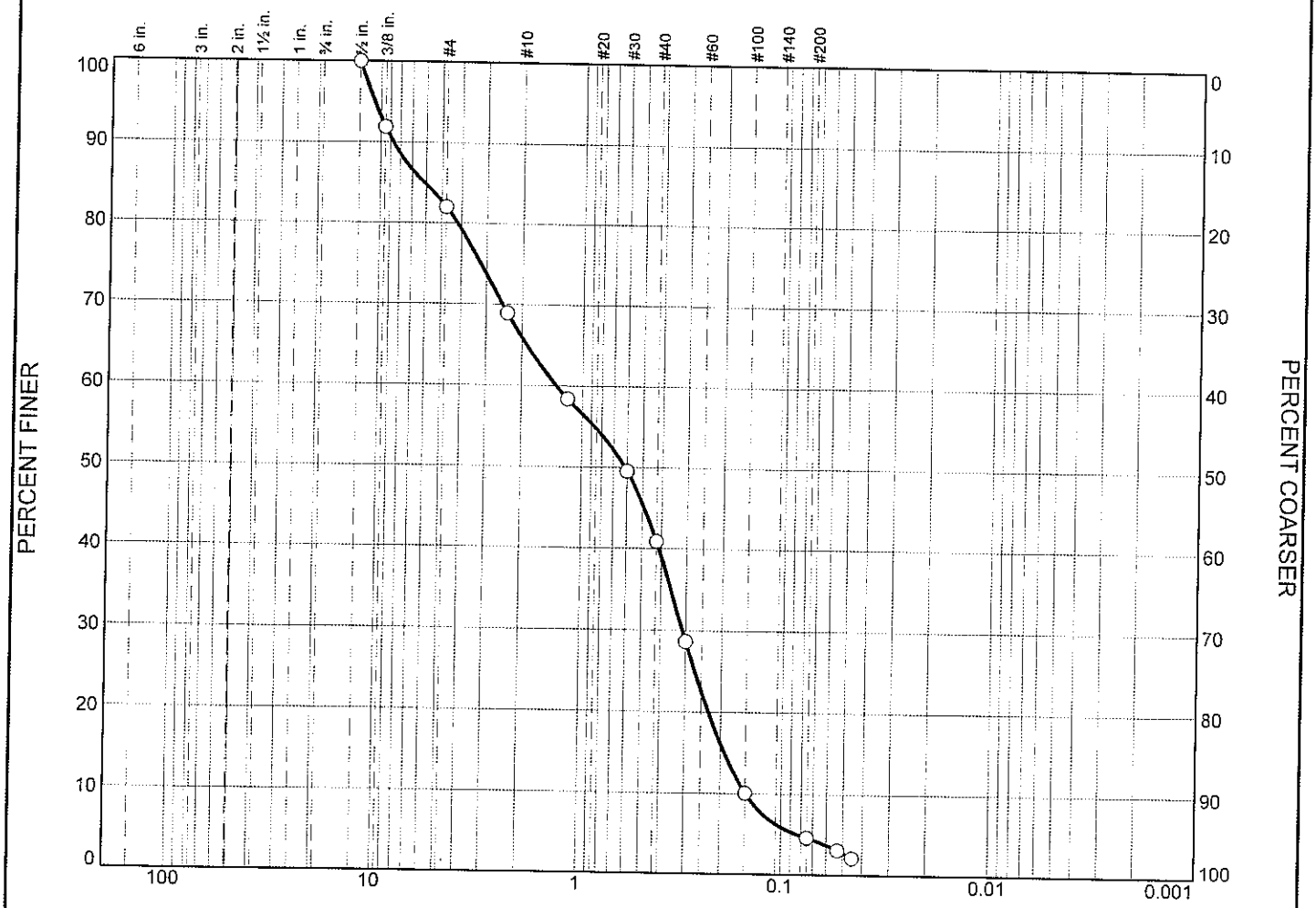
Remarks:

alston associates inc.
consulting engineers

Figure 2

Tested By: KC **Checked By:** NW

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	18	16	25	36	5	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			6.0679	1.3423	0.6133	0.3115	0.1909	0.1492	0.48	9.00

Material Description	USCS	AASHTO
○ SAND, some gravel, trace silt		

Project No. 10-033 **Client:** Genivar

Project: # MA-10-006-00-MA

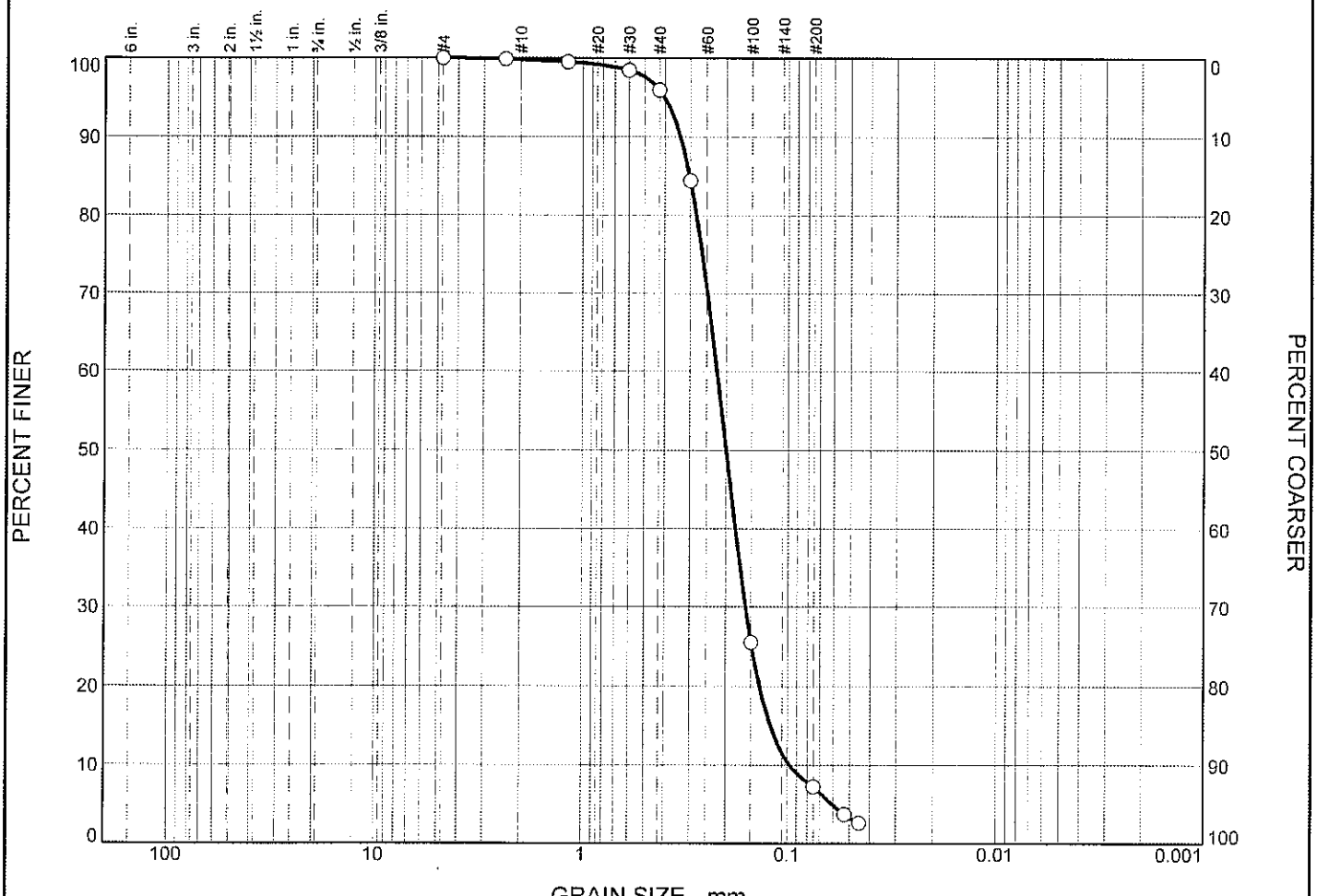
○ **Depth:** 22.5'-24.5' **Sample Number:** MW 09-02 SS10

Remarks:

alston associates inc.
consulting engineers

Figure 3

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	4	89	7	

╳	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.3027	0.2222	0.2002	0.1597	0.1210	0.0977	1.18	2.28

Material Description	USCS	AASHTO
○ SAND, trace silt		

Project No. 10-033 **Client:** Genivar
Project: # MA-10-006-00-MA

○ **Depth:** 20'-22' **Sample Number:** MW 09-01

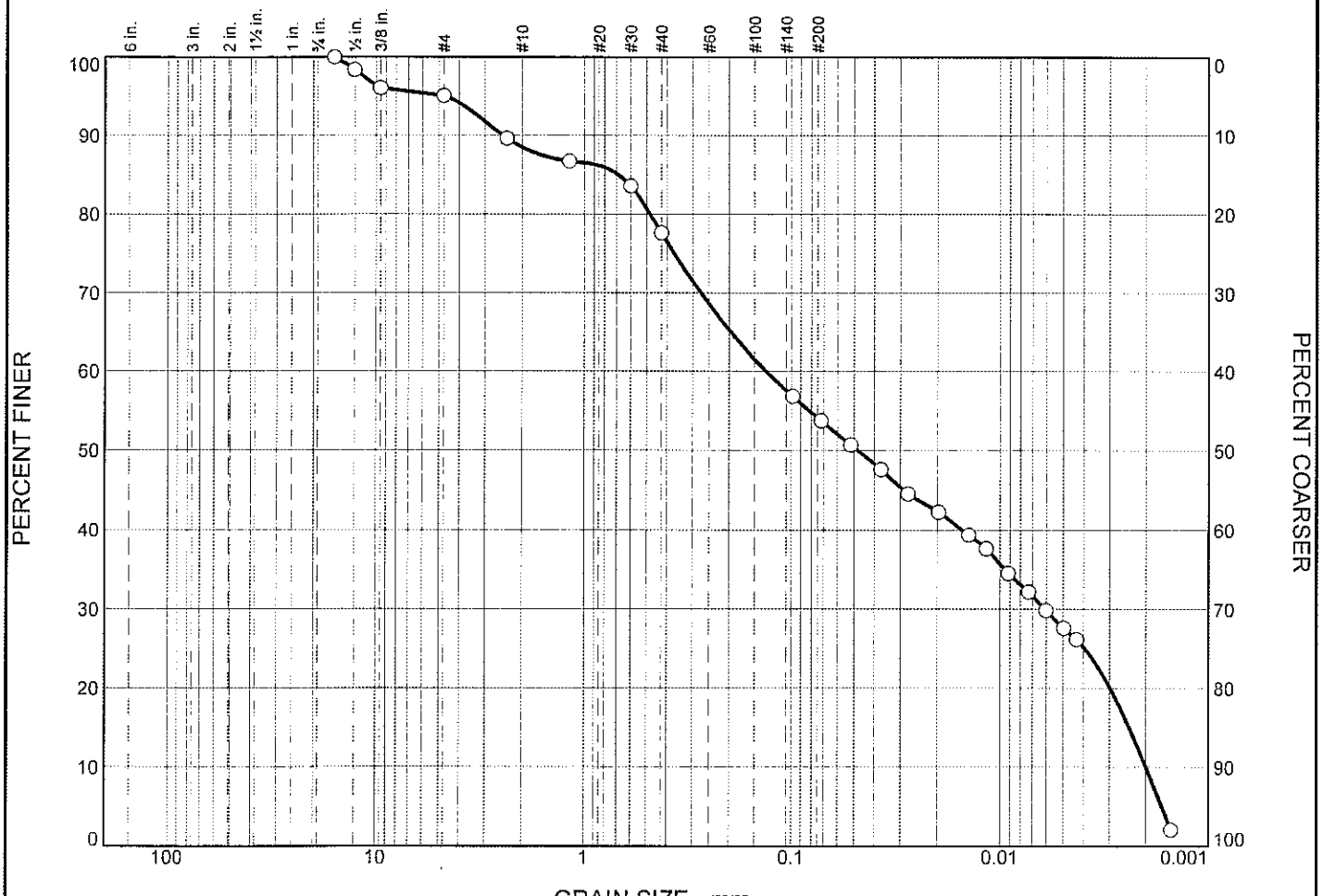
Remarks:

alston associates inc.
consulting engineers

Figure 4

Tested By: KC **Checked By:** NW

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	5	6	11	24	44	10

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.6850	0.1318	0.0479	0.0061	0.0024	0.0020	0.14	65.85

Material Description	USCS	AASHTO
○ SILT and SAND, some clay		

Project No. 10-033 **Client:** Genivar
Project: # MA-10-006-00-MA

○ **Depth:** 0'-2' **Sample Number:** MW 09-7

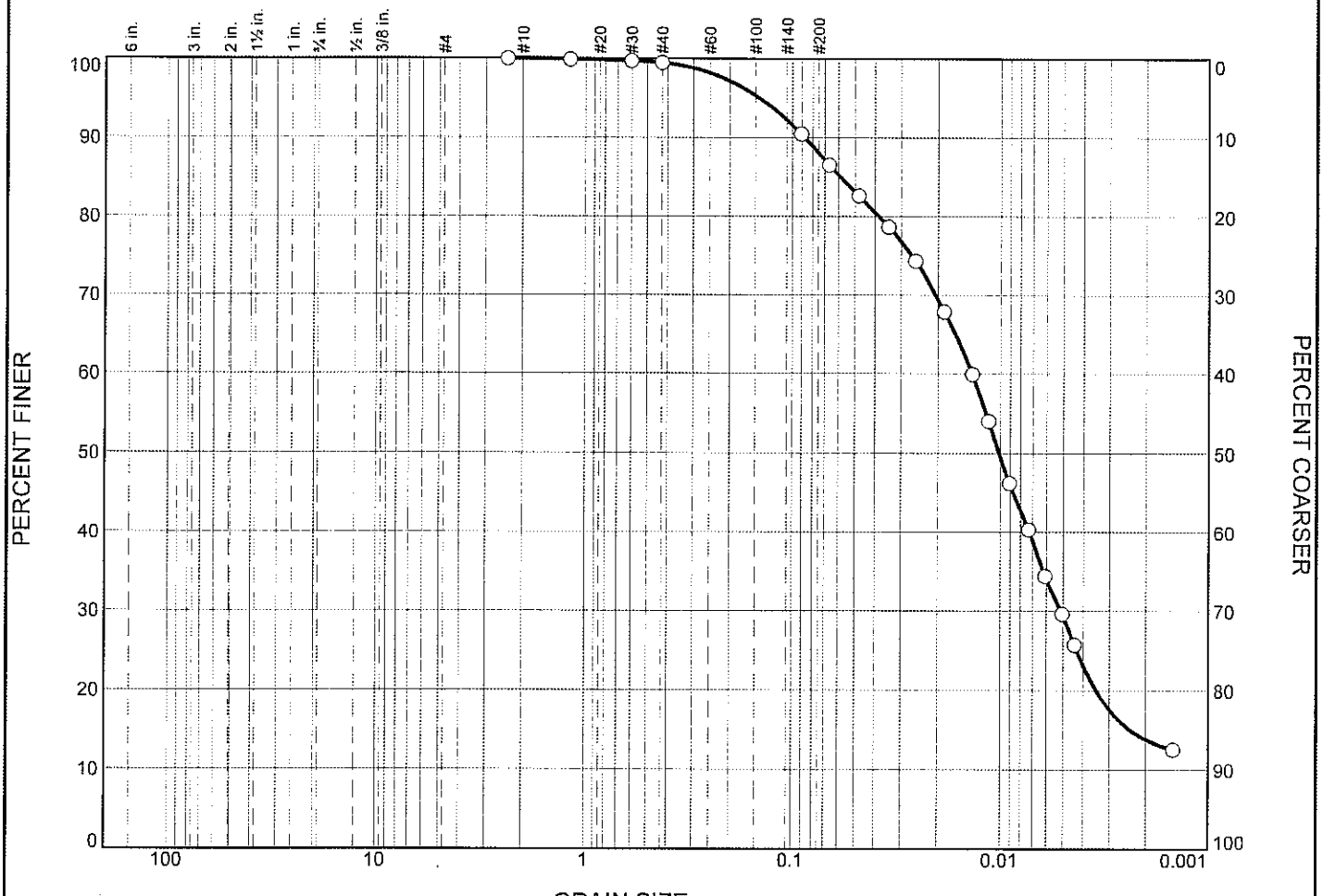
Remarks:

alston associates inc.
consulting engineers

Figure 5

Tested By: NW **Checked By:** NW

Grain Size Distribution Test Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0	0	0	0	1	11	74	14

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			0.0585	0.0137	0.0102	0.0051	0.0024			

Material Description	USCS	AASHTO
○ SILT, some sand, some clay		

Project No. 10-033 **Client:** Genivar
Project: # MA-10-006-00-MA

○ **Depth:** 10'-12' **Sample Number:** MW 09-04

Remarks:

alston associates inc.
consulting engineers

Figure 6

Tested By: KC **Checked By:** NW

Appendix D

Guidance and Orientation for the Selection of Technologies (GOST) Tables

Technology Selection

Date: 2010-03-16 (17:33)
Tag:

Results

Question	Answer
1. Treatment Type	In Situ Treatment, Ex Situ Treatment
2. Contaminants	Cadmium, Chromium, Lead, Arsenic, Copper, Nickel, Zinc, 2-3 rings, 4-6 rings, F3 (C16-C34), F2 (C10-C16)
3. Residual Contamination (depth in relation to the surface of the soil)	0-3 m (Unsaturated Zone), 0-3 m (Saturated Zone)
4. Dissolved Contaminants (depth in relation to the surface of the soil)	0-3 m
5. Non Aquous Phase Liquid (light and dense NAPL)	
6. Overburden	Hydraulic conductivity between 10-6 and 10-4 cm/s
7. RQD / Bedrock	
8. Time Available for Treatment	No time constraint
9. Is the vertical hydraulic gradient more than 1%?	No
10. Are interbeds present?	No
11. Is there a risk of vapour migration into the above-or below-ground structures?	No
12. Are there any potential receptors?	Yes
13. If NAPL is present, is it more than 5 cm thick?	Information not available
14. Is the contamination localized to a confined or semi-confined layer?	No
15. Is the water surface more than 30 m deep?	No
16. Is the water table less than 3 m deep?	Yes
17. Did biodegradation experiments performed in the lab demonstrate a mineralization rate greater than 20% in 28 days?	Information not available
18. Percentage of organic matter.	Between 1 and 10%

Technologies

- Bioaugmentation in situ
- Bioreactor
- Chemical Oxidation Ex Situ/Ozone
- Chemical Oxidation Ex Situ/Peroxyde
- Enhanced Aerobic Bioremediation
- Frozen Walls
- Multi-Phase Extraction Systems
- Phytoremediation of Organic Compounds

Technology Selection

Date: 2010-03-20 (09:38)
Tag:

Results

Question	Answer
1. Treatment Type	In Situ Treatment
2. Contaminants	Arsenic, F3 (C16-C34), F2 (C10-C16)
3. Residual Contamination (depth in relation to the surface of the soil)	0-3 m (Unsaturated Zone), 0-3 m (Saturated Zone)
4. Dissolved Contaminants (depth in relation to the surface of the soil)	0-3 m
5. Non Aquous Phase Liquid (light and dense NAPL)	
6. Overburden	Hydraulic conductivity between 10-6 and 10-4 cm/s
7. RQD / Bedrock	
8. Time Available for Treatment	No time constraint
9. Is the vertical hydraulic gradient more than 1%?	No
10. Are interbeds present?	No
11. Is there a risk of vapour migration into the above-or below-ground structures?	Yes
12. Are there any potential receptors?	Yes
13. If NAPL is present, is it more than 5 cm thick?	Information not available
14. Is the contamination localized to a confined or semi-confined layer?	No
15. Is the water surface more than 30 m deep?	No
16. Is the water table less than 3 m deep?	Yes
17. Did biodegradation experiments performed in the lab demonstrate a mineralization rate greater than 20% in 28 days?	Information not available
18. Percentage of organic matter.	Between 1 and 10%

Technologies

- Bioaugmentation in situ
- Enhanced Aerobic Bioremediation
- Frozen Walls
- Phytoremediation of Organic Compounds

Appendix E

Detailed Site Specific Risk Assessment

DETAILED SITE SPECIFIC RISK ASSESSMENT
WEST WHARF (SOUTH PORTION)

OSHAWA HARBOUR LANDS, ONTARIO
PWGSC PROJECT #R.032459.003

Prepared for:

Public Works and Government Services Canada | Travaux publics et Services gouvernementaux Canada

PUBLIC WORKS AND GOVERNMENT SERVICES CANADA
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Prepared by:

WESA
A Better Environment For Business

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171 Victoria Street North
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July 2010

*Ref: WB8604 SSRA Oshawa West Wharf repf July 14*_10.docx

EXECUTIVE SUMMARY

WESA Inc. (WESA) was retained by GENIVAR Consultants LP (GENIVAR) who was retained by Public Works and Government Services Canada (PWGSC) on behalf of Transport Canada (TC) to conduct a detailed Site Specific Risk Assessment (SSRA) at the West Wharf (south portion) of the Oshawa Harbour Lands to estimate potential human health and ecological risks that the impacts may pose in accordance with the Federal Contaminated Sites Action Plan (FCSAP).

Field work conducted in 2010 by GENIVAR as part of this project confirms that concentrations of petroleum hydrocarbons (PHCs), volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and several inorganic parameters exceed Canadian Council of Ministers of the Environment (CCME) soil quality guidelines (SQG) for industrial/commercial sites. Those parameters are identified as contaminants of potential concern (COPCs) and assessed further in a SSRA and screening level ecological risk assessment (SLERA).

The SSRA examines potential exposures and health risks to two types of receptors: a Remediation Worker and a Commercial Worker. The COPCs examined for human health include: arsenic, benzene, PHC Fraction 2, and PHC Fraction 3 in soil; and sodium, chlorides, PHC Fraction 2, PHC Fraction 3, and PHC Fraction F4 in ground water.

The risks for the Remediation Worker are estimated to be higher than acceptable for arsenic in soil due to ingestion, dermal contact, and inhalation of particles, and for benzene due to inhalation of vapours that migrate to outdoor air. The risks are also unacceptable for PHC Fraction 2 in soil due to dermal contact, and for PHC Fraction 2, Fraction 3, and Fraction 4 in ground water also due to dermal contact.

The risks for the Commercial Worker are estimated to be higher than acceptable for arsenic in soil as a non-threshold toxicant due to ingestion and dermal contact, and as a threshold toxicant due to inhalation of particles. Unacceptable risks were estimated for benzene due to inhalation of vapours that originate in soil and migrate to outdoor air.

These estimates reflect numerous conservative assumptions including the assumption that all exposures involve soil with the maximum measured concentrations of the COPCs. The unacceptable risk estimates for arsenic range from approximately three times to one order of magnitude higher than acceptable for the individual pathways. If average concentrations had been used, the risks would be three times to an order of magnitude lower than have been estimated. A similar rationale can be applied to the risks for benzene which are two to 4.5 times greater than acceptable, and for PHCs whose risks are two to three times greater than acceptable.

The SLERA examines potential exposures and risks to five broad categories of receptors: plants, soil microorganisms, soil invertebrates, birds, and mammals. In addition, aquatic receptors are considered in the assessment of ground water quality. The COPCs in soil are arsenic, HWE boron, hexavalent chromium, selenium, EC, SAR, PHC Fraction 2, and PHC Fraction 3. The COPCs in ground water are sodium, chlorides, PHC Fraction 2, PHC Fraction 3, and PHC Fraction 4.

Risks are estimated to be higher than acceptable for all of the inorganic COPCs except hexavalent chromium at numerous locations. EC and SAR in soil, and sodium and chlorides in ground water are all associated with the use and former storage of road salt. These four COPCs account for approximately three-quarters of instances where ecological risks are estimated to be higher than acceptable.

Finally, the SSRA and SLERA are combined to recommend property specific standards (PSS) for the COPCs that can be used in place of the generic CCME SQG. Risk management measures are required in locations where concentrations in soil and ground water exceed acceptable risk levels.

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1.0 INTRODUCTION

1.1 TERMS OF REFERENCE

Elevated concentrations of some metals, petroleum hydrocarbons, and polycyclic aromatic hydrocarbons have been measured in soil and ground water at the West Wharf (south portion) at the Oshawa Harbour lands, in Oshawa, Ontario (Figure 1.1).

WESA Inc. (WESA) was retained by GENIVAR Consultants LP (GENIVAR) to prepare a Detailed Site Specific Risk Assessment (SSRA) and a Screening Level Ecological Risk Assessment (SLERA) for the West Wharf (south portion) (the Site).

The Site has been used for light industrial and commercial purposes for many years and these types of uses are not expected to change in the foreseeable future. As part of this assignment, GENIVAR conducted a supplemental soil and ground water investigation and those findings, including a remedial options analysis, can be found under separate cover (GENIVAR, 2010) to which this report is appended. WESA was asked to recommend remedial targets that would be adequately protective of both human and ecological receptors associated with the current light industrial and commercial land uses.

The Terms of Reference refer to the other main component of this project as an SSRA. This is a term that was used by Health Canada along with the term Screening Level Risk Assessment (SLRA) when referring to the determination of human health risks. Since 2004, Health Canada has replaced the term SSRA with Detailed Quantitative Risk Assessment (DQRA), and the term SLRA has been replaced with Preliminary Quantitative Risk Assessment (PQRA). The term SSRA is used in this report knowing that an SSRA is the equivalent of a DQRA.

The Terms of Reference also require that a Screening Level Ecological Risk Assessment (SLERA) be prepared. The SLERA follows the guidance outlined in the CCME document entitled *A Framework for Ecological Risk Assessment* (1996) and is the focus of Chapter 6.

1.2 OUTLINE

The first part of this report describes the Site and any environmental conditions of interest. The purpose of the supplemental investigation recently conducted by GENIVAR was to provide additional delineation of previously reported soil impacts and to provide updated ground water information to a SSRA. Findings from the supplemental investigation as well as those from historical reports are then combined to complete a SSRA and SLERA for the Site and described in detail in Chapters 5 and 6.

An SSRA (or DQRA) is an evaluation of the potential for chemicals in the environment to affect human health and ecological organisms including plants and animals. Various questions are considered when evaluating potential risks. What are the chemicals of interest? Where have those chemicals been found and at what concentrations? Who might come into contact with the chemicals? How could this contact or exposure occur? How frequently and for what duration? What types of effects can be caused by the exposure? At what doses can those effects occur?

Risk assessment is a component of methodologies used by regulatory agencies such as the Canadian Council of Ministers of the Environment (CCME) and the Ontario Ministry of the Environment (MOE) to set generic criteria and standards for chemicals in soil and ground water. Both agencies have published guidelines on risk assessment and those guidelines are referenced in this report.

Health Canada has published a standard method for the human health component of SSRAs at federal sites (Health Canada, 2004a), and that document has been used extensively in the preparation of this report. In 2008, Health Canada released a DQRA Spreadsheet tool (along with a PQRA Spreadsheet tool); however, the DQRA tool has not yet been approved or endorsed for broad use.

This report describes the information, the assumptions, and the mathematical models used to estimate the potential risks posed by metals, inorganics, petroleum hydrocarbons (PHC), and polycyclic aromatic hydrocarbons (PAH) in soil and ground water at the Site. The site specific information comes from a site visit and the supplemental investigation conducted by GENIVAR (2010) and from investigations described in previous reports (AquaTerre, 2009; DCS, 2009, 2003). Sample collection and handling methodologies, quality control procedures, and the original laboratory data sheets are provided in the reports prepared by other consultants and are not repeated in this SSRA report.

1.3 SITE DESCRIPTION

The Oshawa Harbour lands are located in between and at the southern end of Simcoe and Farewell Streets in Oshawa, Ontario. The Harbour lands have been divided into approximately six parcels. The 2003 report by DCS describes them as Areas A through E, corresponding to west pier, northwest corner, northeast corner, east block, and marina lands, respectively. The west pier has since been investigated separately. The northeast corner of the harbour lands has been renamed the North Rail Spur and east block is now referred to as the South Rail Spur. The focus of this SSRA report is on the West Wharf (south portion) of the harbour lands. It is situated at the southern end of Simcoe Street (Figure 1.1).

At the Site, the majority of the land was used for materials handling associated with the offloading of vessels. The former Lakes Terminal was used for bulk fuel storage and distribution. That area is currently used by KR Wind for storage of parts for wind turbines. Storage of wood and re-bar was observed on Site. The Site is abutted to the north by lands formerly occupied by Petrocor. There are approximately eight above ground storage tanks (AGSTs) on those lands. There is an above ground fuel pipeline, no longer in use, which travels along the east portion of the Site. There are records of a spill of fuel oil at a location along that pipeline north of Oshawa Creek.

The Site was first developed in the early 1920s and has the longest development of all the parcels in the Oshawa Harbour lands. Most industrial and commercial activities that have taken place on the West Wharf have been related to the operation of the harbour. Fuel storage and distribution activities have taken place on three blocks of land on the west side of the West Wharf. Two of those areas are still active. The third, formerly known as Lakes Terminal, leased land and operated in the southwest corner and included an associated above ground pipeline has been the source of at least one fuel spill to the harbour lands and waters.

The Site is in the shape of a pseudo zig-zag (Figure 1.2). The northwest portion is adjacent to, but does not include, an existing tank farm of eight AGSTs. The Site is predominantly used for storage purposes and extends to the southwest corner, where the main gate access is located. The middle portion runs east-west, is used to store materials such as re-bar and is used to off-load vessels. Extending to the south is the farthest extent of the wharf which terminates with a pier approximately 150 metres in length and eight metres wide. The total Site area is 0.18 hectares. It is predominantly covered by asphalt and concrete although there are gravel-covered sections.

Data collected since 2003 in at least four investigations have measured elevated concentrations of metals, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbons (PAHs), and petroleum hydrocarbons (PHCs) at the Site. Surrounding parcels of land have also been investigated and have identified impacts to soil.

A Site location map is shown in Figure 1.1. A Site plan is shown in Figure 1.2

1.4 HISTORICAL INVESTIGATIONS

1.4.1 Phase I and II ESA (DCS 2003)

In 2003 a Phase I and II Environmental Site Assessment was conducted by Decommissioning Consulting Services Limited (DCS) on various Oshawa Harbour lands. These lands included the West Wharf (south portion) and South Spur (east portion). The Phase I ESA concluded that potential impacts could be realized due to historical activities such as coal and salt storage, as well as the presence and/or the use of underground storage tanks (UST), waste disposal including storage of scrap materials (south and north spur only), and the excavation and placement of soil and sediment during harbour expansion. Adjacent site activities, including bulk fuel distribution facilities, also contributed to potential impacts and as a result, several areas of concern (AOCs) were identified and they were investigated during the Phase II portion of the ESA.

The AOCs include: impacts involving heavy metals and PAHs likely due to past storage of coal to the north and south of Oshawa Creek; impacts involving electrical conductivity (EC) and sodium likely due to salt storage on the south portion; impacts involving petroleum products at the former Lakes Terminal Site and adjacent to Petrocor and OLCO facilities; potential impacts due to the storage of paint and other materials adjacent to the Oshawa Harbour Commission (OHC); and petroleum hydrocarbon impacts due to a spill from the fuel pipeline north of Oshawa Creek along the pier wall.

Adjacent to one of the land parcels of Oshawa Harbour, across Harbour Road, also across from the Marina, there is a ground water well at Roofmart (Ont.) Ltd. at 100 Harbour Road. All Oshawa Harbour lands are supplied with municipal water. Ground water flow direction in the West Wharf parcel north of Oshawa Creek is easterly towards the Harbour and Oshawa Creek. Therefore, the Site is located down gradient of the ground water well and is also hydraulically separated from the well at 100 Harbour Road by Oshawa Creek.

As a result of the findings in the Phase I ESA report prepared by DCS, a Phase II ESA was conducted on the West Wharf in April/May 2003. Three boreholes were drilled to approximately 5 m depth around the former OLCO tank farm north of Oshawa Creek, with the eastern borehole completed as a ground water monitoring well. Soil and ground water samples were collected and analyzed for total petroleum hydrocarbons (TPH), benzene, toluene, ethylbenzene, and xylenes (BTEX), and petroleum hydrocarbons (PHCs). Test pits and boreholes revealed coal layers up to 1.0 m thick.

Three boreholes were advanced around the Petrocor tank farm to approximately 5 m depth, with the southern borehole completed as a ground water monitoring well. Soil and ground water samples were recovered and analyzed for TPH, BTEX and PHCs.

Eight boreholes were drilled across the West Wharf to nominal depths of 5 m, with four of the boreholes completed as ground water monitoring wells. Samples of soil and ground water were analyzed for heavy metals and PAHs. One borehole was drilled in the southeast corner of the West Wharf to evaluate salt impacts.

Sediment samples were collected from three locations in Oshawa Creek and were analyzed for heavy metals, PCBs and PAHs. Two surface water samples were also collected from Oshawa Creek and were analyzed for heavy metals.

Supplementary Work

Five test pits were dug on the northeast side of the tank farm located north of Oshawa Creek to delineate extent of metals, TPH, and PAH impacts identified during the initial Phase II ESA. Recovered soil samples were analyzed for metals, PAHs, and/or TPH, BTEX, and PHCs.

Three test pits and seven boreholes were installed around the Petrocor tank farm to delineate the extent of metals and petroleum hydrocarbon impacts identified during the initial Phase II ESA. Recovered soils were analyzed for metals and/or TPH, BTEX, and PHCs.

One borehole was installed in the southeast corner of the parcel to evaluate salt impacts identified during the initial Phase II ESA. Recovered soil samples were analyzed for EC and/or sodium adsorption ratio (SAR).

In total, the sampling program for West Wharf (DCS 2003) consisted of 22 boreholes, 8 test pits, and 6 monitoring wells with the following numbers of samples submitted for chemical analysis:

Analysis	Soil/Sediment	Ground water/ Surface Water
Heavy Metals	28	5 GW + 2 SW
PAHs	19	5 GW
TPH/BTEX	23	8 GW
CCME/TPH	23	0
PCBs	2	0
EC/SAR	5	0
VOCs	0	1 GW

1.4.2 Phase I ESA Update (DCS, 2009)

In 2009 DCS conducted a Phase I ESA update to the 2003 Phase 1 and II ESA. The DCS 2009 report confirms that the contaminant distribution remains unaffected by the changes to the soil and ground water criteria introduced after the DCS 2003 report was submitted. However, given the change in use of the northern portion of the Site, further investigation is required to see what effects, if any, the McNally Construction storage area has had to the Site. DCS applied MOE SCS Table 1 as the Site is within 30 m of the Harbour. A significant portion of the northern portion of the Site is within 30 m of the Harbour and therefore concentrations for several parameters in either soil or ground water exceed Table 1 (background) SCS. The DCS 2009 report recommends that the portion of the Site that is not already identified as "contaminated" within 30 m of the Harbour be investigated further to define the limits of contamination in comparison to MOE standards. In addition, DCS recommends collecting and analyzing shallow borehole samples of soil and ground water in the vicinity of the storage tank and drums storage areas in order to identify any contamination resulting from leakage from the containers in the McNally Construction storage areas (4 proposed boreholes). DCS recommends that the two existing monitoring wells in this area be sampled. DCS (2009) also recommends installing a borehole and monitoring well south of MW-17 to delineate the extent of soil impacts. Finally, the DCS 2009 report recommends conducting a Preliminary Quantitative Risk Assessment (PQRA) to address the salt-related impacts on the north pier wall of the southeast portion of the West Pier.

1.4.3 Phase II ESA, PQRA (Aqua Terre, 2009)

In 2009, Aqua Terre conducted a drilling program on the Site consisting of ten additional boreholes, six of which were instrumented as monitoring wells. Several samples were collected and analyzed as follows:

Analysis	Soil	Ground water
Metals	6	7
PAHs	0	0
BTEX	6	7
PHC F1-F4	6	7
Na, Cl, cyanide	4	3
EC/SAR	4	0

The Phase II ESA concluded that West Wharf lands north of Oshawa Creek (north of Site) are located down gradient of the ground water well at 100 Harbour Road. Naphthalene, phenanthrene, and benzo(a)anthracene were identified in excess of the applicable CCME criterion under the future land use scenario from surface to a depth of 1.22 m bgs for lands north of Oshawa Creek. The levels of naphthalene encountered in soil have the potential to impact drinking water quality, however, given the distance to the nearest drinking water well and the absence of PAHs in ground water tested, these PAHs would not be expected to cause any adverse health effects to receptors on or off Site. Future zoning of the Site was indicated to be industrial.

South of Oshawa Creek (the Site) petroleum hydrocarbon concentrations in soil were found to exceed CCME criteria in the vicinity of the Petrocor site. A screening level risk assessment indicated that the area immediately surrounding MW-17 poses an unacceptable level of risk if the Site were to be used for industrial purposes. Risk management controls are well suited for the Site as it is to be zoned parkland. It is recommended that the MW-17 area be maintained with controlled access to prevent inhalation of vapours (i.e. fenced off) or remediated to levels which would permit industrial land use. In addition it is recommended that "hot spot" removal with biotreatment be considered south of the Petrocor site. It was recommended that the salt storage area be left as-is.

Additional investigations conducted by Aqua Terre in 2009 revealed concentrations in soil exceed guidelines for EC, chloride, and SAR in the road salt storage area. The report indicates that road salt related impacts in soil remain undelineated on the Site. Of note, a ground water sample collected from MW-302 (near the road salt storage area) exceeded guidelines for toluene. The area of ground water impact by petroleum hydrocarbons is undelineated for the salt storage area. Aqua Terre (2009) indicates that concentrations found in MW-11 suggest that free product is present in the subsurface. The screens of the monitoring wells in the area, however, are mostly located below the water table preventing the identification/detection of free product. Aqua Terre recommends installing additional monitoring wells down gradient of the former Petrocor and former Lakes Terminals locations to delineate the extent of the ground water plume. The report indicates that in the northern portion of the Site (i.e. near Petrocor) soils are impacted by arsenic and selenium. The report indicates that there are limited metals analyses completed in this area, and a large undelineated area exists with regards to metals impacted soils. The report identifies cobalt as a parameter that exceeds MOE (2004) Table 1 criteria in the sensitive area. The report indicates that the extent of soil contamination is relatively undelineated at this location with respect to PHC/BTEX. Aqua Terre recommends a risk management approach as opposed to remediation, including capping and subsurface barriers (to control ground water discharge to surface waters). An asphalt cap and sheet pile barrier (installed to a depth of 7.5 mbgs) is proposed along the waterfront of the West Wharf parcel, along with the development of maintenance and monitoring plans. A slurry wall installed around the remainder of the Site is also recommended.

It is further recommended that the extent of salt impacts be further characterized with an electromagnetic survey, followed by delineation drilling to confirm both horizontal and vertical extents of salt impacts, and to assess the extents of PHC impact in the northern portion of the west wharf. The objective of this study would be to minimize the length of the proposed slurry wall. Supplementary PQRAs are recommended for this area to include additional COCs. A Detailed Quantitative Risk Assessment (DQRA) was also recommended for the West Wharf, and should provide a quantitative evaluation of proposed barrier performance.

This Site was recommended for a PQRA by DCS (2009) based on the results of its Phase II investigation. AquaTerre also conducted a PQRA in addition to its Phase II investigation. The objectives of the PQRA were to provide a quantitative evaluation of receptor specific potential risk that is posed by road salt related chemicals of concern (COC) on the Site to typical receptors who may access the Site for its most conservative reasonably anticipated use. The current and anticipated future use of the Site consists of industrial use. The Site is surrounded by a chain link fence topped with barbed wire and land access to the Site is through gates (locked to control access).

Identified COCs for soil included sodium and chloride in BH 307-6. Identified COCs for ground water included sodium and chloride in MW-302 and total cyanide in MW6.

The exposure assessment looked at terrestrial plants, soil invertebrates, and aquatic communities as potential receptors. The results of the assessment indicated that sodium and chloride concentrations in the soil have an exposure ratio exceeding a value of 1 for terrestrial plants and soil invertebrates. The exposure assessment also indicates that there are probable adverse effects from COPC exposure to omnivorous birds, insectivorous birds, omnivorous mammals and herbivorous mammals based on soil COPC concentrations present. Finally, the exposure assessment indicates that exposure ratios are estimated to exceed a value of 1 for the aquatic community.

1.4.4 Draft Supplemental Soil, Groundwater and Surface Water Sampling South Rail Spur and West Wharf South – Oshawa Harbour (GENIVAR, 2010)

In March 2010, Genivar conducted a Supplemental Phase II ESA in support of this SSRA as well as in support of a remedial alternatives assessment. The Supplemental Phase II ESA was designed to:

- Target and delineate the boundaries of identified contaminants.
- Define, in greater detail, site conditions required to identify all contaminant pathways, particularly with respect to supporting risk-based approaches to managing the impacted soil.
- Provide contaminant and other information necessary for future steps such as risk assessment or remediation.

The investigation was conducted in March 2010 by GENIVAR and all laboratory analytical data and observations made during the investigation were provided to WESA.

The Phase II ESA involved drilling four boreholes in the Site and equipping all of them as monitoring wells. Nine soil samples, including one duplicate, were collected and submitted for analysis of inorganics, PHCs, and VOC and PAH in select samples. Neither BTEX nor PHC parameters were detected above guidelines however naphthalene and phenanthrene were found to exceed CCME guidelines. Eight ground water samples were collected from four newly installed monitoring wells and four existing monitoring wells and submitted for analysis. One blind duplicate sample was also submitted. Analysis included inorganics, PHCs and select samples for PAH and VOCs. Samples were compared to MOE Table 1 SCS (2004) and were found to exceed for free cyanide in four locations (GENIVAR, 2010). Elevated concentrations of various metals including cobalt, copper, lead, sodium and chloride were also noted. Water levels were measured in the eight wells on two separate dates.

The findings of the GENIVAR investigation are not repeated here, although the data is compiled with historical reports' data for use in this SSRA. The data collected by GENIVAR and other historical data is summarized and compiled in Appendix A.

A remedial options assessment was also conducted for the Site. It looked at options considered by others, as well as several other risk management measures. Options assessed by GENIVAR (2010) include:

- In-situ remediation
- Excavation with off-site disposal
- Excavation with on-site biotreatment
- Excavation with soil transfer and off-site disposal
- Capping
- Capping with soil transfer
- Ground water mitigation

The options that were carried forward for further evaluation include excavation with either off-site disposal or with soil transfer and off-site disposal, capping with ground water mitigation, and capping with soil transfer and ground water mitigation. Some of the evaluation factors included effectiveness, regulatory compliance and acceptance, timeframe, and costs. The overall recommendation was to cap with soil transfer and ground water mitigation as it is most cost effective, it is a reliable risk management measure to cut off exposure pathways, it is consistent with recommendations for adjacent properties, and permitting is not required.

2.0 PROPERTY INFORMATION

2.1 LOCATION

The Site is located between and at the southern end of Simcoe and Farewell Streets (Figure 1.1). The west wharf has been divided into north and south portions and each has been investigated separately. This report addresses the portion that is south of Oshawa Creek, as shown in Figure 1.2.

2.1.1 Property Shape and Size

The Site is irregular in shape. The southern end starts with a 150 m long pier. It extends northward where it widens into a materials off-loading area for vessels. Vessels can tie up along the eastern wall of the wharf. The storage and offloading area extends westward along the harbour. The Site then extends northward along the harbor wall. It also extends a bit to the south, where the Site access gate is located. A site plan is shown on Figure 1.2.

The Site is approximately 0.18 hectares.

2.1.2 Services

Businesses that occupy the western portion of the site are serviced municipally by the City of Oshawa for electricity and water. Approximately half the site is used for storage of materials. There is electricity on Site to site overhead light fixtures but otherwise the majority of the Site is not serviced.

2.1.3 Adjacent Sites, Potential Off-site Sources, and Off-site Receptors

The Site is bordered to the east by Oshawa Harbour. North of the Site is a continuation of the West Wharf and it is also used for materials storage including bulk fuel. South of the Site are two residential properties that face Simcoe Street, across from which is a waterfront parking lot and trail facing Lake Ontario.

The main off-site source of possible impacts is the Petrocor Site to the north and west. This is consistent with impacts confirmed in previous investigations.

Impacts to ground water have been detected in the eastern portion of the Site as well as in the northern portion, and are likely the result of on-Site and adjacent-site historical activities. The Site is surrounded by a chain link fence on all land sides restricting pedestrian access. The fence would not prevent avian receptors from visiting the site, although with limited vegetation, there would be little reason to spend much time on-site. The adjacent surrounding properties are serviced through a municipal water supply and thus ground water impacts to off-site receptors is also highly unlikely.

As noted in Section 1.4.1, there is a well located at 100 Harbour Road. It is separated from the site by Oshawa Creek and is approximately 700 metres up gradient and thus on-site impacts do not pose a concern to this well.

2.1.4 Proposed Use of the Property

The proposed use for the Site is similar to current land use of commercial and light industrial activities.

2.2 SITE PLAN AND HYDROGEOLOGICAL INTERPRETATION

2.2.1 Topography and Stratigraphy

The West Wharf is located on generally flat land, and is intersected by Oshawa Creek in the middle of the parcel of land. The site is predominantly covered with asphalt, although there are some un-paved portions. The ground surface at the wharf is approximately six metres above the water level in the harbour.

In March 2010, four new boreholes were drilled by GENIVAR in the West Wharf, all of which were instrumented as monitoring wells. According to observations made while drilling, soils at the wharf are predominantly of silt fill underlain in areas by layers of sand fill. Peat was noted at approximately 3-4 m bgs in three of the four new boreholes as well as in those drilled by DCS (2003) between 2-3 m bgs.

2.2.2 Surface Water

The Site is bordered to the east by the Oshawa Harbour Basin. Approximately 100 metres of the southern site boundary is bordered by Lake Ontario. Surface water is not part of the subject site, although several samples were collected to determine whether impacts to ground water, if any, would be measured in the Harbour Basin waters.

2.2.3 Hydrogeology

The assumed direction of ground water flow is to the Harbour Basin. This was confirmed by a round of water level monitoring in March 2010 by GENIVAR. There is one exception to this in the northwest portion of the site at MW310 where ground water flow would appear to be away from the harbor basin in a west or northwesterly direction. This is in an area of PHC impacted ground water and therefore the possibility exists that there are off-site remedial measures affecting ground water flow in this area. Overall, water levels measured indicate that the direction of ground water flow is to the Harbour Basin, with the exception at MW310.

The average hydraulic conductivity at the property was not determined. GENIVAR (2010) references a hydraulic conductivity determined by others to be 1.4 $x10^{-6}$ m/s. Soil permeability was measured to be 1 x 10^{-2} in the deep well MW09-01 at a depth of approximately 6.2 m bgs, which is to be expected as the sample can be described as loose, grey sand (GENIVAR, 2010). Permeability was measured to be 1 x 10^{-7} at a depth of 3 m bgs at MW09-04, corresponding to a sample described as silt (GENIVAR, 2010).

Ground water is not used as a potable water supply at the Site. Water used for consumption is obtained from the municipal supply.

3.0 SOIL AND GROUND WATER QUALITY

3.1 STANDARDS AND GUIDELINES USED

3.1.1 Soil

The investigations described in Section 1.4 have resulted in the chemical analysis of 39 soil samples (including three duplicates). The parameters analyzed include inorganic parameters (mostly metals), PHCs and BTEX, PAHs, and VOCs.

As a first step in identifying the chemicals of potential concern (COPCs) in this SSRA, concentrations of chemicals measured in soil samples are compared to numerical values recommended by regulatory agencies. This SSRA is being conducted for Transport Canada, the federal agency responsible for harbours, so the preferred numerical values are the CCME soil quality guidelines (SQGs) for commercial sites. For some parameters, the SQG for coarse soil is different from the SQG for medium or fine soil. In those instances, the SQG for coarse soil is used. Although much of the soil at the Site is medium to fine textured, using the SQG for coarse soil is a conservative choice (i.e. intended to avoid missing possible COPCs).

Many of the SQG come from the CCME document entitled *Canadian Environmental Quality Guidelines*. A major component of that document is entitled *Canadian Soil Quality Guidelines* (CSQG). In the CSQG, for each parameter, there is a separate fact sheet or in some cases a scientific supporting document that presents the rationale for the guideline values assigned to that specific parameter. The fact sheets and supporting documents are updated on occasion. This SSRA references the most recent individual fact sheets or support documents when discussing specific parameters. The dates for these references range from 1997 to 2009.

For petroleum hydrocarbons (PHC), federal values come from the 2008 CCME document entitled *Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil*. The values used in this SSRA are the Tier 1 levels for coarse-grained soils at commercial sites.

For parameters that have been measured but for which SQG have not been set by the CCME, then MOE site condition standards (SCS) are used to identify COPCs. The MOE recently announced revisions to the SCS, and while those revisions do not come into use until July 2011, the future SCS are used. Specifically, this SSRA uses the MOE Table 3 SCS for industrial/commercial/community sites with coarse soil at locations where ground water is not used as a potable water source. The MOE has set more stringent SCS for lands that are within 30 m of surface water. The Site is adjacent to Oshawa Harbour; however, the CCME has not set SQG for similar conditions and the Site falls under federal jurisdiction. Furthermore, one of the main concerns with sites next to a surface water body is the potential for contaminants to be transferred to the adjacent surface water body. The CCME does take this into consideration when setting SQGs by calculating an "off-site migration" check value and/or a "groundwater check" value. As a result, it is not necessary or appropriate to use the MOE SCS for lands within 30 m of surface water in this SSRA.

The MOE SCS appear in "Table 3: Full Depth Generic Site Condition Standards in a Non-Potable Ground Water Condition" as presented in *Soil, Ground Water and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act* (MOE, 2009).

3.1.2 Ground Water

The investigations described in Section 1.4 have resulted in the chemical analysis of a total of 20 ground water samples (including three duplicates) from 11 locations across the Site. The parameters analyzed include inorganic parameters, VOCs, PHCs, and PAHs. In total, more than 100 different chemical parameters have been analyzed.

To identify the COPCs, all of the concentrations measured in those 20 ground water samples are compared to appropriate guidelines recommended by the CCME augmented as necessary by standards from the MOE.

The CCME has not established guidelines for ground water quality. It does have guidelines to be protective of aquatic life, and guidelines for the protection of a community's water supply. Neither of those two types of guidelines are appropriate for assessing ground water quality at the Site. Therefore, COPCs in ground water are identified by comparing measured concentrations to the MOE Table 3 SCS (2009). When measured concentrations do not exceed the generic Table 3 SCS, unwanted effects or impacts should not occur and do not require further evaluation.

The Table 3 SCS come from *Soil, Ground Water and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act* (Queen's Printer for Ontario, 2009). They are for ground water that may be not used as a potable water supply where soil is coarse-grained. (The same SCS are used for all sites regardless of land-use). Ground water is not used as a drinking water source at the Site or elsewhere on the Oshawa Harbour lands.

3.2 COPCs IN SOIL

Collectively, the investigations undertaken in 2003, 2009, and 2010 have resulted in the analysis of a total of 39 soil samples (including three duplicates). More than 20 of the samples have been analyzed for inorganic parameters (mostly metals), more than 20 have been analyzed for PHC and BTEX, 12 have been analyzed for PAHs, and eight have been analyzed for VOCs.

The CCME guidelines and MOE standards used to identify COPCs in soil are shown in Appendix A.

Table 3.1 is the initial list of COPCs. The locations where concentrations exceed the CCME guidelines or MOE standards are highlighted on Figure 3.1.

3.3 COPCs IN GROUND WATER

Collectively, the investigations undertaken in 2003, 2009, and 2010 have resulted in the analysis of twenty ground water samples (including three duplicates). All twenty samples were analyzed for inorganic parameters (mostly metals) and BTEX, PHC and BTEX, six for PAHs, and seven for VOCs.

The MOE standards used to identify COPCs in soil are tabulated in Appendix A.

Table 3.2 is the initial list of COPCs. The locations of the monitoring wells where concentrations exceed the MOE standards are highlighted on Figure 3.2.

Table 3.1 Initial List of COPCs in Soil

Parameter	Value used to Identify COPC	Maximum Measured Concentration	Number of Measured Concentrations that Exceed the Value Used to Identify COPC
Arsenic	12	110	5 of 21 samples
Boron (Hot Water Extractable)	2*	4.17	2 of 9 samples
Chromium (hexavalent)	1.4	<2	3 of 16 samples
Selenium	2.9	3.1	1 of 21 samples
Electrical Conductivity	1.4*	12	12 of 19 samples
Sodium Adsorption Ratio	12*	150	10 of 19 samples
Benzene	0.030	1.5	2 of 23 samples
Toluene	0.37	4.1	2 of 23 samples
Ethylbenzene	0.082	2.1	2 of 23 samples
Xylenes (Total)	11	13	1 of 23 samples
PHC Fraction 2	260	7440	3 of 23 samples
PHC Fraction 3	1700	4250	1 of 23 samples
Acenaphthylene	0.15*	0.16	1 of 12 samples
Anthracene	0.67*	1	1 of 12 samples

Notes:

- All values are expressed as µg/g.
- *For parameters lacking CCME SQG, the MOE Table 3 (2009) SCS for industrial/ commercial/ community lands is used.

Table 3.2 Initial List of COPCs in Ground Water

Parameter	Value Used to Identify COPC	Maximum Measured Concentration	Number of Measured Concentrations that Exceed the Value Used to Indentify COPC
Sodium	4.9×10^5	1.78×10^7	7 of 16 samples
Chloride	2.3×10^7	3.33×10^7	1 of 9 samples
PHC Fraction 2	150	2,600	5 of 17 samples
PHC Fraction 3	500	1,200	2 of 17 samples
PHC Fraction 4	500	620	1 of 17 samples
Indeno(1,2,3-cd)pyrene	0.2	<0.27	2 of 6 samples

Notes:

- Value used to Identify COPC comes from the MOE Table 3 site conditions standards (SCS) which apply to all land uses where ground water may not be used as a potable water supply.
- All values are expressed as µg/L.

3.4 CONTAMINANTS OF CONCERN FOR THE HUMAN HEALTH RISK ASSESSMENT

3.4.1 Qualitative Discussion of Impacts in Soil

As shown in Table 3.1, 14 parameters are in the initial list of COPCs in soil. Each of these parameters is examined in more detail below from a human health perspective. (A similar discussion from an ecological perspective appears in Section 3.6.)

The measured concentrations of those 14 parameters are compared to various component values upon which CCME guidelines and MOE standards are based with the emphasis where parameters exceed human health component values. Through this evaluation, it is determined whether each of the 14 parameters needs to be carried forward into the quantitative portion of the HHRA.

Arsenic

Twenty-one samples (including two duplicates) from the Site have been analyzed for arsenic. The maximum measured concentration is 110 µg/g (at BH-09-03A). The average concentration is approximately 16 µg/g,

The CCME SQG of 12 µg/g is based on human health considerations and assumed rates of soil ingestion (CCME, 1997). Six of the measured concentrations exceed the SQG, therefore, arsenic is carried forward as a COPC in soil in the human health portion of this SSRA.

Boron (hot water extractable)

Nine soil samples from the Site have been analyzed for hot water extractable (HWE) boron. The maximum measured concentration is 4.17 µg/g (at MW09-04). The average concentration is approximately 1.5 µg/g.

There is no CCME guideline for hot water extractable boron.

The MOE SCS Table 3 of 2 µg/g is based on ecological considerations (specifically the protection of plants). The MOE recently introduced revisions to the SCS that are to come into effect in 2011; however, this SCS for HWE boron remains at 2 µg/g based on ecological considerations. Two samples from MW09-04 exceed the Table 3 SCS; however, HWE boron is not relevant in the context of human health and therefore is not assessed further in the human health portion of this SSRA.

Chromium (hexavalent)

Sixteen soil samples from the Site have been analyzed for hexavalent chromium. None produced quantifiable concentrations with detection limits ranging from 0.4 to 2 μg/g.

The CCME SQG of 1.4 μg/g is based on soil contact for ecological receptors (CCME, 1999). The CCME provides no component values based on human health. No measured concentrations exceed the SQG, but the detection limit of 2 μg/g for the three samples (BH304-4, BH309-5, and BH310-4 in 2009) is slightly higher than the SQG.

The MOE Table 3 SCS for hexavalent chromium at industrial/commercial sites with coarse-grained soil and non-potable ground water is 8 μg/g. This is based on ecological considerations and specifically those to be protective of plants and soil organisms. The most stringent human health component value identified by the MOE is 40 μg/g. This S3 risk value is based on the inhalation of airborne soil particles and direct soil contact by workers at industrial/commercial sites.

Given that hexavalent chromium was not quantified in any sample from the Site, the SQG is based on ecological considerations, and no samples from the Site exceed the most stringent human health based component value, hexavalent chromium is not assessed further in the human health portion of this SSRA.

Selenium

Twenty-one soil samples (including 2 duplicate samples) from the Site have been analyzed for selenium. The results range from 0.5 to 3.1 μg/g.

The CCME SQG of 2.9 μg/g is not based on human health considerations. According to the Canadian Soil Quality Guideline (CCME, 2009), the concentration of selenium in soil needed to protect human health is 80 μg/g. One sample collected at MW4 from a depth of 0.6 to 1.2 m bgs slightly exceeds the SQG.

Since the maximum measured concentration of selenium does not exceed the most stringent human health component value established by the CCME, selenium is not assessed further in the human health portion of this report.

Electrical Conductivity (EC)

Nineteen soil samples from the Site have been analyzed for electrical conductivity (EC). The results range from 0.18 to 12 mS/cm. The average is approximately 3.4 mS/cm.

There is no CCME SQG for EC.

The MOE Table 3 SCS for EC is 1.4 mS/cm. It is not based on human health considerations. According to the MOE Rationale document (both the original published in 2004 and the revised version published in 2009), the SCS is an ecotoxicity value intended to be protective of plants and soil organisms. The SCS is exceeded in 12 of 19 samples analyzed.

Since EC is not relevant in the context of human health, it is not assessed further in the human health portion of this SSRA.

Sodium Absorption Ratio (SAR)

Nineteen soil samples from the Site have been analyzed for sodium absorption ratio (SAR). The results range from 0.02 to 150 μg/g, and the average is 36 μg/g.

There is no CCME SQG for SAR.

The MOE Table 3 SCS for SAR is 12 μg/g and is based on ecological considerations to be protective of plants and soil organisms. The SCS is exceeded in ten of the 19 samples analyzed.

SAR is a measure of the amount of sodium (an undesirable element) relative to calcium and magnesium (desirable elements), and is an indicator of the suitability of soil to support plant growth. It is not related to human health considerations.

Since SAR is not relevant in the context of human health, it is not assessed further in the human health portion of this SSRA.

Benzene

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for benzene. The results range from <0.002 to 1.5 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 0.03 μg/g is based on human health considerations for protecting ground water supplies (CCME, 2004). Drinking water at the Site (and throughout the Oshawa Harbour lands) is obtained from the municipal supply, and so the SQG is not an appropriate benchmark. The next most stringent human health component value for benzene is 0.30 μg/g for protection of human health for inhalation of vapours in indoor air. That value is exceeded in a sample from BH308-1 which produced a concentration of 1.2 μg/g and a concentration of 1.5 μg/g in its duplicate.

The current MOE SCS for benzene is 5.3 μg/g and is also based on human health considerations, and specifically the pathway for inhalation of vapours inside a building. The MOE has recently revised its standards and has decreased this SCS to 0.32 μg/g based on the inhalation of vapours in indoor air at industrial/commercial sites with coarse-grained soil. The next most stringent human health component value is 13 μg/g and is a soil contact number.

There are no buildings on the Site, only temporary trailers, so the indoor air exposure pathway that is central to the CCME and MOE values is not appropriate, but it is assumed that a more permanent structure could be put on the Site. Therefore, given that benzene exceeds the most stringent human health component values, benzene is carried forward as a COPC in soil in the human health portion of this SSRA.

Toluene

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for toluene. The results range from <0.002 to 4.1 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 0.37 μg/g is based on human health considerations for protecting ground water as a source of drinking water (CCME, 2007). That value is exceeded in a sample from BH308-1 which produced a concentration of 3.6 μg/g and a concentration of 4.1 μg/g in its duplicate. Drinking water at the Site (and throughout the Oshawa Harbour lands) is obtained from the municipal supply, and so the SQG is not an appropriate benchmark. The next most stringent human health component value for toluene is 1,400 μg/g for protection of human health for inhalation of vapours in indoor air. That value is not exceeded in any of the samples from the Site.

The MOE Table 3 SCS is 34 μg/g and is based upon the human health pathway of inhaling indoor vapours (MOE, 2004). The MOE has recently revised the Table 3 SCS for toluene and it will decrease to 6.4 μg/g with the key consideration being the protection of ground water as a source of drinking water. The next most stringent human health component value is 99 μg/g for the inhaling of indoor vapours at industrial/commercial sites with coarse-grained soil.

Given that two of 23 results exceed the SQG that is based on protecting ground water as a drinking water source, and that ground water is not used for that purpose, and that no other relevant human health component value is exceeded, toluene is not is not assessed further in the human health portion of this SSRA.

Ethylbenzene

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for ethylbenzene. The results range from <0.002 to 2.1 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 0.082 μg/g is based on human health considerations for protecting ground water as a source of drinking water (CCME, 2004). That value is exceeded in a sample from BH308-1 which produced a concentration of 1.8 μg/g and a concentration of 2.1 μg/g in its duplicate. Drinking water at the Site (and throughout the Oshawa Harbour lands) is obtained from the municipal supply, and so the SQG is not an appropriate benchmark. The next most stringent human health component value for ethylbenzene is 630 μg/g for protection of human health for inhalation of vapours in indoor air. That value is not exceeded in any of the samples from the Site.

The MOE Table 3 SCS is 290 μg/g and is based upon the human health pathway of inhaling indoor vapours (MOE, 2004). The MOE has recently revised the Table 3 SCS for ethylbenzene and it will decrease to 1.1 μg/g with the key consideration being the protection of ground water as a source of drinking water. The next most stringent human health component value is 99 μg/g for the inhaling of indoor vapours at industrial/commercial sites with coarse-grained soil.

Given that two of 23 results exceed the SQG that is based on protecting ground water as a drinking water source, and that ground water is not used for that purpose, and that no other relevant human health component value is exceeded, ethylbenzene is not is not assessed further in the human health portion of this SSRA.

Xylenes

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for xylenes. The results range from <0.002 to 13 µg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 11 µg/g is based on human health considerations for protecting ground water as a source of drinking water (CCME, 2004). That value is exceeded in a sample from BH308-1 which produced a concentration of 11 µg/g and a concentration of 13 µg/g in its duplicate. Drinking water at the Site (and throughout the Oshawa Harbour lands) is obtained from the municipal supply, and so the SQG is not an appropriate benchmark. The next most stringent human health component value for xylenes is 160 µg/g for protection of human health for inhalation of vapours in indoor air. That value is not exceeded in any of the samples from the Site.

The MOE Table 3 SCS is 34 µg/g and is based upon the human health pathway of inhaling indoor vapours (MOE, 2004). The MOE has recently revised the Table 3 SCS for xylenes and it will decrease to 26 µg/g with the key consideration being the protection of ground water as a source of drinking water. The next most stringent human health component value is 50 µg/g for the inhaling of indoor vapours at industrial/commercial sites with coarse-grained soil.

Given that one of 23 results exceeds the SQG that is based on protecting ground water as a drinking water source, and that ground water is not used for that purpose, and that no other relevant human health component value is exceeded, xylenes is not is not assessed further in the human health portion of this SSRA.

PHC Fraction 2

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for PHC Fraction 2. The maximum measured concentration is 7,440 µg/g at MW17 (SS2). The average concentration is approximately 570 µg/g.

The CCME SQG of 260 µg/g in coarse-grained surface soil in an industrial or commercial land-use setting is based on ecological considerations (CCME, 2008). The next highest component value is 320 µg/g and is based on the protection of potable ground water. Drinking water at the Site (and throughout the Oshawa Harbour lands) is obtained from the municipal supply, and so that component value is not an appropriate benchmark for the Site. A management limit of 1,000 µg/g has been set. It is intended to prevent various types of unwanted conditions such as excessive staining or odours, effects on buried infrastructure, exposures to workers in trenches, fire and explosive hazards, and the formation of free phase petroleum product. That management limit is exceeded in two samples and the duplicate of one of the samples.

The current MOE Table 3 SCS of 150 µg/g has been revised and will increase to 230 µg/g and is based on the protection of a ground water as a drinking water supply. The next most stringent human health component value is 380 µg/g and is based on the inhalation of indoor vapours at industrial/commercial sites with coarse-grained soil. The next most stringent human health component value is 22,000 µg/g and is for soil contact.

Given that three or more results exceed the CCMG SQG and all of the human health component values (although many of these are not relevant to the Site), PHC Fraction 2 is carried forward as a COPC in soil in the human health portion of this SSRA.

PHC Fraction 3

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for PHC Fraction 3. The maximum measured concentration is 4,250 µg/g at MW17 (SS2). The average concentration is approximately 435 µg/g.

The CCME SQG of 1,700 µg/g in coarse-grained surface soil in an industrial or commercial land-use setting is based on ecological considerations (CCME, 2008). The next highest component value is the management limit of 3,500 µg/g. Both of these values are exceeded in the sample noted above from MW17.

The current MOE SCS is 1,700 µg/g and this standard is not changed in the recently announced revisions. The standard is protective of plants and soil organisms, and not based on human health considerations. The MOE also cites a free-phase threshold value of 5,800 µg/g. The most stringent human health value of 3,000 µg/g is based on soil contact.

Although the one result exceeds the CCMG SQG but does not exceed human health component values (although many of these are not relevant to the Site), PHC Fraction 3 is carried forward as a COPC in soil in the human health portion of this SSRA.

Acenaphthylene

Twelve soil samples (including one duplicate) from the Site have been analyzed for acenaphthylene. The results range from <0.02 to 0.16 µg/g. Most of the results are reported as less than detection limits.

The CCME has not established a SQG for acenaphthylene.

The current MOE SCS is 840 µg/g. The revisions recently announced by the MOE will lower the SCS for acenaphthylene to 0.15 µg/g for coarse-grained soil and slightly higher at 0.17 µg/g for medium and fine-grained soil at industrial/commercial sites in non-potable ground water settings. The revised values are intended to prevent excessive leaching from soil to ground water. The maximum measured concentration of 0.16 µg/g (from MW6) would marginally exceed the new SCS for coarse-grained soil

The most stringent human health component value is 6.6 µg/g to protect people who inhale indoor vapours.

Given that one sample marginally exceeds the future MOE Table 3 SCS but does not exceed human health component value or the current Table 3 SCS, acenaphthylene is not is not assessed further in the human health portion of this SSRA.

Anthracene

Twelve soil samples (including one duplicate) from the Site have been analyzed for anthracene. The results range from <0.02 to 1 µg/g. Most of the results are reported as less than detection limits.

The CCME has not established a SQG for anthracene. It recently recommended an ecological component value, but none for human health (CCME, 2010).

The current MOE SCS is 28 µg/g. The revisions recently announced by the MOE will lower the SCS for anthracene to 0.67 µg/g for coarse-grained soil at industrial/commercial sites in non-potable ground water settings. The revised value is intended to prevent excessive leaching from soil to ground water. The maximum measured concentration of 1 µg/g (from MW6) would marginally exceed the new SCS.

The various component values directly relevant to human health are all in excess of 10,000 µg/g. There is a free-phase threshold is set at 2,700 µg/g.

Given that one sample marginally exceeds the future MOE Table 3 SCS but does not exceed human health component value or the current Table 3 SCS, anthracene is not assessed further in the human health portion of this SSRA.

Summary for Soil

The initial comparing of measured concentrations to generic CCME guidelines or MOE standards identified 14 COPCs in soil: arsenic, boron (hot water extractable), hexavalent chromium, selenium, EC, SAR, benzene, toluene, ethylbenzene, xylenes, PHC Fraction 2, PHC Fraction 3, acenaphthylene, and anthracene. Closer consideration of the information upon which those generic guidelines and standards are based shows that ten of the 14 parameters do not need to be assessed further in the human health portion of the SSRA: boron (hot water extractable), hexavalent chromium, selenium, EC, SAR, toluene, ethylbenzene, xylenes, acenaphthylene, and anthracene. **This leaves four COPCs that need to be assed further in the HHRA: arsenic, benzene, PHC Fraction 2 and PHC Fraction 3.**

3.4.2 Qualitative Discussion of Impacts in Ground Water

As shown in Table 3.2, six parameters are in the initial list of COPCs in ground water. Each of these parameters is examined in more detail below from a human health perspective. (A similar discussion from an ecological perspective appears in Section 3.6.)

The measured concentrations of those six parameters are compared to various component values upon which MOE standards are based with the emphasis where parameters exceed human health component values. (There are no analogous CCME guidelines for ground water.) Through this evaluation, it is determined whether each of the six parameters needs to be carried forward into the quantitative portion of the HHRA.

Sodium and Chlorides in Ground Water

Sixteen ground water samples (including two duplicates) from the Site have been analyzed for sodium and seven samples analyzed for chlorides. The results range from 35,000 to 17,800,000 μg/L for sodium, and 20,300 to 33,300,000 μg/L for chlorides.

There currently is no Table 3 SCS for sodium in ground water, but the recently announced revisions set the Table 3 SCS at 4.9 x 10^5 µg/L. It is based on background conditions found in Ontario. Seven results from the Site exceed the Table 3 SCS. The elevated concentrations likely are the result of the storage and use of road salt on the Site, and the use of road salt at locations that are up gradient. The maximum concentration of 1.78 x 10^7 µg/L was measured in a sample from MW09-01 which is near to where salt was stored in the past.

There currently is no Table 3 SCS for chlorides in ground water, but the recently announced revisions set the Table 3 SCS at 2.3 x 10^6 µg/L. It is based on the protecting of aquatic habitat. No human health component values are provided. Two results from the Site exceed the Table 3 SCS. Like sodium, the maximum chlorides concentration of 3.3 x 10^7 µg/L was measured in a sample from MW09-01 which is near to where salt was stored in the past.

The Table 3 SCS are not based on human health component values, but the maximum measured concentrations are well above the standards based on background concentrations and ecological considerations. Therefore, sodium and chlorides are carried forward as COPCs in ground water in the human health portion of this SSRA.

PHC Fraction F2

Seventeen ground water samples from the Site have been analyzed for PHC Fraction 2. The results range from <100 to 2,600 µg/L. Many of the results are less than detection limits.

There currently is no Table 3 SCS for PHC Fraction 2 in ground water, but the recently announced revisions set the Table 3 SCS at 150 µg/L. It is set equal to one-half its aqueous solubility limit. It is exceeded in five of the results from the Site. The most stringent human health component value is for the protection of residential receptors at a concentration of 2,300 µg/L. It is exceeded in one of the results from the Site. In an industrial land-use setting, this value increase to 47,000 µg/L. It is not exceeded by results from the Site. Nevertheless, PHC Fraction 2 is carried forward into the quantitative portion of the RA.

The Table 3 SCS is not based on human health component values, but several measured concentrations are well above the standards based on solubility limits and the maximum measured concentration exceeds a human health component value for residential land use. To be conservative, PHC Fraction 2 is carried forward as a COPC in ground water in the human health portion of this SSRA.

PHC Fraction F3

Seventeen ground water samples from the Site have been analyzed for PHC Fraction 3. The results range from <100 to 1,200 µg/L. Many of the results are less than detection limits.

There currently is no Table 3 SCS for PHC Fraction 3 in ground water, but the recently announced revisions set the Table 3 SCS at 500 µg/L. It is set equal to the Ontario background concentration. It is exceeded in two of the results from the Site. No human health component values are provided for PHC Fraction 3 in ground water.
The Table 3 SCS is not based on human health component values, but two measured concentrations are above background concentrations. To be conservative, PHC Fraction 3 is carried forward as a COPC in ground water in the human health portion of this SSRA.

PHC Fraction F4

Seventeen ground water samples from the Site have been analyzed for PHC Fraction 4. The results range from <100 to 620 µg/L. Many of the results are less than detection limits.

There currently is no Table 3 SCS for PHC Fraction 4 in ground water, but the recently announced revisions set the Table 3 SCS at 500 µg/L. It is set equal to the Ontario background concentration. It is exceeded in one of the results from the Site. No human health component values are provided for PHC Fraction 4 in ground water.

The Table 3 SCS is not based on human health component values, but two measured concentrations are above background concentrations. To be conservative, PHC Fraction 4 is carried forward as a COPC in ground water in the human health portion of this SSRA.

The basis for the MOE guideline of 500 µg/L (2009) is based on Ontario background levels. There are no human health component values recorded in the MOE (2009) Rationale document. Nevertheless, PHC F4 is carried forward into the quantitative portion of the RA.

Indeno(1,2,3-cd)pyrene

Six ground water samples (including one duplicate) from the Site have been analyzed for indeno(1,2,3-cd)pyrene. Results range from <0.03 to <0.27 µg/L.

The current MOE Table 3 SCS is 0.27 μg/L. The recently announced revisions set the Table 3 SCS at 0.2 μg/L. It is set equal to the Ontario background concentration. Two samples analyzed in 2003 are reported as < 0.27 μg/L which means that the new Table 3 SCS might be exceeded. The most stringent human health component value is 2,200 μg/L (and is intended to be applied to residential receptors). No results exceed the most stringent human health component value. Therefore, indeno(1,2,3-cd)pyrene is not assessed further in the human health portion of this SSRA.

Summary for Ground Water

The initial comparing of measured concentrations to generic MOE standards identified six COPCs in ground water: sodium, chlorides, PHC Fraction 2, PHC Fraction 3, PHC Fraction 4, and indeno(1,2,3-cd)pyrene. Closer consideration of the information upon which those generic guidelines and standards are based shows that one of the six parameters does not need to be assessed further in the human health portion of the SSRRA: indeno(1,2,3-cd)pyrene. **This leaves five COPCs that need to be assed further in the HHRA: sodium, chlorides, PHC Fraction 2, PHC Fraction 3, and PHC Fraction 4.**

3.4.3 PHC in Soil and Dividing PHC into Fractions

Petroleum hydrocarbons (PHC) present a challenge to risk assessment because many individual chemicals can contribute to measurements of PHC. The chemicals present in PHC can vary widely from site to site.

The Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) was formed in 1993 to develop scientifically defensible methods for establishing risk-based criteria for petroleum hydrocarbons. TPHCWG reports describe an approach that divides TPH into numerous fractions, each of which is assigned physical-chemical and toxicological properties based on the chemicals that can be present in that fraction (TPHCWG, 1997; Gustafson *et al.*, 1997).

The fractions are defined by molecular structure and the number of carbon atoms present. On the basis of structure, all compounds are either aromatic (those with ring-like structures) or aliphatic (those with straight or branched structures). Compounds in both groups are divided further using the number of carbon atoms present (or more correctly the equivalent carbon number or EC). For example, one fraction is defined as all the aromatic hydrocarbons with EC values of greater than 12 but not more than 16. This is abbreviated $EC_{>12}$ to EC_{16} or as $C_{>12}$ to C_{16} if the more familiar carbon notation is used, as is the case in the remainder of this report. (Even the TPHCWG documents do not use the EC notation consistently.) Additional details are presented in Appendix A.

The work of the TPHCWG subsequently was used as a basis by the CCME to develop another approach that divides PHC into four fractions:

- Fraction 1 (F1) includes all aromatics and aliphatics (excluding BTEX) up to C_{10}. The compounds in F1 will account for the majority of the PHC measured in gasoline or jet fuel. Once released into the environment, the compounds in F1 will degrade and volatilize at relatively fast rates. Eventually, the relative proportion of the F2 fraction will increase.
- Fraction 2 (F2) includes all aromatics and aliphatics in the range of $C_{>10}$ to C_{16}. The compounds in F2 will account for the majority of the PHC measured in "fresh" kerosene and approximately half the constituents in diesel fuel, home heating oil or fuel oil (three relatively similar products).
- Fraction 3 (F3) includes all aromatics and aliphatics in the range of $C_{>16}$ to C_{34}. The compounds in F3 will account for the other half of the constituents in diesel fuel, as well as the majority of the PHC measured in lubricants such as motor oil, paraffin wax, and petroleum jelly.
- Fraction 4 (F4) includes all aromatics and aliphatics beyond C_{34}. This fraction includes tars and resins.

The CCME approach of dividing PHC into four fractions subsequently has been adopted by the MOE.

Dividing PHC Fractions Further

Chapter 5 of this SSRA explains that CCME fractions must be divided further for human health risks to be assessed. If not done by an analytical laboratory, the CCME describes a way to divide PHC fractions into the finer fractions defined by the TPHCWG. This process is illustrated below with the data from AquaTerre (2009) sample BH308-1 (a sample collected from 0.6 to 1.2 m bgs).

Using the composition suggested by the CCME, the 250 μg/g of PHC F1 measured at BH308-1 can be divided as follows:

Aliphatic C_6 to C_8 = 55% = 137.5 μg/g
Aliphatic $C_{>8}$ to C_{10} = 36% = 90 μg/g
Aromatic $C_{>8}$ to C_{10} = 9% = 22.5 μg/g

Using the composition suggested by the CCME, the 2,600 μg/g of PHC F2 measured at BH308-1 can be divided as follows:

Aliphatic $C_{>10}$ to C_{12} = 36% = 936 μg/g
Aliphatic $C_{>12}$ to C_{16} = 44% = 1,144 μg/g
Aromatic $C_{>10}$ to C_{12} = 9% = 234 μg/g
Aromatic $C_{>12}$ to C_{16} = 11% = 286 μg/g

Using the composition suggested by the CCME, the 1,700 μg/g of PHC F3 measured at BH308-1 can be divided as follows:

Aliphatic $C_{>16}$ to C_{21} = 56% = 952μg/g
Aliphatic $C_{>21}$ to C_{34} = 24% = 408 μg/g
Aromatic $C_{>16}$ to C_{21} = 14% = 238 μg/g
Aromatic $C_{>21}$ to C_{34} = 6% = 102 μg/g

3.4.4 PHC in Ground Water

Most constituents of PHCs are less dense than water, and as a result downward movement through soil tends to stop where the water table is encountered. Since water tables move up and down over time in response to weather, floating PHCs will move up and down with the water table, often creating a "smear zone" that extends from the low water table to the high water table. In general, where PHCs have reached the water table, concentrations of PHCs will be highest in the vicinity of the average water table.

Depth to the ground water table at the Site has been measured at less than 1 m bgs at MW308 and MW09-02ii, between 1.25 to 1.5 m bgs in MW6, MW302, and MW09-01, and greater than 1.5 to 1.9 m bgs at MW09-01i and MW310.

As described for soil data in Section 3.4.3, concentrations of PHC fractions measured in ground water must be divided further for risks to be assessed. This is illustrated below using the data from MW308 and MW310.

Using the composition suggested by Health Canada for PHC F1 in ground water (although not a COPC), the 610 μg/L of PHC F1 measured at MW310 (March 2010) can be divided as follows:

Aliphatic C_6 to C_8 = 63.5% = 387 μg/L
Aliphatic $C_{>8}$ to C_{10} = 6.3% = 38 μg/L
Aromatic $C_{>8}$ to C_{10} = 33.2% = 203 μg/L

Using the composition suggested by the Health Canada for PHC F2 in ground water, the 2,600 μg/L of PHC F2 measured at MW308 (March 2009) can be divided as follows:

Aliphatic $C_{>10}$ to C_{12} = 2.4% = 62 μg/L
Aliphatic $C_{>12}$ to C_{16} = 0.1% = 3 μg/L
Aromatic $C_{>10}$ to C_{12} = 60.3% = 1,568 μg/L
Aromatic $C_{>12}$ to C_{16} = 37.1% = 965 μg/L

Using the composition suggested by the Health Canada for PHC F3 in ground water, the 1,200 μg/L of PHC F3 measured at MW310 (March 2009) can be divided as follows:

Aliphatic $C_{>16}$ to C_{21} = 0% = 0 μg/L
Aliphatic $C_{>21}$ to C_{34} = 0% = 0 μg/L
Aromatic $C_{>16}$ to C_{21} = 95% = 1,140 μg/L
Aromatic $C_{>21}$ to C_{34} = 5% = 60 μg/L

Using the composition suggested by the Health Canada for PHC F4 in ground water, the 620μg/L of PHC F4 measured at MW310 (March 2009) can be divided as follows:

Aliphatic $C_{>34}$ = 0% = 0 μg/L
Aromatic $C_{>34}$ = 100% = 620 μg/L

3.4.5 Taking Degradation Products into Consideration

Some chemicals can degrade to form other chemicals that pose concerns equal to or greater than the original chemical. Although a degradation product may not have been measured in the environment, it may be prudent to carry it forward in the risk assessment. The degradation products of COPCs at the Site do not raise this concern.

3.5 OTHER TYPES OF DATA GATHERED

Various types of information have been collected during investigations at and around the Site. These include: organic vapour readings, and qualitative observations such as the presence of staining or odours. These are general indicators of conditions and are used to select samples for chemical analysis, or delineate the lateral or vertical extent of impacts, but are not directly useable for quantifying potential risks.

Surface water samples have also been collected at Oshawa Harbour. Four surface water samples were collected along three sides of the West Wharf and one closer to the South Spur lands to determine whether impacts to ground water at the Site are affecting surface water quality. The surface water samples were analyzed for inorganics parameters. Sodium and chloride are the only inorganic COPCs in ground water and they did not exceed CCME water quality guidelines for the protection of aquatic life in the samples from the harbour.

Soil grain size analysis was determined in four samples. Two samples that were described as silt or sand fill had more than 75% of the sample passing through the 200 mesh and are therefore classified as fine-grained. This is consistent with the silt-fill soil descriptions in the borehole logs. The other two samples had more than 75% retained on the 200 mesh and are therefore classified as coarse-grained. This is consistent with the gravel and sand soil descriptions on the borehole logs (GENIVAR, 2010)

Two samples from the Site were analyzed for total organic carbon. Results range from 0.93 to 2.1%. These organic carbon contents can be considered to be average. Atypically high values can have implications for soil quality since most metals will absorb onto organic material and over time can result in concentrations considerably higher than those measured in other soils. Atypically low values can suggests that chemicals in soil are relatively available to ecological receptors and that generic guidelines and standards may not be adequately protective.

3.6 CONTAMINANTS OF CONCERN FOR THE ECOLOGICAL RISK ASSESSMENT

3.6.1 Qualitative Discussion of Impacts in Soil

As shown in Table 3.1, 14 parameters are in the initial list of COPCs in soil. Each of these parameters is examined in more detail below from an ecological perspective. (A similar discussion from a human health perspective appears in Section 3.4.)

The measured concentrations of those 14 parameters are compared to various component values upon which CCME guidelines and MOE standards are based with the emphasis where parameters exceed ecological component values. Through this evaluation, it is determined whether each of the 14 parameters needs to be carried forward into the ecological risk assessment presented in Chapter 6.

As noted in Section 3.2, COPCs are identified initially by comparing measured concentrations on the Site to the appropriate CCME and MOE values. Based on the CCME and MOE values provided in Tables 3.1 and 3.2, the initially identified COPCs are:

- Arsenic, boron (hot water extractable), chromium (hexavalent), selenium, electrical conductivity (2:1), sodium absorption ratio (2:1), benzene, toluene, ethylbenzene, xylenes, PHC F2, PHC F3, acenaphthylene, and anthracene in soil
- Sodium, chloride, PHC F2, PHC F3, PHC F4, and indeno(1,2,3-cd)pyrene in ground water

As explained in Section 3.1, not all of the CCME and MOE values used to identify the initial COPCs are based on human health considerations. So too, not all of the values are based on ecological considerations. For example, many of the MOE Table 1 SCS are based primarily upon data collected by the MOE to characterize "background" concentrations in Ontario (locations removed from contaminant sources). A better (more appropriate) approach is to compare the concentrations measured at the West Wharf Site to the ecological "component values" that appear in the CCME and MOE processes for setting guidelines and standards. The ecological component values that are appropriate to use in this SLERA are listed below.

- There are values intended to be protective of ecological receptors in the Canadian Soil Quality Guidelines (CSQGs) set by the CCME (CCME, 1997a; 1997b; 1997c; 1999a; 1999b).
- There are ecotoxicity component values in the MOE Guideline for the 3 SCS (1996, 2009).

Each of the 14 initial COPCs in soil is examined in more detail below from an ecological perspective. (A similar discussion from a human health perspective appears in Section 3.4.)

Arsenic

Twenty-one samples (including two duplicates) from the Site have been analyzed for arsenic. The maximum measured concentration is 110 μg/g (at BH-09-03A). The average concentration is approximately 16 μg/g,

The CCME SQG of 12 μg/g is based on human health considerations and assumed rates of soil ingestion (CCME, 1997). The most stringent ecological component value is 26 μg/g. Two of the results from the Site exceed that component value, therefore, arsenic is carried forward as a COPC in soil in the ecological portion of this SSRA.

Boron (hot water extractable)

Nine soil samples from the Site have been analyzed for hot water extractable (HWE) boron. The maximum measured concentration is 4.17 µg/g (at MW09-04). The average concentration is approximately 1.5 µg/g.

There is no CCME guideline for hot water extractable boron.

The MOE SCS Table 3 of 2 µg/g is based on ecological considerations (specifically the protection of plants). The MOE recently introduced revisions to the SCS that are to come into effect in 2011; however, this SCS for HWE boron remains at 2 µg/g and based on ecological considerations. Two samples from MW09-04 exceed the Table 3 SCS, therefore, HWE boron is carried forward as a COPC in soil in the ecological portion of this SSRA.

Chromium (hexavalent)

Sixteen soil samples from the Site have been analyzed for hexavalent chromium. None produced quantifiable concentrations with detection limits ranging from 0.4 to 2 µg/g.

The CCME SQG of 1.4 µg/g is based on soil contact for ecological receptors (CCME, 1999). No measured concentrations exceed the SQG, but the detection limit of 2 µg/g for the three samples (BH304-4, BH309-5, and BH310-4 in 2009) is slightly higher than the SQG.

The MOE Table 3 SCS for hexavalent chromium at industrial/commercial sites with coarse-grained soil and non-potable ground water is 8 µg/g. This is based on ecological considerations and specifically those to be protective of plants and soil organisms.

Although hexavalent chromium was not quantified in any sample from the Site, the detection limit for three samples exceeded the SQG which is based on ecological considerations. Therefore, to be conservative, hexavalent chromium is carried forward as a COPC in soil in the ecological portion of this SSRA.

Selenium

Twenty-one soil samples (including 2 duplicate samples) from the Site have been analyzed for selenium. The results range from 0.5 to 3.1 µg/g.

The CCME SQG of 2.9 µg/g is based on ecological considerations (CCME, 2009). One sample collected at MW4 slightly exceeds the SQG.

Since the maximum measured concentration of selenium exceeds the SQG which is based on ecological considerations, selenium is carried forward as a COPC in soil in the ecological portion of this SSRA.

Electrical Conductivity (EC)

Nineteen soil samples from the Site have been analyzed for electrical conductivity (EC). The results range from 0.18 to 12 mS/cm. The average is approximately 3.4 mS/cm.

There is no CCME SQG for EC.

The MOE Table 3 SCS for EC is 1.4 mS/cm and it is based on ecological considerations. According to the MOE Rationale document (both the original published in 2004 and the revised version published in 2009), the SCS is an ecotoxicity value intended to be protective of plants and soil organisms. The SCS is exceeded in 12 of 19 samples analyzed. Therefore EC is carried forward as a COPC in soil in the ecological portion of this SSRA.

Sodium Absorption Ratio (SAR)

Nineteen soil samples from the Site have been analyzed for sodium absorption ratio (SAR). The results range from 0.02 to 150 μg/g, and the average is 36 μg/g.

There is no CCME SQG for SAR.

The MOE Table 3 SCS for SAR is 12 μg/g and is based on ecological considerations to be protective of plants and soil organisms. The SCS is exceeded in ten of the 19 samples analyzed. Therefore, SAR is carried forward as a COPC in soil in the ecological portion of this SSRA.

Benzene

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for benzene. The results range from <0.002 to 1.5 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 0.03 μg/g is based on human health considerations for protecting ground water supplies (CCME, 2004). The most stringent ecological component value is 180 μg/g based on soil contact in coarse-grained soil. That component value is not exceeded by any of the results from the Site.

The current MOE SCS for benzene is 5.3 μg/g and is based on human health considerations. The MOE has recently revised its standards and has decreased this SCS to 0.32 μg/g based on the human health considerations. The most stringent ecological component value is 180 μg/g to protect plants of soil organisms. None of the results from the Site exceed that ecological component value.

Given that the maximum measured concentrations of benzene in soil do not exceed either the CCME or MOE ecotoxicity component values, benzene is not carried forward as a COPC in soil in the ecological portion of this SSRA.

Toluene

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for toluene. The results range from <0.002 to 4.1 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 0.37 μg/g is based on human health considerations (CCME, 2004). The most stringent ecological component value for toluene is 180 μg/g and is based on soil contact. That component value is not exceeded by any of the results from the Site.

The MOE Table 3 SCS is 34 μg/g and is based upon the human health pathway of inhaling indoor vapours (MOE, 2004). The MOE has recently revised the Table 3 SCS for toluene and it will decrease to 6.4 μg/g with the key consideration being the protection of ground water as a source of drinking water. The most stringent ecological component value is 500 μg/g for the protection of plants and soil organisms. That component value is not exceeded by any of the results from the Site.

Given that the maximum measured concentrations of toluene in soil do not exceed either the CCME or MOE ecotoxicity component values, toluene is not carried forward as a COPC in soil in the ecological portion of this SSRA.

Ethylbenzene

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for ethylbenzene. The results range from <0.002 to 2.1 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 0.082 μg/g is based on human health considerations (CCME, 2004). The most stringent ecological component value is 300 μg/g and is based on soil and food ingestion. That value is not exceeded in any of the samples from the Site.

The MOE Table 3 SCS is 290 μg/g and is based upon the human health considerations (Queen's Printer, 2004). The MOE has recently revised the Table 3 SCS for ethylbenzene and it will decrease to 1.1 μg/g with the key consideration being the protection of ground water as a source of drinking water. The most stringent ecological component value is 300 μg/g for the protection of plants and soil organisms.

Given that the maximum measured concentrations of ethylbenzene in soil do not exceed either the CCME or MOE ecotoxicity component values, ethylbenzene is not carried forward as a COPC in soil in the ecological portion of this SSRA.

Xylenes

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for xylenes. The results range from <0.002 to 13 μg/g. Most of the results are reported as less than detection limits.

The CCME SQG of 11 μg/g is based on human health considerations (CCME, 2004). The most stringent ecological component value is 350 μg/g and is based on direct soil contact. That value is not exceeded in results from the Site.

The MOE Table 3 SCS is 34 μg/g and is based upon the human health pathway of inhaling indoor vapours (MOE, 2004). The MOE has recently revised the Table 3 SCS for xylenes and it will decrease to 26 μg/g with the key consideration being the protection of ground water as a source of drinking water. The most stringent ecological component value is 350 μg/g for protecting plants and soil organisms.

Given that the maximum measured concentrations of xylenes in soil do not exceed either the CCME or MOE ecotoxicity component values, xylenes is not carried forward as a COPC in soil in the ecological portion of this SSRA.

PHC Fraction 2

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for PHC Fraction 2. The maximum measured concentration is 7,440 μg/g at MW17 (SS2). The average concentration is approximately 570 μg/g.

The CCME SQG of 260 µg/g in coarse-grained surface soil in an industrial or commercial land-use setting is based on ecological considerations (CCME, 2008). That SQG is exceeded in two samples and the duplicate of one of the samples.

The current MOE Table 3 SCS of 150 µg/g has been revised and will increase to 230 µg/g and is based on the protection of a ground water as a drinking water supply. The most stringent ecological component value is 260 µg/g (i.e. the same as the CCME value noted above).

Given that three results exceed the CCME SQG which is based on ecological considerations, PHC Fraction 2 is carried forward as a COPC in soil in the human health portion of this SSRA.

PHC Fraction 3

Twenty-three soil samples (including two duplicates) from the Site have been analyzed for PHC Fraction 3. The maximum measured concentration is 4,250 µg/g at MW17 (SS2). The average concentration is approximately 435 µg/g.

The CCME SQG of 1,700 µg/g in coarse-grained surface soil in an industrial or commercial land-use setting is based on ecological considerations (CCME, 2008). It is exceeded in the sample noted above from MW17.

The current MOE SCS is 1,700 µg/g and this standard is not changed in the recently announced revisions. The standard is protective of plants and soil organisms.

Given that one result exceeds the CCMG SQG which is based on ecological considerations, PHC Fraction 3 is carried forward as a COPC in soil in the human health portion of this SSRA.

Acenaphthylene

Twelve soil samples (including one duplicate) from the Site have been analyzed for acenaphthylene. The results range from <0.02 to 0.16 µg/g. Most of the results are reported as less than detection limits.

The CCME has not established a SQG for acenaphthylene.

The current MOE SCS is 840 μg/g. The revisions recently announced by the MOE will lower the SCS for acenaphthylene to 0.15 μg/g for coarse-grained soil and slightly higher at 0.17 μg/g for medium and fine-grained soil at industrial/commercial sites in non-potable ground water settings. The revised values are intended to prevent excessive leaching from soil to ground water. The maximum measured concentration of 0.16 μg/g (from MW6) would marginally exceed the new SCS for coarse-grained soil

Since neither the CCME nor the MOE provide ecological component values for acenaphthylene, other sources were consulted. The U.S. EPA Region 5 Ecological Screening Level for acenaphthylene in soil is 682 μg/g (U.S.EPA, 2003). Therefore, given that acenaphthylene was not measured above 0.15 μg/g, it is not examined further in the ecological portion of the RA.

Given that one sample marginally exceeds the future MOE Table 3 SCS but does not exceed the current Table 3 SCS or the one ecological benchmark that could be found, acenaphthylene is not carried forward as a COPC in soil in the human health portion of this SSRA.

Anthracene

Twelve soil samples (including one duplicate) from the Site have been analyzed for anthracene. The results range from <0.02 to 1 μg/g. Most of the results are reported as less than detection limits.

The CCME has not established a SQG for anthracene. It recently recommended an ecological component value of 32 μg/g for soil contact (CCME, 2010). That value is not exceeded in results from the Site.

The current MOE SCS is 28 μg/g. The revisions recently announced by the MOE will lower the SCS for anthracene to 0.67 μg/g for coarse-grained soil at industrial/commercial sites in non-potable ground water settings. The revised value is intended to prevent excessive leaching from soil to ground water. The maximum measured concentration of 1 μg/g (from MW6) would marginally exceed the new SCS. The most stringent ecological component value for anthracene is 32 μg/g and is based on protecting plants and soil organisms. That value is not exceeded in results from the Site.

Given that the maximum measured concentrations of anthracene in soil do not exceed either the CCME or MOE ecotoxicity component values, anthracene is not carried forward as a COPC in soil in the ecological portion of this SSRA.

Summary for Soil

The initial comparing of measured concentrations to generic CCME guidelines or MOE standards identified 14 COPCs in soil: arsenic, boron (hot water extractable), hexavalent chromium, selenium, EC, SAR, benzene, toluene, ethylbenzene, xylenes, PHC Fraction 2, PHC Fraction 3, acenaphthylene, and anthracene. Closer consideration of the information upon which those generic guidelines and standards are based shows that six of the 14 parameters do not need to be assessed further in the ecological portion of the SSRRA: benzene, toluene, ethylbenzene, xylenes, acenaphthylene, and anthracene. **This leaves eight COPCs that need to be assed further in the HHRA: arsenic, boron (hot water extractable), hexavalent chromium, selenium, EC, SAR, PHC Fraction 2, and PHC Fraction 3.**

3.6.2 Qualitative Discussion of Impacts in Ground Water

As shown in Table 3.2, six parameters are in the initial list of COPCs in ground water. Each of these parameters is examined in more detail below from an ecological perspective. (A similar discussion from a human health perspective appears in Section 3.4.)

The measured concentrations of those six parameters are compared to various component values upon which MOE standards are based with the emphasis where parameters exceed ecological component values. (There are no analogous CCME guidelines for ground water.) Through this evaluation, it is determined whether each of the six parameters needs to be carried forward into the ecological risk assessment.

Sodium and Chlorides in Ground Water

Sixteen ground water samples (including two duplicates) from the Site have been analyzed for sodium and seven samples analyzed for chlorides. The results range from 35,000 to 17,800,000 μg/L for sodium, and 20,300 to 33,300,000 μg/L for chlorides.

There currently is no Table 3 SCS for sodium in ground water, but the recently announced revisions set the Table 3 SCS at 4.9×10^5 μg/L. It is based on background conditions found in Ontario. Seven results from the Site exceed the Table 3 SCS. The elevated concentrations likely are the result of the storage and use of road salt on the Site, and the use of road salt at locations that are up gradient. The maximum concentration of 1.78×10^7 μg/L was measured in a sample from MW09-01 which is near to where salt was stored in the past.

No ecological component values are provided with the Table 3 SCS. While considerable research has been published on the potential risks that chloride, road salt, and some specific sodium salts can pose to ecological organisms (mostly aquatic organisms), relatively little has been published for sodium. No regulatory agencies in Canada have established limits for sodium in water to be protective of aquatic habitat.

There currently is no Table 3 SCS for chlorides in ground water, but the recently announced revisions set the Table 3 SCS at 2.3×10^6 µg/L. It is based on the protecting of aquatic habitat. Two results from the Site exceed the Table 3 SCS. Like sodium, the maximum concentration of 3.3×10^7 µg/L was measured in a sample from MW09-01 which is near to where salt was stored in the past.

The maximum measured concentrations of both sodium and chloride are well above the Table 3 SCS. The SCS for chlorides is based on ecological considerations. Therefore, sodium and chlorides are carried forward as COPCs in ground water in the ecological portion of this SSRA.

PHC Fraction F2

Seventeen ground water samples from the Site have been analyzed for PHC Fraction 2. The results range from <100 to 2,600 µg/L. Many of the results are less than detection limits.

There currently is no Table 3 SCS for PHC Fraction 2 in ground water, but the recently announced revisions set the Table 3 SCS at 150 µg/L. It is set equal to one-half its aqueous solubility limit. It is exceeded in five of the results from the Site. The most stringent ecological component value is 970 µg/L and is intended to protect aquatic receptors in surface water. It is exceeded in two of the results from the Site. Therefore, PHC Fraction 2 is carried forward as a COPC in ground water in the ecological portion of this SSRA.

PHC Fraction F3

Seventeen ground water samples from the Site have been analyzed for PHC Fraction 3. The results range from <100 to 1,200 µg/L. Many of the results are less than detection limits.

There currently is no Table 3 SCS for PHC Fraction 3 in ground water, but the recently announced revisions set the Table 3 SCS at 500 µg/L. It is set equal to the Ontario background concentration. It is exceeded in two of the results from the Site. No ecological component values are provided for PHC Fraction 3 in ground water.

The Table 3 SCS is not based on ecological component values, but two measured concentrations are above background concentrations. To be conservative, PHC Fraction 3 is carried forward as a COPC in ground water in the ecological portion of this SSRA.

PHC Fraction F4

Seventeen ground water samples from the Site have been analyzed for PHC Fraction 4. The results range from <100 to 620 µg/L. Many of the results are less than detection limits.

There currently is no Table 3 SCS for PHC Fraction 4 in ground water, but the recently announced revisions set the Table 3 SCS at 500 µg/L. It is set equal to the Ontario background concentration. It is exceeded in one of the results from the Site. No ecological component values are provided for PHC Fraction 4 in ground water.

The Table 3 SCS is not based on ecological component values, but one measured concentration is above background concentrations. To be conservative, PHC Fraction 4 is carried forward as a COPC in ground water in the ecological portion of this SSRA.

Indeno(1,2,3-cd)pyrene

Six ground water samples (including one duplicate) from the Site have been analyzed for indeno(1,2,3-cd)pyrene. Results range from <0.03 to <0.27 µg/L.

The current MOE Table 3 SCS is 0.27 µg/L. The recently announced revisions set the Table 3 SCS at 0.2 µg/L. It is set equal to the Ontario background concentration. Two samples analyzed in 2003 are reported as < 0.27 µg/L which means that the new Table 3 SCS might be exceeded. The most stringent ecological component value is 2.3×10^{12} µg/L. No results exceed that component value. Therefore, indeno(1,2,3-cd)pyrene is not assessed further in the ecological portion of this SSRA.

Summary for Ground Water

The initial comparing of measured concentrations to generic MOE standards identified six COPCs in ground water: sodium, chlorides, PHC Fraction 2, PHC Fraction 3, PHC Fraction 4, and indeno(1,2,3-cd)pyrene. Closer consideration of the information upon which those generic guidelines and standards are based shows that one of the six parameters does not need to be assessed further in the ecological portion of the SSRRA: indeno(1,2,3-cd)pyrene. **This leaves five COPCs that need to be assed further in the HHRA: sodium, chlorides, PHC Fraction 2, PHC Fraction 3, and PHC Fraction 4.**

3.6.3 Discussion of Dilution for Ground Water Entering Oshawa Harbour

Given the proximity of the Site to Oshawa Harbour, it is likely that relatively little dilution occurs of ground water as it flows through the harbor wall along its eastern flank and into the open water of the harbour. In such circumstances, the MOE advises that one-tenth of the GW3 ecological component value be used to assess ground water quality; however, for the Site, it appears that other large sources of dilution are inescapable and that the GW3 values are appropriate. For example, the three harbour walls that border the Site total approximately 900 metres. The surface area of the Site (less than 1,800 m^2), is a small fraction of Oshawa Harbour, which in turn, is dwarfed by the size of Lake Ontario. Therefore, any ground water migrating from beneath the Site into the harbour is diluted by much more than a factor of ten virtually instantaneously upon contact with open water. Therefore, the GW3 ecological component values (and the assumed ten-fold dilution factor) are still relevant for the discussions of COPCs in ground water that appear earlier in this section.

3.7 QUALITY ASSESSMENT AND QUALITY CONTROL (QA/QC)

Thirty-six soil samples plus three blind duplicate samples have been analyzed for the Site. The majority relative percent difference (RPD) for duplicate samples collected at MW09-02A were below 35%. However, the RPD for chromium was 39%, and thus greater than 35% (but lower than 55%). This is not of concern since chromium does not exceed its CCME SQG in any of the samples.

The calculated relative percent difference (RPD) for parameters analyzed at BH30-5 were below 35% and therefore the analytical results for the QA/QC sample were consistent with those of the original sample.

The majority RPD for duplicate samples collected at BH308-1 were below 35%. However, the RPD for arsenic, selenium, and PHC Fraction 4 were greater than 35% (but lower than 55%). For arsenic, both measurements exceed guidelines and is thus a COPC. Selenium and PHC Fraction 4 measurement do not exceed its CCME SQG in either samples and is therefore not a concern.

Eighteen ground water samples plus two blind duplicate samples have been analyzed for the Site. The RPD for duplicate samples collected at MW09-02i and MW307 were all below 35% and are thus considered representative of the original samples collected.

3.8 SUMMARY OF FINDINGS

Approximately 40 soil samples and 20 ground water samples from the Site have been analyzed. Collectively, more than 100 different parameters have been analyzed in both soil and ground water. The results for several parameters exceed the applicable CCME guidelines or MOE standards. Table 3.3 lists all of the initial COPCs and summarizes which are to be carried forward into the quantitative portions of the human health and ecological risk assessments in Chapters 5 and 6, respectively.

Table 3.3 Summary of COPC in Soil and Ground Water

Chemical of Potential Concern (COPC)			Carried Into Quantitative Portion of the HHRA?		Carried Into Quantitative Portion of the SLERA?	
Parameter	Soil	GW	Soil	GW	Soil	GW
Arsenic	X		Yes		Yes	
Boron (HWE)	X		No		Yes	
Chromium (hexavalent)	X		No		Yes	
Selenium	X		No		Yes	
EC	X		No		Yes	
SAR	X		No		Yes	
Sodium		X		Yes		Yes
Chloride		X		Yes		Yes
Benzene	X		Yes		No	
Toluene	X		No		No	
Ethylbenzene	X		No		No	
Xylenes	X		No		No	
PHC Fraction 2	X	X	Yes	Yes	Yes	Yes
PHC Fraction 3	X	X	Yes	Yes	Yes	Yes
PHC Fraction 4		X		Yes		Yes
Acenaphthylene	X		No		No	
Anthracene	X		No		No	
Indeno(1,2,3-cd)pyrene		X		No		No

4.0 OVERVIEW OF THE RISK ASSESSMENT PROCESS

4.1 ASSESSING RISKS TO HUMAN HEALTH

Human health risk assessment often is divided into four main stages:

- problem formulation or hazard identification;
- exposure assessment;
- toxicity assessment also called dose response assessment or hazard assessment; and
- risk characterization.

In the problem formulation stage, information about the area of interest is reviewed with the goals of describing the area(s) where impacts are found, describing the nature and extent of the impacts, and identifying the chemicals that need to be assessed further. Some aspects of this stage are discussed in Chapter 3, and further discussion appears in Section 5.1.

In the exposure assessment stage, the potential for people ("receptors") to come into contact with the chemicals of interest via "exposure pathways" is estimated. Monitoring will provide some information to describe the material (such as soil or ground water) that the receptor contacts, but mathematical equations or models often are used to estimate concentrations in other materials such as vapours in air, contaminated soil particles in air, or at locations other than those where samples have been collected. These aspects of exposure assessment are described in Section 5.2.

In the toxicity assessment stage, information is assembled from the published literature that describes the types of health effects that can be caused by exposure to the chemicals of interest. This SSRA uses toxicity information published by Health Canada, the MOE, the CCME, and the U.S. Environmental Protection Agency. The information is summarized in Section 5.3 and presented in detail in Appendix C.

The risk characterization stage combines the results of the exposure assessment and the toxicity assessment to estimate the likelihood of adverse effects occurring. This stage is described in Section 5.6.

4.2 ASSESSING HAZARDS TO ECOLOGICAL (NON-HUMAN) RECEPTORS

A basic framework for conducting ecological risk assessment (ERA) appears in the CCME document entitled *A Framework for Ecological Risk Assessment* (1996). That document describes a methodology for assessing ecological (non-human) receptors at contaminated sites. Ecological receptors include the various types of plants and animals that can live on a site or visit it.

The Ecological SLRA component of this assessment is presented in Chapter 6. The methodology followed is that from the CCME (1996) document entitled *A Framework for Ecological Risk Assessment.*

In an SLERA, concentrations of chemicals are compared to toxicity reference values (TRVs) for various types of ecological receptors. If concentrations measured are lower than TRVs, then the risks likely are acceptable. Conversely, if measured concentrations exceed TRVs, then the risks likely are unacceptable.

Totally quantitative assessments use (numerous) equations and (numerous) assumptions to estimate exposures and then compare the estimates to TRVs. For example, it might be calculated that a robin consumes 2 mg/kg/d of nickel due to ingesting worms that live in impacted soil at a site. If the TRV is 3 mg/kg/d, then the EHQ is 2÷ 3 = < 1 and risks to the robin are acceptable. If the TRV was actually 0.03 mg/kg/d, then the EHQ would be approximately 2 ÷ 0.03 = 67 and the risks would be unacceptable. The process of starting with a nickel concentration in soil and ending with an EHQ for the robin requires numerous assumptions about nickel uptake by the worm, and many characteristics of the robin including dietary habits, food sources, range, and body weight.

Totally qualitative assessments usually comment on acceptability strictly based on field observations (such as vegetation looks stressed, or habitat seems lush and thriving, etc.).

The SLERA in this SSRA does not fit neatly into either of these categories. It does not present equations and assumptions to estimate a bird's exposure. Instead, the SLERA lists numerous ecological TRVs, mostly from organization in Canada, U.S., and The Netherlands. Some are better than others in that they are more recent or based upon impressive reviews of the literature. An example of rigorously set values is the U.S. EPA work that sets ecological soil screening levels (SSL). To prepare the SSL document for nickel, the authors reviewed close to 2,000 published papers. The majority of these did not meet the acceptance criteria that U.S. EPA set, but from those that did a statistical analysis was done of the data to recommend SSLs for several types of receptors (i.e. not just one value for all birds but three separate values for herbivores, omnivores, and carnivores). Those SSLs take into account diet, soil ingestion, and bioaccumulation.

For each COPC in the SLERA, there is a commentary on the numbers and percentages of measured concentrations that exceed not only the preferred TRV (for all ecological receptors of interest) but for each of the specific types of receptors of interest. This commentary mentions how many concentrations exceed each TRV and the resulting EHQs. Then there is further commentary that tries to place those EHQs in context. For example, if only one EHQ is >1 and then by only a small margin, the risks are seen as acceptable. Similarly, the SLERA takes into account background concentrations (which sometimes are higher than TRVs).

5.0 HUMAN HEALTH RISK ASSESSMENT

5.1 PROBLEM FORMULATION

5.1.1 Contaminants of Potential Concern

A COPC is a chemical with one or more measured concentrations that exceed the CCME guideline, augmented where necessary by the MOE standard, for that chemical. When measured concentrations do not exceed these guidelines or standards, unwanted effects or impacts should not occur and do not require further evaluation.

For the human health risk assessment (HHRA) component of this SSRA, the following COPCs are identified in Chapter 3:

- In soil these are arsenic, benzene, PHC F2, and F3.
- In ground water, these are sodium, chlorides, PHC F2, PHC F3, and PHC F4.

5.1.2 Setting Exposure Point Concentrations for Soil

To assess the potential exposures and risks posed by COPCs in soil, concentrations need to be selected that are representative of the soil that receptors could contact. The most conservative approach is to set exposure point concentrations (EPCs) equal to the highest measured concentrations. While a single measurement cannot represent an entire impact zone (U.S. EPA, 1991), this is done frequently and often described as a "worst case" approach.

Highest measured concentrations are often used in various types of RAs, and that approach is used in this SSRA. Of the initial fourteen COPCs, Section 3.4 demonstrates that EPCs are not needed for ten of the parameters. The EPCs for the remaining four (arsenic, benzene, PHC F2, and PHC F3) in soil are presented in Table 5.1. As discussed and demonstrated in Section 3.4.3, additional EPCs are needed for each of the smaller TPHCWG fractions that constitute PHC F2 and PHC F3. Those additional EPCs also are shown in Table 5.1.

Table 5.1 Summary of Exposure Point Concentrations in Soil

COPC	EPC (µg/g)– Sample Location and Depth	
Arsenic	110	BH09-03A (0 to 0.3 m bgs) (Genivar, 2010)
Benzene	1.5	BH-308-1 (0 to 0.6 m bgs) (AquaTerre, 2009)
PHC F2	7,440	MW17 (SS2) (0.6 to 1.2) (DCS, 2003)
Aliphatic $C_{>10}$ to C_{12}	2,678	Estimated from MW17 (SS2)
Aliphatic $C_{>12}$ to C_{16}	3,274	
Aromatic $C_{>10}$ to C_{12}	670	
Aromatic $C_{>12}$ to C_{16}	818	
PHC F3	4,250	MW17 (SS2) (0.6 to 1.2) (DCS, 2003)
Aliphatic $C_{>16}$ to C_{21}	2,380	Estimated from MW17 (SS2)
Aliphatic $C_{>21}$ to C_{34}	1,020	
Aromatic $C_{>16}$ to C_{21}	595	
Aromatic $C_{>21}$ to C_{34}	255	

Notes:

Although boron (hot water extractable), selenium, EC, SAR, toluene, ethylbenzene, xylenes, acenaphthylene, and anthracene are identified as COPCs, maximum measured concentrations do not exceed those protective of human health therefore EPCs are not needed for the HHRA component of the SSRA.

5.1.3 Setting Exposure Point Concentrations for Ground Water

To assess the potential exposures and risks posed by COPCs in ground water, concentrations need to be selected that are representative of the ground water in and around the release point. The most conservative approach is to use the highest measured concentrations. While it is recognized that a single measurement cannot represent an entire impact zone (U.S. EPA, 1991), this is done frequently and often described as a "worst case" approach. As noted in Section 5.2 this is the approach used in this SSRA.

Concentrations of COPCs at sample locations where liquid phase hydrocarbons (LPH) has been observed are not used to set EPCs since those locations would be recommended for remediation. LPH has not been observed at the Site and therefore this condition does not apply. Therefore, the EPCs for ground water are based on the highest measured concentrations and these are presented in Table 5.2 for the five COPCs (sodium, chlorides, PHC F2, PHC F3, and PHC F4). As discussed and demonstrated in Section 3.4.4, additional EPCs are needed for each of the smaller TPHCWG fractions that constitute PHC F2, PHC F3, and PHC F4. Those additional EPCs also are shown in Table 5.2.

Table 5.2 Summary of Exposure Point Concentrations in Ground Water

COPC	EPC (μg/L)– Sample Location	
Sodium	17,800,000	MW09-01 (Genivar, March 2010)
Chlorides	33,300,000	MW09-01 (Genivar, March 2010)
PHC F2	2,600	MW308
Aliphatic $C_{>10}$ to C_{12}	62	Estimated from MW308 (AquaTerre, March 2009)
Aliphatic $C_{>12}$ to C_{16}	3	
Aromatic $C_{>10}$ to C_{12}	1,568	
Aromatic $C_{>12}$ to C_{16}	965	
PHC F3	1,200	MW310
Aliphatic $C_{>16}$ to C_{21}	0	Estimated from MW310 (AquaTerre, March 2009)
Aliphatic $C_{>21}$ to C_{34}	0	
Aromatic $C_{>16}$ to C_{21}	1,140	
Aromatic $C_{>21}$ to C_{34}	60	
PHC F4	620	MW310
Aliphatic $C_{>34}$	0	Estimated from MW310 (AquaTerre, March 2009)
Aromatic $C_{>34}$	620	

5.2 HUMAN RECEPTORS AND EXPOSURE PATHWAYS

5.2.1 Relevant Receptors

The term "receptors" is used to describe the types of people who have the potential to come into contact with the COPCs.

It often is necessary to assess only those receptors expected to have the most opportunities for contact with COPCs. For the Site, one type of receptor to be assessed further is the **Remediation Worker**. This person is an adult whose job involves activities such as excavating that could result in direct contact with impacted soil.

A second type of receptor that needs to be considered is the **Commercial Worker**. This person is an adult whose job involves activities related to the operation of the wharf. This type of receptor is assumed to work at the Site for many years (as compared to the Remediation Worker who might be on the Site for only weeks or months).

The Site is not currently used for residential purposes nor is any change in land use contemplated. Therefore, a residential receptor is not examined.

A third type of receptor often considered is a person who visits the location of interest. The Site is fenced and access is controlled. It is recognized that the individuals might visit the Site occasionally for short periods, but their exposures would be significantly less than the Commercial Worker who is assumed to be at the Site every work day for many years and therefore occasional visitors (including trespassers) are not examined further.

The ways in which these two types of receptors could come into contact with COPCs at the Site are examined in Sections 5.2.2 through 5.4.

5.2.2 Exposure Pathways for the Remediation Worker

Ingestion of soil - This pathway is relevant where people can come into direct contact with contaminated soil. It is assumed that the Remediation Worker participates in activities that involve excavating or handling impacted soil, and therefore this pathway is complete (in spring, summer, and fall, but not in the winter when the ground is frozen) and needs to be examined further.

Dermal contact with soil particles - The description above for ingestion of soil applies to this pathway as well. Therefore, dermal contact with soil particles is considered further for this receptor.

Inhalation of soil particles - The description above for ingestion of soil applies to this pathway as well. (This pathway would not be complete when the soil is wet or covered by snow.) Therefore, the inhalation of soil particles is considered further for this receptor.

Inhalation of vapours - For any assessment of volatile chemicals, the inhalation of vapours will be a pathway of interest. Some of the COPCs at the Site in both soil and ground water are sufficiently volatile to produce vapours that can migrate to outdoor air and therefore this pathway does need to be examined further for this receptor.

Dermal contact with ground water – This pathway is relevant where people can come into direct contact with impacted ground water. The possibility exists that the Remediation Worker could excavate to depths that reach ground water and therefore this pathway does need to be evaluated further for this receptor.

Ingestion of ground water – This pathway is relevant where people can ingest impacted ground water. Ground water is not used as a potable water supply at the Site (or elsewhere at the Oshawa Harbour lands). Although the Remediation Worker could come into direct dermal contact with ground water, they are unlikely to ingest ground water in any measureable quantity and this pathway is not evaluated further for this receptor.

Ingestion of contaminated food - This pathway is not relevant for this receptor because crops are not grown and livestock are not raised at the Site. Therefore, ingestion of contaminated food is not evaluated further for this receptor.

Any pathways involving ground water that flows into a surface water feature – The Site is located on Oshawa Harbour which flows into Lake Ontario. Ground water was investigated as part of this SSRA. In addition, four surface water samples were collected from the harbour to determine whether the chemical impacts in ground water at the Site are being detected in the harbour. The impacts were not detected in any surface water sample. Furthermore, these pathways are not relevant in the context of the Remediation Worker and are not evaluated further for this receptor.

For the Remediation Worker, it is concluded that the potentially complete exposure pathways include the ingestion of soil, dermal contact with soil and ground water, the inhalation of soil particles, and the inhalation of vapours that migrate to outdoor air from impacts in both soil and ground water.

Figure 5.1 summarizes this discussion of relevant pathways. Such a drawing often is referred to as a Conceptual Site Model (or CSM).

5.2.3 Exposure Characteristics of the Remediation Worker

Health Canada has provided two spreadsheet tools. The one for Preliminary Quantitative Risk Assessments (PQRA) is in general use but not the best match for this SSRA. The other is for Detailed Quantitative Risk Assessment (DQRA) and is a better match for the SSRA but has not been approved for general use. Both spreadsheet tools include default values for numerous exposure pathways and several types of receptors. Although the spreadsheet tools are not used directly in this SSRA, many of the default values are used. The receptor most similar to the Remediation Worker is the one identified as "Occupational – Outdoors"; however, there are default values that need to be modified to better represent the Remediation Worker. Each of these modifications is explained below. All of the characteristics are summarized in Table 5.3.

Breathing Rate

The Health Canada default value is 15 m^3/d which is equivalent to 0.63 m^3/h. This value is commonly used for adults, but the Remediation Worker is assumed to be involved in moderately strenuous activity and therefore is assigned a value of 1.5 m^3/h. That value has been used by the U.S. EPA for outdoor construction workers (U.S. EPA, 2001).

Exposed Skin

Various values are used in risk assessments to characterize the area of exposed skin in adults. Health Canada suggests 9,110 cm^2 for adults (Health Canada, 2004a) but this assumes the adult wears short pants. The MOE Guideline assumes 5,070 cm^2 and is based on hands, forearms, lower legs, and feet. The Remediation Worker most likely will wear shoes and long pants; therefore the Health Canada and MOE values are too high. The U.S. EPA describes outdoor and construction workers as adults who wear short-sleeved shirts, long pants, and shoes. They are assumed to have 3,300 cm^2 of exposed skin based on the face, hands, and forearms (U.S. EPA, 2001). If the Health Canada value is used less the skin surface of the legs (5,720 cm^2), the net result is an area of 3,390 cm^2 of exposed skin which is very similar to the recommended by the U.S. EPA. Therefore, the value of 3,390 cm^2 is assigned to this receptor. This value will over estimate the amount of exposed skin during cool and cold weather and that aspect of exposure is addressed below under the headings that describe time spent at the Site.

Soil Ingestion

Risk assessments often assume that adults ingest 20 to 330 mg of soil a day. The Health Canada Spreadsheet tool uses 20 mg/d as the default value; however, Health Canada recommends 100 mg for construction workers and the U.S. EPA recommends 100 mg for outdoor workers. Therefore, the Remediation Worker is assumed to ingest 100 mg/d of soil each day they work at the Site.

Hours/Day and Days/Year at the Site

The Remediation Worker is a person whose job can involve excavating or handling impacted soil. Those types of activities could lead to "intense" exposure, but for relatively short durations (as little as a couple of days and maybe as long as a couple of months).

While Health Canada describes an industrial worker as on Site 240 d/y (Health Canada, 2004a), and the U.S. EPA recommends 225 d/y for outdoor workers, these overstate the time a worker will remediate at one location (except at very large remediation projects). Health Canada also describes a construction worker as on Site for 10 d/y. This likely understates the time the Remediation Worker would be involved in remediation at the Site.

The MOE characterizes an excavation/construction worker as an adult who is at a specific site for 92 d/y (MOE, 1996c). This appears to be a better match for the Remediation Worker. Assuming that a typical work day lasts eight hours, 92 d/y is equivalent to 736 h/y.

The exposure pathways of soil ingestion, dermal contact, and soil particle inhalation will not be complete while the ground is covered with snow or frozen. Weather conditions at the Site make these pathways incomplete for several months of the year. To be conservative, it is assumed that the 92 d/y that the Remediation Worker is at the Site do not occur when the ground is covered with snow or frozen and therefore all exposure pathways are complete for those 92 d/y.

Years at the Site

One of the COPCs is classified as non-threshold toxicant and therefore it is necessary to determine how many years the Remediation Worker will spend at the Site.

The amount of impacted soil and ground water at the Site would not take 56 years (duration of adulthood) to remediate even if remediation activities take place only 92 d/y (as assumed above). The value of seven years is used by the MOE to derive some risk-based values for commercial and industrial workers (MOE, 1996c) and that value is assigned to the Remediation Worker.

Table 5.3 Summary of Characteristics for the Remediation Worker

Characteristic	Value and Units	Basis or Reference
Body Weight	70.7 kg	Health Canada, 2004a and used in the Spreadsheet tool
Breathing Rate	1.5 m^3/h	U.S. EPA, 2001 for construction workers; higher than the value in Health Canada, 2004a and converts to a daily inhalation rate higher than the default in the Spreadsheet tool
Area of Exposed Skin	3,390 cm^2 for soil	Health Canada, 2004a for hands, and lower and upper arms; marginally higher than the U.S. EPA, 2001 for head, hands, and forearms
Soil Loading on Skin	1 mg/cm^2 /event for hands and 0.1 mg/cm^2 /event for arms	Rates for hands and arms in Health Canada, 2004a and default values in the Spreadsheet tool; and U.S. EPA, 2001 for construction workers
Soil Ingestion Rate	100 mg/d	U.S. EPA, 2001 for outdoor workers at industrial sites; Health Canada, 2004a for construction workers
Time at Locations with Impacts	92 d/y = 736 h/y; always outdoors	MOE, 1996c assumptions for setting S-3 component values
Time that Soil Ingestion and Particle Inhalation are Complete	736 h/y	Assumed that all outdoor work occurs in spring, summer, and fall and these pathways are complete those days
Years Working at Locations with Impacts	7 y	Similar or lower values used to describe tenures for various occupations; used to determine S-3 component values in MOE, 1996c Health Canada, 2004a
Worker's Lifetime	75 y	Health Canada, 2004a.

5.2.4 Exposure Pathways for the Commercial Worker

Ingestion of soil - This pathway is relevant where people can come into direct contact with contaminated soil. At the Site, the contaminated soil is present at the surface or in shallow soil, therefore, this pathway is complete (in spring, summer, and fall, but not in the winter when the ground is frozen) and needs to be examined further for the Commercial Worker.

Dermal contact with soil particles - The description above for ingestion of soil applies to this pathway as well. Therefore, dermal contact with soil particles is considered further for the Commercial Worker. This is a conservative assumption.

Inhalation of soil particles - The description above for ingestion of soil applies to this pathway as well. (This pathway would not be complete when the soil is wet or covered by snow.) Therefore, the inhalation of soil particles is considered further for the Commercial Worker.

Inhalation of vapours - For any assessment of volatile chemicals, the inhalation of vapours will be a pathway of interest. Vapours originating beneath the surface from contaminated soil and ground water can migrate into outdoor or indoor air and be inhaled. Some of the COPCs at the Site are sufficiently volatile to produce vapours and therefore inhalation of vapours is a relevant pathway, and is evaluated for the Commercial Worker.

Ingestion of ground water - This pathway is not relevant because ground water is not used as a potable water supply at the Site (or elsewhere at the Oshawa Harbour lands). Furthermore, the Commercial Worker is unlikely to excavate to the water table. Therefore, this pathway is not evaluated further.

Dermal contact with ground water – The description above applies to this pathway as well. Therefore, this pathway is not evaluated further for the Commercial Worker.

Ingestion of contaminated food – This pathway is not relevant for this receptor because crops are not grown and livestock are not raised at the Site. Therefore, ingestion of contaminated food is not evaluated further for the Commercial Worker.

Any pathways involving ground water that flows into a surface water feature – The Site is located on Oshawa Harbour which flows into Lake Ontario. Ground water was investigated as part of this SSRA. In addition, four surface water samples were collected from the harbour to determine whether the chemical impacts in ground water at the Site are being detected in the harbour. The impacts were not detected in any surface water sample. Furthermore, these pathways are not relevant in the context of the Commercial Worker and are not evaluated further for this receptor.

For the Commercial Worker, it is concluded that the potentially complete exposure pathways are the ingestion of soil, dermal contact with soil, and the inhalation of soil particles and vapours.

Figure 5.1 summarizes this discussion of relevant pathways. Such a drawing often is referred to as a Conceptual Site Model (or CSM). The CSM for the Commercial Worker is the same as for the Remediation Worker with the exception that the dermal contact with ground water pathway is not complete for the Commercial Worker.

5.2.5 Exposure Characteristics of the Commercial Worker

The Commercial Worker is assumed to be an adult working at the Site. Some physical labour, much of it outdoors, is expected due to the nature of the job and the activities that take place at the Site. Therefore, the exposure characteristics for the Commercial Worker are similar to those for the Remediation Worker with a few exceptions addressed below.

Soil Ingestion

Risk assessments often assume that adults ingest 20 to 330 mg of soil a day. The Health Canada Spreadsheet tool uses 20 mg/d as the default value for adults and 100 mg for construction workers and the U.S. EPA recommends 100 mg for outdoor workers. Therefore, the Commercial Worker is assumed to ingest 20 mg/d of soil each day they work outside at the Site.

Amount of Soil on Exposed Skin

Risk assessments often assume that the "soil loading" (sometimes called an "adherence factor") on the exposed skin of adults is in the range of 0.1 to 1 mg/cm^2/event. Health Canada recommends values of 0.1 mg/cm^2/event on hands and 0.01 mg/cm^2/event on other exposed skin (Health Canada, 2004a). These two loading factors are applied to the Commercial Worker.

Hours/Day and Days/Year at the Site

The Commercial Worker is an adult whose job likely involves being outside at least part of the time assisting and facilitating with the handling, storage and transfer of products and materials from one mode of transportation to another. Those types of activities are unlikely to result in "intense" exposures such as occur during excavation, but it is reasonable to assume that some direct contact with soil could also occur.

Health Canada describes a long-term worker as a person at the workplace 240 d/y, or 48 weeks/year (Health Canada, 2004a). The U.S. EPA recommends 225 d/y for outdoor workers. The value of 240 d/y is assigned to this receptor. That 240 d/y is assumed to consist of 5 days/week for 48 w/y. Each work day is assumed to be 8 h, therefore the total time the Commercial Worker is at the Site is 48 x 5 x 8 = 1,920 h/y. This is a reasonable maximum amount of time a person would spend at the Site.

Years at the Site

The Commercial Worker is assumed to work at the Site for 25 years. This is the value recommended by Health Canada.

Time when Exposure Pathways are Complete

It is likely that the Commercial Worker will spend some of their time at the Site indoors, and some time outdoors. To be conservative, it is assumed that the Commercial Worker spends all of their time at the Site outdoors.

The exposure pathways of soil ingestion, dermal contact, and soil particle inhalation will not be complete while the ground is covered with snow or frozen. Weather conditions at the Site make these pathways incomplete for approximately three months of the year. According to Environment Canada, the long-term weather normals for Oshawa (based on records from 1971 to 2000) show an average monthly temperature below freezing for December, January, and February. Therefore, it is assumed that the pathways for soil ingestion, dermal contact with soil, inhalation of soil particles are incomplete for three months and therefore pathways are complete for 35 w/y, or 175 d/y, or 1,400 h/y.

Lifetime of the Commercial Worker

Two of the COPCs are classified as non-threshold toxicant and therefore it is necessary to determine how many years the Commercial Worker will live.

Risk assessments typically assume that people live for approximately 70 or 75 years. Health Canada recommends 75, while the U.S. EPA recommends 70. Both values appear in the supporting documentation to the MOE Guideline. The Health Canada value of 75 years is assigned to this receptor.

Table 5.4 Summary of Characteristics for the Commercial Worker

Characteristic	Value and Units	Basis or Reference
Body Weight	70.7 kg	Health Canada, 2004a and used in the Spreadsheet tool
Breathing Rate	1.5 m^3/h	U.S. EPA, 2001 for construction workers; higher than the value in Health Canada, 2004a and converts to a daily inhalation rate higher than the default in the Spreadsheet tool
Area of Exposed Skin	3,390 cm^2 for soil	Health Canada, 2004a for hands, and lower and upper arms; marginally higher than the U.S. EPA, 2001 for head, hands, and forearms
Soil Loading on Skin	0.1 mg/cm^2 /event for hands and 0.01 mg/cm^2 /event for arms	Rates for hands and arms in Health Canada, 2004a and default values in the Spreadsheet tool
Soil Ingestion Rate	20 mg/d	Health Canada, 2004a for adults
Time at Locations with Impacts	240 d/y = 1,920 h/y; always outdoors	48 weeks a year, 5 days/week, 8 hours/d
Time that Soil Ingestion and Particle Inhalation are Complete	1,400 h/y	Assumed that all outdoor work occurs in year round. Pathways incomplete due to freezing 3 months (13 weeks) of the year.
Years Working at Locations with Impacts	25 y	Health Canada, 2004a
Worker's Lifetime	75 y	Health Canada, 2004a

5.2.6 Estimating Exposure Point Concentrations for Soil Particles in Air

The concentration of soil particles in the air can be estimated several ways. One relatively simple approach recommended by Health Canada is to assume that the concentration of total suspended soil particles in the air is 250 $\mu g/m^3$ (Health Canada, 2004a). That value is recommended for situations where there is vehicle traffic on unpaved roads and the receptor is on the down-wind side of the traffic. Therefore, the EPC values for soil (shown in Table 5.1) are multiplied by 250 $\mu g/m^3$ to estimate the concentration of a COPC in the air. For example, the EPC for arsenic is 110 $\mu g/g$ and the estimated concentration in airborne particles is $110 \times 10^{-6} \times 250 = 2.8 \times 10^{-2}$ $\mu g/m^3$. It is assumed that the Remediation Worker inhales air with these EPCs.

For situations without major dust generating activities, Health Canada recommends that the average concentration of respirable particles (those with aerodynamic diameters not larger than 10 μm) be assumed to be 0.76 $\mu g/m^3$ (Health Canada, 2004a). Therefore, the EPC values in Table 5.1 are multiplied by 0.76 $\mu g/m^3$ to estimate the concentration of a COPC in the air. For example, the EPC for arsenic in soil is 110 $\mu g/g$ and the estimated concentration in respirable particles is $110 \times 10^{-6} \times 0.76 = 8.4 \times 10^{-5}$ $\mu g/m^3$. It is assumed that the Commercial Worker inhales air with these EPCs.

The EPCs for soil particles in air for all COPC are shown in Table 5.5.

Table 5.5 EPC for Soil Particles in Air

	COPC	EPC for Soil (µg/g)	Corresponding EPC for Airborne Particles (µg/m³)	Corresponding EPC for Respirable Particles (µg/m³)
	Arsenic	110	2.8E-02	8.4E-05
	Benzene	1.5	3.8E-04	1.1E-06
PHC F2	Aliphatic $C_{>10}$ to C_{12}	2,678	0.67	2.0E-03
PHC F2	Aliphatic $C_{>12}$ to C_{16}	3,274	0.82	2.5E-03
PHC F2	Aromatic $C_{>10}$ to C_{12}	670	0.17	5.1E-04
PHC F2	Aromatic $C_{>12}$ to C_{16}	818	0.20	6.2E-04
PHC F3	Aliphatic $C_{>16}$ to C_{21}	2,380	0.60	1.8E-03
PHC F3	Aliphatic $C_{>21}$ to C_{34}	1,020	0.26	7.8E-04
PHC F3	Aromatic $C_{>16}$ to C_{21}	595	0.15	4.5E-04
PHC F3	Aromatic $C_{>21}$ to C_{34}	255	0.06	1.9E-04

Notes:

- EPC are the same as shown in Table 5.1
- Airborne Soil Particles assumed to equal 250 µg/m3, therefore [airborne particles] = [soil] x10^{-6} x 250 (Health Canada, 2004)
- Respirable Soil Particles assumed to equal 0.76 µg/m3, therefore [respirable particles] = [soil] x 10^{-6} x 0.76 (Health Canada, 2004)

5.2.7 Estimating Exposure Point Concentrations for Vapours in Outdoor Air

Some of the COPCs at the Site are capable of generating vapours that could migrate into outdoor air at or near the impacted areas.

The inhalation of vapours that migrate to outdoor air is identified as a potentially complete exposure pathway for both the Remediation Worker and the Commercial Worker.

Concentrations of COPCs in outdoor vapours are estimated in this SSRA using parts of the Johnson-Ettinger model (J-E). The J-E model is widely used for estimating the migration of vapours from the subsurface into overlying buildings. Both the CCME and MOE consulted the original publication of the J-E model when setting generic levels and criteria. An updated version of the J-E model provided by the U.S. Environmental Protection Agency (U.S. EPA) is used in this SSRA.

The concentrations of vapours in outdoor air caused by impacted soil tend to be substantially lower than those in indoor air. Vapours that migrate from the subsurface to outdoor air are rapidly diluted and degraded.

Concentrations in outdoor air can be modelled as a flux of vapours from the subsurface into the air that the receptor then breathes. The flux rate can be estimated from two parameters calculated in the J-E model. These parameters are the vapour concentration in soil (described as the "source vapour concentration" in J-E model output) and the "effective diffusion coefficient". Both parameters are chemical specific.

As noted previously, the Remediation Worker and the Commercial Worker are assumed to spend all of their time outside. The inhalation of vapours is assumed to occur whenever they are outside. Therefore, the Remediation Worker is assumed to breathe outdoor air for 8 h/d, 5 d/w, 18.4 w/y = 736 h/y for 7 years. The Commercial Worker is assumed to breathe outdoor air for 8 h/d, 5 d/w, 48 w/y = 1,920 h/y for 25 years.

For the Remediation Worker, the potential accumulation of vapours in trenches or other types of excavations will depend upon the configuration and size of the excavation, and its orientation relative to wind direction. This poses a level of complexity that is not addressed here. In lieu of estimating vapours in trenches, the Remediation Worker is assumed to be always in areas where vapours are being generated.

The J-E Model

Various parameters can be adjusted in the J-E model. There are several characteristics related to building dimensions for the estimation of vapours in indoor air including whether the building is of slab-on-grade or basement construction. These are not relevant for the Site as the Remediation Worker and the Commercial Worker are assumed to be outside at all times.

Two versions of the J-E model can be used in SSRAs. One assumes that impacted soil is the source of the vapours. The second assumes that ground water is the source.

At the Site, when the source of the vapours is impacted soil, it is assumed that the vapours need to travel 0.3 m through sand to reach the surface. The depth of 0.3 m corresponds to the minimum depth of the measured concentrations that were used to determine the EPCs (Table 5.1).

At the Site, when the source of the vapours is impacted ground water, it is assumed that the vapours need to travel 1.2 m through sand to reach the surface. The distance of 1.2 m corresponds to the average depth to ground water for the EPCs as shown in Table 5.1.

The receptor is assumed to breathe air at 1.5 m above the ground surface while standing at the downwind end of an impacted area that is 80 m long. The maximum measured concentrations for the COPCs that are volatile were collected from locations that would "fit" within a rectangular area with sides of approximately 80 m. A spreadsheet in Appendix B shows the results of these calculations which are summarized in Table 5.6.

<u>Characteristics of the Soil and Ground Water</u>

Other parameters that can be adjusted in the J-E model pertain to environmental characteristics such as the type of soil present, temperature in the subsurface, etc. As noted in Section 2.2, many of the borehole logs report medium to fine sand. To be conservative, it is assumed that vapours will migrate through relatively porous medium sand. The medium sand is assigned the following characteristics (all from EQM, 2003):

dry bulk density	1.66 g/cm^3
total porosity	0.375 (unitless)
soil-water filled porosity	0.054 cm^3/cm^3
air filled porosity	0.321 cm^3/cm^3

The same reference (EQM, 2003) also recommends a value of 0.002 for organic carbon content of soil.

There are some differences between the U.S. EPA version of the J-E model and earlier versions including the approach used by the MOE to set generic criteria (now the SCS).

One important difference is that the MOE approach adds a "dilution factor" that is intended to reflect the fact that actual soil gas measurements typically are lower than those predicted by mathematical models. The MOE uses a dilution factor of ten, and applies that factor to all organic compounds in all types of soil. No such factor is included in the U.S. EPA version of the model. Conversely, the U.S. EPA version takes into account the presence of a capillary zone in the soil (which slows or reduces the upward migration of vapours) while the MOE version does not take into account the capillary zone. The version of the J-E model used in this SSRA lacks the MOE dilution factor.

Other modifications to the recent U.S. EPA version of the model reflect improved understanding of vapour migration processes, but these differences lead to only minor changes in vapour predictions. These differences are described in Appendix B. One example is temperature. Earlier versions of the J-E model and the MOE approach predict vapour migration in environments with temperatures of 20 to 25 °C. This overestimates vapour migration since temperatures in the subsurface usually are much cooler. The U.S. EPA version of the model allows more representative temperatures to be used and provides a map of suggested temperatures for the U.S. and southern parts of Canada. Therefore, a lower temperature (10 °C) is used to characterize the subsurface at the Site. More details about the J-E model and some examples of the model output are presented in Appendix B.

Overall, the J-E model is a conservative model. This will have the effect of possibly over-estimating vapour concentrations however this is done as a conservative assumption. In order to use more realistic data, additional information would need to be collected, such as soil vapour data.

The predicted concentrations for outdoor air are summarized in Table 5.6. These become the EPCs for outdoor air and are carried forward in this SSRA to estimate exposures and risks.

Table 5.6 EPCs for Vapours in Outdoor Air

	COPC	EPC in Soil (µg/g)	Corresponding EPC in Outdoor Air (µg/m³)	EPC in Ground Water (µg/L)	Corresponding EPC in Outdoor Air (µg/m³)
	Arsenic	110	NR	NCOPC	-
	Benzene	1.5	1,900	NCOPC	-
	Sodium	NCOPC	-	17,800,000	NR
	Chlorides	NCOPC	-	33,300,000	NR
PHC F2	Aliphatic $C_{>10}$ to C_{12}	2,678	400	62	6.4×10^{-3}
PHC F2	Aliphatic $C_{>12}$ to C_{16}	3,274	35	3	5.6×10^{-4}
PHC F2	Aromatic $C_{>10}$ to C_{12}	670	340	1,568	4.6×10^{-3}
PHC F2	Aromatic $C_{>12}$ to C_{16}	818	27	965	4.4×10^{-4}
PHC F3	Aliphatic $C_{>16}$ to C_{21}	2,380	NR	0	NR
PHC F3	Aliphatic $C_{>21}$ to C_{34}	1,020	NR	0	NR
PHC F3	Aromatic $C_{>16}$ to C_{21}	595	NR	1,140	NR
PHC F3	Aromatic $C_{>21}$ to C_{34}	255	NR	60	NR
PHC F4	Aliphatic $C_{>34}$	NCOPC	-	0	NR
PHC F4	Aromatic $C_{>34}$	NCOPC	-	620	NR

Notes:

- PHC F2 to F4 are represented by the various TPHCWG fractions noted above.
- NR- not relevant. Chemical is not sufficiently volatile to produce vapours.
- NCOPC = not a contaminant of potential concern

5.3 TOXICITY ASSESSMENT

Two general terms used to describe the types of health effects that a chemical can cause are "threshold toxicant" (i.e. a non-carcinogen) and "non-threshold toxicant" (i.e. a carcinogen).

When a chemical is to be assessed as a threshold toxicant and the exposure involves ingestion and inhalation, documents from Health Canada, the MOE, or other regulatory agencies provide various types of toxicity reference values (TRVs) that can include: total daily intake (TDI), tolerable concentration (TC), oral reference dose (RfD), inhalation reference concentration (RfC), and chronic inhalation reference dose (CIR).

When a chemical is to be assessed as a non-threshold toxicant, documents from Health Canada, the MOE, or other regulatory agencies provide various types of TRVs that can include: oral cancer potency factor (CPF) or slope factor (SF), inhalation unit risk (IUR), and inhalation cancer unit risk (ICUR).

The TRVs used in this SSRA are summarized in Table 5.7. Most come from the database in the Health Canada Spreadsheet tool with the exceptions noted below.

For arsenic as a non-threshold toxicant, the database in the Spreadsheet does not contain TRVs. For ingestion, this SSRA uses an RfD set by the U.S EPA. For inhalation, an RfC recently set by the California Environmental Protection Agency is used.

For PHC F3 and PHC F4, the database in the Spreadsheet tool contains a TRV for oral ingestion but not for inhalation. In such cases, the Spreadsheet will estimate a TRV for inhalation from the TRV for ingestion. This is not ideal, but commonly done since the other option would be not to estimate the potential risks due to inhalation pathways. The need to extrapolate this TRV is addressed further in Section 5.5.

For sodium and chlorides, the frequently cited sources of TRVs (including the MOE, Health Canada, and the U.S. EPA) provide no such values. This is of no consequence and TRVs are not needed due to the following considerations:

- Sodium and chlorides are not COPCs in soil; therefore none of the soil exposure pathways need to be evaluated.
- Sodium and chlorides are COPCs in ground water; however, neither type of receptor is assumed to ingest ground water. Therefore, ingestion of ground water does not need to be evaluated.

- Sodium or chlorides are not volatile, therefore inhalation of vapours is not relevant for these two COPCs.
- The only potentially complete pathway is dermal exposure to ground water for the Remediation Worker.
- Sodium and chlorides are essential minerals and therefore some adverse health effects can occur if intake is insufficient, and other adverse health effects can occur if intake is excessive. Between these two extremes, exposures are beneficial. Exposures for all people are dominated by the presence of salt in food and drinking water.
- Relative to ingestion in food and drinking water, any dermal contact via ground water by the Remediation Work would be trivial.

Absorption Factors

In addition to TRVs, absorption factors are needed for some exposure pathways including ingestion of soil, inhalation of soil particles, inhalation of vapours, ingestion of water, and ingestion of food. These have a maximum value of 1.0 (meaning that all of the COPC taken into a person's body is absorbed) and one often is used as a conservative default value when better information is lacking.

The "chemicals" worksheet in the HC PQRA Spreadsheet provides the absorption factors (sometimes called relative absorption factors of RAFs) used in this SSRA.

Absorption factors for oral ingestion, inhaled particles, and inhaled vapours are assumed to be 1.0 for all COPCs. For dermal contact, an absorption factor of 0.2 is used for all of the hydrocarbons as recommended by the CCME (2000). Other values used are 0.08 for benzene, and 0.03 for arsenic (Health Canada, 2004b).

Permeability Coefficients

For dermal contact with chemicals in ground water, one of the parameters used to estimate dose is the permeability coefficient (sometimes called the permeability constant). Values have been established for relatively few inorganic chemicals. For arsenic, the value is 0.03 cm/h (Health Canada, 2004; RAIS, 2007). For all other inorganic chemicals, a value of 0.001 cm/h commonly is used (U.S. EPA, 2001; Health Canada, 2004; RAIS, 2007).

Table 5.7 Toxicity Information for the COPCs

COPC	TRV for Oral Ingestion (in mg/kg-bw/d unless shown as other)	TRV for Inhalation (in µg/m³ unless shown as other)	TRV for Dermal (mg/kg-bw/d unless shown as other)	Relative Dermal Absorption Factor (unitless)
Arsenic (threshold toxicant)	TDI = 0.0003 mg/kg-bw/d (IRIS, 1993)	RfC = 0.000015 mg/m³ (CalEPA, 2009)	0.0003	GI =1 (max) Dermal = 0.03 (HC, 2004a) Inhalation = 0.5 (CalEPA, 2009)
Arsenic (non-threshold toxicant)	Oral SF = 2.8 (mg/kg-bw/d)$^{-1}$ (HC, 2004a)	IUR = 6.4 (mg/m³)$^{-1}$ (HC, 2004a)	Dermal SF = 2.8 (mg/kg-bw/d)$^{-1}$	
Benzene	Oral SF = 0.226 (mg/kg-bw/d)$^{-1}$	IUR = 3.3 x 10^{-6} (µg/m³)$^{-1}$	0.0292 (mg/kg-bw/d)$^{-1}$	0.08
Aliphatic $C_{>10}$ to C_{12} (F2)	TDI = 0.1	TC = 1,000	0.1	0.2
Aliphatic $C_{>12}$ to C_{16} (F2)	TDI = 0.1	TC = 1,000	0.1	0.2
Aromatic $C_{>10}$ to C_{12} (F2)	TDI = 0.04	TC = 200	0.04	0.2
Aromatic $C_{>12}$ to C_{16} (F2)	TDI = 0.04	TC = 200	0.04	0.2
Aliphatic $C_{>16}$ to C_{21} (F3)	TDI = 2	TC = 7.1 (extrapolated[a])	2	0.2
Aliphatic $C_{>21}$ to C_{34} (F3)	TDI = 2	TC = 7.1 (extrapolated[a])	2	0.2
Aromatic $C_{>16}$ to C_{21} (F3)	TDI = 0.03	TC = 0.1 (extrapolated[a])	0.03	0.2
Aromatic $C_{>21}$ to C_{34} (F3)	TDI = 0.03	TC = 0.1 (extrapolated[a])	0.03	0.2
Aliphatic $C_{>34}$ (F4)	TDI = 20	TC = 7.1 (extrapolated[a])	20	0.2
Aromatic $C_{>34}$ (F4)	TDI = 0.03	TC = 0.1 (extrapolated[a])	0.03	0.2

Notes:

a - TRV for inhalation estimated from TRV for ingestion.

- All other values come from the Health Canada (2008), unless otherwise shown.
- Benzene is a non-threshold toxicant. Arsenic is assessed as both a threshold toxicant and non-threshold toxicant.
- Details for all of the toxicity reference values are provided in Appendix C.
- Dermal RfD estimated to = Oral TRV (i.e. the TDI or IOC) x AF_{GI}
- Dermal SF estimated to = Oral SF ÷ AF_{GI}
- TDI = tolerable daily intake; RfD = reference dose; RfC = reference concentration; IUR = inhalation unit risk; IOC = intake of concern

5.4 HUMAN HEALTH RISK CHARACTERIZATION

5.4.1 Potential Risks for the Remediation Worker

Soil Ingestion and Dermal Contact with Soil

The EPCs for arsenic, benzene, PHC F2, and PHC F3 in soil are combined with characteristics for the Remediation Worker to estimate exposures and doses for these two pathways. The equations used (from Health Canada, 2004a) are provided in Appendix D. The results are summarized in Table 5.8.

For a chemical that is to be assessed as a threshold toxicant, the estimated doses for each pathway are summed and then divided by the appropriate RfD or TDI from Table 5.7 to produce a hazard quotient (HQ).

HQ = estimated dose / TRV

Health Canada prefers that HQ values not exceed 0.2 for any one exposure pathway. For the Remediation Worker, none of the individual HQ values exceeds 0.2. When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2 and PHC F3.

The HQ sums for PHC F3 for dermal contact with soil is 0.08 and for soil ingestion is 0.01. The HQ sum for soil ingestion with soil with PHC F2 is 0.04. These results suggest that the potential health risks posed by this pathway to this receptor are acceptable. One of the HQ sums exceeds 0.2:

PHC F2 (dermal contact) HQ = 0.27

This higher than acceptable risk estimate should be tempered by the fact that several conservative assumptions have been made, such as it is assumed that the Remediation Worker does not wear gloves and that their arms are exposed. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by remediation workers.

Two of the COPCs are assessed as non-threshold toxicants (NTT) and therefore risks are estimated over the receptor's lifetime.

ILCR = Dose x TRV

Heath Canada prefers that the incremental lifetime cancer risk (ILCR) not exceed 1×10^{-5}. The ILCR for the Remediation Worker due soil ingestion and dermal contact exceeds 1×10^{-5} and are therefore are considered greater than acceptable.

Arsenic (dermal contact)	ILCR = 1.3×10^{-4}
Arsenic (ingestion)	ILCR = 4.6×10^{-5}

These higher than acceptable risk estimates should be tempered by the fact that several conservative assumptions have been made, such as it is assumed that the Remediation Worker does not wear gloves and that their arms are exposed. Furthermore, it is assumed that they ingest 100 mg soil every day that they are on Site. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by remediation workers.

Inhalation of Soil Particles

For the COPCs assessed as threshold toxicants, the HQ values are calculated as EPCs and divided by RfC values (from Table 5.7) with adjustments for the receptor's body weight and inhalation rate.

$$HQ = Dose \times Body\ Weight / Inhalation\ Rate / TRV$$

The dose and hazard quotient are summarized in Table 5.8. None of the individual HQ values exceed 0.2 and should therefore be considered acceptable.

When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2 (there are no toxicity values for inhalation for PHC F3). The HQ sum for PHC F2 due to inhalation of soil particles is 6.2×10^{-5} and is therefore considered acceptable.

Two of the COPCs are assessed as non-threshold toxicants (NTT) and therefore risks are estimated over the receptor's lifetime.

$$ILCR = Dose \times Body\ Weight / Inhalation\ Rate \times TRV$$

Heath Canada prefers that the incremental lifetime cancer risk (ILCR) not exceed 1×10^{-5}. The ILCR for the Remediation Worker due the inhalation of soil particles exceeds 1×10^{-5} and are therefore are considered greater than acceptable.

Arsenic (inhalation of particles) ILCR = 1.7×10^{-5}

This higher than acceptable health risk estimate should be tempered by the knowledge that several conservative factors have been applied in reaching this conclusion. It is assumed exposure pathways are complete every day the Remediation Worker is on the Site regardless of whether the ground is frozen or other aspects of weather make some pathways incomplete some of the time. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by remediation workers.

Dermal Contact with Ground Water

To estimate risks to the Remediation Worker as a result of dermal contact with ground water, it is assumed that the Remediation Worker excavates below the water table and therefore has dermal contact with ground water every day they are on the Site. For the COPCs assessed as threshold toxicants, the EPC are combined with the Kp value, the dermal permeability coefficient, to calculate an "absorbed dose" per event. The absorbed dose is combined with the days on-Site, number of events, and receptor characteristics in order to estimate a dose. The HQ values are calculated from doses divided by RfC values (from Table 5.7).

$$HQ = Dose / TRV$$

Health Canada prefers that HQ values not exceed 0.2 for any one exposure pathway. For the Remediation Worker, two HQ values exceed 0.2:

Aromatic C>16 to C21 (F3)	HQ = 0.45
Aromatic C>34 (F4)	HQ = 0.45

When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2 and PHC F3, and the two components of PHC F4. For the Remediation Worker, the HQ for PHC F2 to F4 due to dermal contact with ground water exceed 0.2:

PHC F2 (dermal contact)	HQ = 0.50
PHC F3 (dermal contact)	HQ = 0.50
PHC F4 (dermal contact)	HQ = 0.66

These higher than acceptable risk estimates should be tempered by the fact that several conservative assumptions have been made, such as it is assumed that the Remediation Worker does not wear gloves and that they are exposed to ground water every day that they are on-Site. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by remediation workers.

None of the COPCs in ground water are assessed as non-threshold toxicants (NTT) and therefore it is not necessary to estimate risks over the receptor's lifetime.

Inhalation of Outdoor Vapours

Some of the COPCs in soil and ground water are sufficiently volatile to produce vapours. Vapours are able to migrate to outdoor air from impacts to both soil and ground water. The Remediation Worker is assumed to spend all of their time outdoors.

The outdoor air concentrations are calculated based on coefficients obtained from the J-E model. These are combined with characteristics of the Remediation Worker to estimate an exposure and then compare those estimates to the TRVs for inhalation pathways to estimate the potential health risks. Examples of these calculations are shown in Appendix B. Table 5.8 summarizes the estimated risks for inhalation of vapours in outdoor air due to soil and ground water.

$$HQ = Dose / Inhalation\ Rate / TRV$$

For chemicals that are assessed as threshold toxicants, none of the HQs for inhalation of vapours in outdoor air that originate from impacts in soil exceed 0.2. This suggests that the risks due to inhalation of vapours in outdoor air is acceptable.

When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2. The HQ sums for PHC F2 in outdoor air due to soil is 0.016. These results suggest that the potential health risks posed by this pathway to this receptor are acceptable. This conclusion should be reinforced by the knowledge that numerous conservative assumptions have been made in the calculations.

Two of the COPCs are non-threshold toxicants, but only benzene is sufficiently volatile to produce vapours. For NTT, the risks are estimated over the receptor's lifetime. Heath Canada prefers that the incremental lifetime cancer risk (ILCR) not exceed 1×10^{-5}. The ILCR for the Remediation Worker for benzene for vapours in outdoor air is 4.5×10^{-5} and is therefore considered unacceptable.

This higher than acceptable health risk due to the inhalation of benzene vapours that originate in impacted soil should be tempered by the knowledge that several conservative factors have been applied in reaching this conclusion. It is assumed exposure pathways are complete every day the Remediation Worker is at the Site regardless of whether the ground is frozen or other aspects of weather make some pathways incomplete some of the time. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by remediation workers.

For COPCs in ground water, only PHC F2 is sufficiently volatile to produce vapours. It is a threshold toxicant and the resulting HQ is well below 0.2 for inhalation of vapours in outdoor air. The results suggest that the potential health risks posed by this pathway to this receptor are acceptable. This conclusion should be reinforced by the knowledge that numerous conservative assumptions have been made in the calculations.

Table 5.8 Risk Estimates to the Remediation Worker

Pathway	Arsenic (TT) HQ	Arsenic (NTT) ILCR	Benzene (NTT) ILCR	PHC F2 HQ	PHC F3 HQ	PHC F4 HQ
Inhalation of Soil Particles	0.03	**$1.7x10^{-5}$**	$2.4x10^{-10}$	$6.2x10^{-5}$	NA	NCOPC
Dermal Contact with Soil	0.15	**$1.3x10^{-4}$**	$4.5x10^{-9}$	**0.27**	0.08	NCOPC
Ingestion of Soil	0.06	**$4.6x10^{-5}$**	$1.6x10^{-8}$	0.036	0.011	NCOPC
Inhalation of Outdoor Vapours (from soil)	NA	NA	**$4.5x10^{-5}$**	0.016	NA	NCOPC
Inhalation of Outdoor Vapours (from ground water)	NCOPC	NCOPC	NCOPC	<0.001	NA	NA
Dermal Contact with Ground Water	NCOPC	NCOPC	NCOPC	**0.50**	**0.50**	**0.66**

Notes:

- See Appendix D for the dose calculations.
- See Table 5.7 for TRVs.
- Higher than acceptable risks are shown in **bold**. These are an HQ > 0.2 or an ILCR > 1 x 10^{-5}.
- NA – not applicable. COC-pathway is not applicable. PHC F3 and F4 are not sufficiently volatile to produce vapours
- Sodium and Chloride, although COPCs in ground water, are not included. Only the dermal contact with ground water pathway would be complete. Exposures would be trivial relative to the ingestion of salt in food and drinking water.
- NCOPC – refers to not being a chemical of potential concern in that media

5.4.2 Potential Risks for the Commercial Worker

Soil Ingestion and Dermal Contact with Soil

The EPCs for arsenic, benzene, PHC F2, and PHC F3 in soil are combined with characteristics for the Commercial Worker to estimate exposures and doses for these two pathways. The equations used (from Health Canada, 2004a) are provided in Appendix D. The results are summarized in Table 5.9.

For a chemical that is to be assessed as a threshold toxicant, the estimated doses for each pathway are summed and then divided by the appropriate RfD or TDI from Table 5.7 to produce a hazard quotient (HQ).

HQ = estimated dose / TRV

Health Canada prefers that HQ values not exceed 0.2 for any one exposure pathway. For the Commercial Worker, none of the individual HQ values exceeds 0.2 and are therefore considered acceptable. When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2 and PHC F3. For the Commercial Worker, the HQ sum for PHC F2 is 0.05 for dermal contact and 0.01 for soil ingestion, and for PHC F3 is 0.02 for dermal contact with soil and 0.004 for soil ingestion and are therefore considered acceptable.

These acceptable risk estimates should be reinforced by the knowledge that several conservative assumptions have been made, such as it is assumed that the Commercial Worker does not wear gloves and that their arms are exposed. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by anyone who job involves the types of activities assumed for this receptor.

Two of the COPCs are assessed as non-threshold toxicants (NTT) and therefore risks are estimated over the receptor's lifetime.

ILCR = Dose x Body Weight / Inhalation Rate x TRV

Heath Canada prefers that the incremental lifetime cancer risk (ILCR) not exceed 1×10^{-5}. The ILCR for the Commercial Worker due to soil ingestion and dermal contact exceed 1×10^{-5} and are therefore are considered greater than acceptable.

Arsenic (dermal contact)	ILCR = 2.3×10^{-5}
Arsenic (ingestion)	ILCR = 1.7×10^{-5}

These higher than acceptable risk estimates should be tempered by the fact that several conservative assumptions have been made, such as it is assumed that the Commercial Worker does not wear gloves and that their arms are exposed. Furthermore, it is assumed that they ingest 20 mg soil every day that they are on Site. These risks can be reduced with the implementation of personal protective equipment and procedures that are widely used by anyone who job involves the types of activities assumed for this receptor.

Inhalation of Soil Particles

For the COPCs assessed as threshold toxicants, the HQ values are calculated as EPCs and divided by RfC values (from Table 5.7) with adjustments for the receptor's body weight and inhalation rate.

$$HQ = Dose \times Body\ Weight / Inhalation\ Rate / TRV$$

Health Canada prefers that HQ values not exceed 0.2 for any one exposure pathway. For the Commercial Worker, none of the HQ values exceeds 0.2 and are therefore considered acceptable.

These acceptable risk estimates should be reinforced by the fact that several conservative assumptions have been made, such as the Commercial Worker inhales soil particles impacted with the maximum concentration of arsenic for three-quarters of the days they are on the Site. (The ground is assumed to be frozen or snow-covered the other quarter of the year.) This estimate also ignores that some of the Site is covered with asphalt. These risks can be further reduced with the implementation of personal protective equipment and procedures that are widely used by anyone who job involves the types of activities assumed for this receptor.

When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2 (there are no inhalation TRV for PHC F3). For the Commercial Worker, the HQ sum for PHC F2 is 3.7×10^{-6} and is therefore considered acceptable.

Two of the COPCs are assessed as non-threshold toxicants (NTT) and therefore risks are estimated over the receptor's lifetime.

$$ILCR = Dose \times Body\ Weight / Inhalation\ Rate \times TRV$$

Heath Canada prefers that the incremental lifetime cancer risk (ILCR) not exceed 1×10^{-5}. Arsenic is assessed by as a threshold and NTT. For the Commercial Worker, none of the ILCR exceed 1×10^{-5} due the inhalation of soil particles and therefore the risks are considered acceptable.

This acceptable health risk due to inhalation of soil particles containing arsenic should be reinforced by the knowledge that several conservative factors have been applied in reaching this conclusion. It is assumed exposure pathways are complete every day the Commercial Worker is at the Site regardless of whether there are aspects of weather make some pathways incomplete some of the time.

Inhalation of Outdoor Vapours

Some of the COPCs in soil and ground water are sufficiently volatile to produce vapours. Vapours are able to migrate to outdoor air from impacts to both soil and ground water. The Commercial Worker is assumed to spend all of their time outdoors.

The outdoor air concentrations are calculated based on coefficients obtained from the J-E model. These are combined with characteristics of the Commercial Worker to estimate an exposure and then compare those estimates to the TRVs for inhalation pathways to estimate the potential health risks.

Examples of these calculation are shown in Appendix D. Table 5.9 summarizes the estimated risks for inhalation of vapours in outdoor air due to soil and ground water.

$$HQ = Dose / Inhalation\ Rate / TRV$$

For chemicals that are assessed as threshold toxicants, none of the HQs for inhalation of vapours in outdoor air that originate from impacts in soil exceed 0.2. This suggests that the risk due to inhalation of vapours in outdoor air is acceptable.

When chemicals can cause the same or similar types of health effects, the sum of the HQ values should not exceed 0.2. As described in Appendix C, the key health effects for many of the PHC fractions involve kidney or liver functions. To be conservative, it is assumed that it is appropriate to sum the HQ values for the four components of PHC F2. The HQ sum for PHC F2 in outdoor air due to soil is 0.008. These results suggest that the potential health risks posed by this pathway to this receptor are acceptable. This conclusion should be reinforced by the knowledge that numerous conservative assumptions have been made in the calculations.

Two of the COPCs are non-threshold toxicants. Only benzene is sufficiently volatile to produce vapours. For NTT, the risks are estimated over the receptor's lifetime. Heath Canada prefers that the incremental lifetime cancer risk (ILCR) not exceed 1×10^{-5}. The ILCR for the Commercial Worker for benzene for vapours in outdoor air is 2.3×10^{-5} and is therefore considered unacceptable.

This greater than acceptable health risk due to inhalation of vapours that originate in soil containing benzene should be tempered by the knowledge that several conservative factors have been applied in reaching this conclusion. It is assumed exposure pathways are complete every day the Outdoor Remedial Worker is on-Site regardless of whether the ground is frozen or other aspects of weather make some pathways incomplete some of the time. These risks can be further reduced with the implementation of personal protective equipment and procedures that are widely used by anyone who job involves the types of activities assumed for this receptor.

For COPCs in ground water, only PHC F2 is sufficiently volatile to produce vapours. It is a threshold toxicant and none of the HQ for the various PHC fractions exceeds 0.2 for inhalation of vapours in outdoor air. Furthermore, the HQ sum for the four fractions that make up PHC F2 ground water is $2.1 \times 10^{-4.}$ These results suggest that the potential health risks posed by this pathway to this receptor are acceptable. This conclusion should be reinforced by the knowledge that numerous conservative assumptions have been made in the calculations.

Table 5.9 Risk Estimates to the Commercial Worker

Pathway	Arsenic (TT) HQ	Arsenic (NTT) ILCR	Benzene (NTT) ILCR	PHC F2 HQ	PHC F3 HQ	PHC F4 HQ
Inhalation of Soil Particles	0.001	3.3×10^{-11}	1.4×10^{-12}	3.7×10^{-6}	NA	NCOPC
Dermal Contact with Soil	0.03	**2.3×10^{-5}**	3.0×10^{-9}	0.05	0.02	NCOPC
Ingestion of Soil	0.02	**1.7×10^{-5}**	5.9×10^{-9}	0.01	0.004	NCOPC
Inhalation of Outdoor Vapours (from soil)	NA	NA	**2.3×10^{-5}**	0.008	NA	NA
Inhalation of Outdoor Vapours (from ground water)	NCOPC	NCOPC	NCOPC	1.1×10^{-4}	NA	NA

Notes:

- See Appendix D for the dose calculations.
- See Table 5.7 for TRVs.
- Higher than acceptable risks are shown in **bold**. These are an HQ > 0.2 or an ILCR > 1×10^{-5}.
- NA – not applicable. COC-pathway is not applicable. PHC F3 and F4 are not sufficiently volatile to produce vapours
- NCOPC – refers to not being a chemical of potential concern in that media
- Sodium and Chloride, although COPC in ground water, are not included. Only the dermal contact with ground water pathway would be complete. Exposures would be trivial relative to the ingestion of salt in food and drinking water.
- Dermal Contact with ground water is not a complete pathway for the Commercial Worker

5.5 UNCERTAINTY AND THE USE OF CONSERVATIVE ASSUMPTIONS

Virtually every aspect of a risk assessment, from the selection of the receptors and COPCs to the selection of equations and toxicity reference values, has some degree of uncertainty associated with it. Some sources of uncertainty can be reduced (often by collecting more information about site specific conditions), but many are outside the scope or influence of individual risk assessments. For example, the physical-chemical and toxicological data for chemicals typically come from the published literature.

One approach to compensating for uncertainty is to make conservative assumptions when estimating exposures and risks. Such assumptions are deliberately made to avoid underestimating exposures and risks. This is particularly the case when preparing a SSRA. Several conservative assumptions have been made in this SSRA as illustrated below.

Could the impacted soil have higher concentrations of COPCs than have been modelled? There is always the potential for higher concentrations to be measured; however, samples from many locations around the Site have been analyzed, and the EPCs are set equal to the maximum measured concentrations. Since substantial numbers of samples have been analyzed, it can be stated with confidence that the maximum measured concentrations are well above average concentrations. Exposures to COPCs would correlate more closely with average concentrations than the maximums that have been used to estimate risks.

Could some receptors have characteristics that result in larger exposures and risks? This is highly unlikely. The characteristics assigned to the two different receptors contain several conservative elements. The Remediation Worker is assumed to come into contact with the worst of the impacted soil and to inhale outdoor particles for 92 days a year for seven years. The Commercial Worker also is assumed to come into contact with the worst of the impacted soil all of the time they are at the Site and to inhale outdoor particles the entire time they are at the Site, when in reality, the EPCs come from three different locations at the Site and it is highly unlikely that contact is made with the soil from those specific locations only.

For both types of receptors, little if any credit is taken for the standard health and safety plans that typically are mandatory for people who participate in the activities that would take place at the Site.

The standard precautions would include wearing gloves and clothing to reduce dermal exposure, prohibiting eating or smoking in the immediately work area, dampening soil or taking other steps to minimize the amounts of dust generated, covering stockpiles of impacted soil, using partial or full face masks if necessary, and providing workers with information about the types of chemicals that might be encountered. These basic precautions would greatly reduce exposures.

5.6 SUMMARY FOR THE HHRA

Human health risks have been estimated for two receptors – the Remediation Worker, and the Commercial Worker. The COPCs in soil are arsenic, benzene, PHC Fraction 2, and PHC Fraction 3. Those in ground water are sodium, chlorides, PHC Fraction 2, PHC Fraction 3, and PHC Fraction 4.

The risks for the Remediation Worker are estimated to be higher than acceptable for arsenic in soil due to ingestion, dermal contact, and inhalation of particles, and for benzene due to inhalation of vapours that migrate to outdoor air. The risks are also unacceptable for PHC Fraction 2 in soil due to dermal contact, and for PHC Fraction 2, Fraction 3, and Fraction 4 in ground water due to dermal contact.

The risks for the Commercial Worker are estimated to be higher than acceptable for arsenic in soil due to ingestion, dermal contact, and due to inhalation of particles. Unacceptable risks were estimated for benzene due to inhalation of vapours that originate in soil and migrate to outdoor air.

These estimates reflect numerous conservative assumptions including the assumption that all exposures involve soil with the maximum measured concentrations of the COPCs. The unacceptable risk estimates for arsenic range from approximately three times to one order of magnitude higher than acceptable for the individual pathways. If average concentrations had been used, the risks due to arsenic would be three times to an order of magnitude lower than have been estimated. A similar rationale can be applied to the risks for benzene which are two to 4.5 times greater than acceptable, and for PHCs whose risks are two to three times greater than acceptable.

Table 5.10 outlines the proposed specific standards (PSS) based on protection of human health.

Table 5.10 Proposed Standards Based on Protection of Human Health

COPC	Maximum Total Risk Corresponding to the EPC	EPC (µg/g)	PSS (µg/g)	Number of samples that exceed PSS
Arsenic (soil)	HQ =0.15	110 µg/g	146 µg/g	0 out of 21 samples
Arsenic* (soil)	**ILCR =1.7 x 10^{-4}**	110 µg/g	6.3 µg/g	6 out of 21 samples
Benzene* (soil)	**ILCR =4.5 x 10^{-5}**	1.5 µg/g	0.33 µg/g	2 out of 33 samples
PHC F2 (soil)	**HQ =0.30**	7,440 µg/g	4,941 µg/g	1 out of 23 samples
PHC F3 (soil)	HQ =0.09	4,250 µg/g	10,308 µg/g	0 out of 23 samples
PHC F2 (GW)	**HQ =0.50**	2,600 µg/L	1,037 µg/L	2 out of 17 samples
PHC F3 (GW)	**HQ =0.50**	1,200 µg/L	484 µg/L	3 out of 17 samples
PHC F4 (GW)	**HQ =0.66**	620 µg/L	187 µg/L	2 out of 17 samples

Notes:

- Total risk estimates are sums of estimated presented in Section 5.4. For example, the ILCR of 1.7 x 10^{-4} for arsenic (NTT) is the sum of the dermal and ingestion exposure pathways for the Remediation Worker in Table 5.8.
- * indicates that COPC is assessed as non-threshold toxicant. All other COPC are threshold toxicants.
- Values in **bold** exceed acceptable risk levels.
- PSS are calculated as the EPC ÷ the HQ for the EPC x 0.2. For arsenic as a non-threshold toxicant, the PSS is calculated as the EPC x (1x 10^{-5} ÷ the ILCR for the EPC).

6.0 SCREENING LEVEL ECOLOGICAL RISK ASSESSMENT

6.1 OVERVIEW

The basic framework for conducting an ecological risk assessment (ERA) appears in the CCME document entitled *A Framework for Ecological Risk Assessment* (1996). That document describes a methodology for assessing ecological (non-human) receptors at contaminated sites. Ecological receptors include the various types of organisms that can live on a site or visit it, or in the case of aquatic organisms, come into contact with ground water that originates at the contaminated site.

The CCME document recognizes that not all sites warrant the same level of effort and complexity, and accordingly describes three levels of ERA:

- Screening Level ERA - a primarily qualitative assessment of the potential environmental risks to specific ecological receptors that have been determined to be of major importance and relies heavily on the published literature and data collected at the site
- Preliminary Quantitative ERA - published information and site specific data collected specifically for ecological risk assessment purposes are combined to determine preliminary quantitative risk estimates for specified valued ecosystem components exposed to the chemicals of interest
- Detailed Quantitative ERA - extensive and complex field assessments and modelling are combined to assess ecological risks quantitatively

Typically, the assessor progresses through the levels until the point where it is judged that the risks have been adequately assessed. For this ERA, a Screening Level Assessment is adequate. It relies upon concentrations of COPCs measured at the Site and ecological toxicity information in the published literature. Therefore, a screening level ecological risk assessment (SLERA) is presented below. In the absence of site specific information, any assumptions that are made are identified.

6.1.1 Risk Assessment Objectives

The objectives of the SLERA are:

- Characterize the potential risks posed by the COPCs to ecological receptors. Depending on the toxicity reference values (TRVs) found in the published literature, it may be sufficient to compare measured concentrations of COPCs to the TRVs.
- Establish and justify ecological standards for each COPC.
- If risk management measures are needed to ensure that potential risks are acceptable, describe those measures in terms of design, performance monitoring, maintenance, duration needed, and responsibilities for construction and maintenance.

These objectives are to be undertaken within the following context:

- The Site is to continue to be used for industrial/commercial purposes.
- The ecological COPCs are those identified in Section 3.6.
- Sediments were not investigated and are not considered in the ERA.
- Several COPCs were identified in ground water could have impacts on aquatic receptors. Therefore, four surface water samples (three in proximity to West Wharf) were collected for chemical analysis. The surface water samples collected adjacent to the West Wharf did not have elevated concentrations of metals. This suggests that COPCs are not migrating into the harbour in quantities that have a potential to cause adverse effects.
- The ecological receptors of interest are: all types of terrestrial receptors including soil microorganisms, soil-dwelling invertebrates, plants, birds, and animals. Aquatic receptors are not considered.
- Given that plants and soil invertebrates are assumed to have opportunities to come into contact with COPCs, then food web effects need to be considered.

The environmental data available are sufficient to meet these objectives. The soil quality information was collected in 2003, 2009, and 2010. Issues such as poor data quality or gaps in data that can increase uncertainty in risk estimates are not a concern in this SLERA and have not influenced the setting of the objectives for the SLERA.

6.1.2 Problem Formulation

The objective of the problem formulation stage of the ERA is to develop a focused understanding of how COPCs can impact the health of ecological receptors inhabiting the Site. Several previous assessments were completed for the Site. These assessments identified contaminants of potential concern and possible migration routes (exposure pathways), and provided observations about wildlife activities on Site. The problem formulation process is presented as an ecological conceptual site model which provides a visual depiction of the relevant pathways linking COPCs in various media to ecological receptors of interest.

6.1.3 Identifying Ecological COPCs

As noted in Section 3.6, COPCs are identified initially by comparing concentrations measured in samples collected from the Site to the appropriate CCME guidelines and MOE standards. As explained in Chapter 3, not all of the CCME and MOE values are based on ecological considerations. A better (more appropriate) approach is to compare the concentrations measured at the Site to the ecological "component values" that appear in the CCME and MOE processes for setting guidelines and standards. This comparison was described in Section 3.6. From that comparison the following COPCs are carried forward into the SLERA:

- Arsenic, boron (hot water extractable), chromium (hexavalent), selenium, electrical conductivity, sodium absorption ratio, PHC F2, and PHC F3 in soil.
- Sodium, chloride, PHC F2, PHC F3, and PHC F4 in ground water.

6.1.4 Selection of Ecological Receptors

Various portions of the Oshawa Harbour have been addressed in environmental assessments and risk assessments by other consultants. In a recent ERA of other adjacent parcels of land encompassing the mouth of the Oshawa creek north of the West Wharf, Jacques Whitford completed a survey of flora and fauna on Site (JWEL, 2009). Table 6.1 shows the results of that survey. Reportedly, there were no endangered, threatened or special concern species identified during the survey, as designated by COSWIC and/or the Ontario Ministry of Natural Resources.

Table 6.1 Wildlife Survey of Lands on the West Wharf (Reproduced from JWEL, 2009)

Species	Comments
Birds	
American Crow (*Corvus brachyrhynchos*)	
American Goldfinch (*Carduelis tristis*)	
Black-Capped Chickadee (*Poecile atricapilla*)	
Blue Jay (*Cyanocitta cristata*)	
Canada Goose (*Branta canadensis*)	Observed in Oshawa Creek.
Common Grackle (*Quiscalus quiscula*)	
Dark-Eyed Junco (*Junco hyemalis*)	
Great Blue Heron (*Ardea heroidas*)	Observed on Oshawa Creek shoreline.
Herring Gull (*Larus argentatus*)	One individual observed NE of Site.
Ring-Billed Gull (*Larus delawarensis*)	Large flock observed NE of Site.
Mourning Dove (*Zenaida macroura*)	
Mute Swan (*Cygnus olor*)	Observed in Oshawa Creek (mouth).
Mallard (*Anas platyrhynchos*)	Observed in Oshawa Creek.
Tree Sparrow (*Spizella arborea*)	
Tundra Swan (*Cygnus columbianus*)	Observed in Oshawa Creek (mouth).
Mammals	
American Beaver (*Castor canadensis*)	Numerous signs of current beaver activity observed.
Domestic Cat (*Felis catus*)	
Eastern Cottontail Rabbit (*Sylvilagus floridanus*)	
Raccoon (*Procyon lotor*)	Tracks observed on Oshawa Creek shoreline.
Red Fox (*Vulpes vulpes*)	Numerous dens located on berm.
Squirrel (*Sciurus carolinensis*)	
White-Tailed Deer (*Odocoileus virginianus*)	Tracks observed in shoreline under Simcoe St.

For the purposes of this ERA it is not practical to assess each species that may potentially visit or inhabit the Site, so specific species have been selected from several trophic levels to evaluate the potential adverse effects imposed on Site receptors. These Valued Ecological Components (VECs) were selected based on species that:

- are indigenous to the area;
- are most likely to receive the greatest exposure to contaminants due to their habitat preferences, behaviours, and home range;
- represent various trophic levels in the ecosystem (e.g. carnivore, herbivore, insectivore, piscivore); and
- are of cultural, economic or social significance.

Selection of VECs ensures that each applicable habitat and trophic level at the Site receives adequate representation. This also ensures that sufficiently robust exposure data is available in the scientific literature for the selected VEC. Using these criteria, the VECs assessed in the ERA are expected to provide adequate and conservative representation of the faunal and floral diversity at the Site.

The Site is mainly paved and is enclosed by a fence. Large animals such as deer could not enter the Site and nor would they be enticed to enter due to the lack of food at the Site. Smaller foraging animals from the nearby creek bank are more likely to visit the Site.

It is assumed that birds and small mammals could consume the plants and soil-dwelling invertebrates at the Site, although the Site could not support large populations of these types of receptors due to its size, the presence of asphalt over portions of the Site, and the commercial/light industrial activities that take place year round.

The following species were selected for evaluation in the ERA:

- Masked Shrew (*Sorex cinereus*) – generalis insectivorous mammal
- Meadow Vole (*Microtus pennsylanicus*) – generalist herbivorous mammal
- American Robin (*Turdus migratorius*) – generalist omnivorous bird
- Red Fox (*Vulpes vulpes*) – carnivorous mammal
- Plants – evaluated as a class
- Earth Worm (*Eisenia foetida*) – soil invertebrate

Selected VECS are briefly profiled in the following section.

6.1.5 Receptor Characterization

Masked Shrew (*Sorex cinereus*): is a common rodent in Canada, with an average weight of 4 g and length of 0.10 m. Masked shrews inhabit moist environments such as open and closed forests, meadows, riverbanks, lakeshores, and willow thickets. Their home ranges vary from 2,000 to 6,000 m^2 in size. They do not hibernate and feed primarily (97.5%) on terrestrial invertebrates, including insect larvae, ants, beetles, crickets, grasshoppers, slugs, snails, spiders, harvestmen, and centipedes. They also feed on terrestrial plant material, such as seeds and fungi, which comprises 2.5% of their diet (Lee, 2001). Based on this consumption, the masked shrew will incidentally ingest approximately 4.44×10^{-5} kg/d of dry soil.

Meadow Vole (*Microtus pennsylvanicus*): is the most widely distributed small grazing herbivore in North America. The average meadow vole weighs 45 g and is 0.15 m in length. Voles inhabit moist to wet habitats including marshes, bogs, grassy fields, and open grassy woodland. Their home ranges vary from less than 2 m^2 to over 830 m^2; females tend to have the smaller home ranges. Meadow voles feed primarily on terrestrial plant material, which comprises 95% of their diet. They eat grasses, leaves, seeds, roots, bark, fruits, and fungi. 2% of their diet comes from terrestrial invertebrates, such as insects and animal matter (Jackson, 1961). These mammals will incidentally ingest approximately 3.15×10^{-4} kg/d of dry soil.

American Robin (*Turdus migratorius*): occurs throughout most of Canada and weighs approximately 80 g. This species requires access to fresh water, protected nesting habitat, and foraging areas; the nesting habitat includes moist forest, swamps, open woodlands, orchards, parks, and lawns. These birds feed on insects, earthworms, and fruit. Robins are migratory and their seasonal home ranges vary from 1,500 m^2 to 8100 m^2 (Sallabanks and James, 1999). Their diet includes 52.3% terrestrial plant material and 47.8% soil invertebrates, resulting in an estimated incidental soil ingestion rate of 4.85×10^{-4} kg/d of dry soil.

Red Fox (*Vulpes vulpes*): can be found throughout Canada and has an average weight of 4.5 kg. Home ranges are often shared with individuals from the same family and vary from 0.60 km^2 to over 30 km^2. These mammals live in a wide range of habitats, including forest, tundra, prairies, farmland, desert, mountains, and urban areas. They prefer mixed vegetation communities, such as woodlands, mixed shrubs, and edge habitats. Red Foxes prey on small mammals, especially voles, mice, and rabbits. They also eat birds, insects, fruits, and nuts (MacDonald and Reynolds, 2005). Their diet is roughly 85% small mammal and bird prey, 10% terrestrial plant material, and 5% terrestrial invertebrates; they are estimated to incidentally ingest 3.0×10^{-3} kg/d of dry soil.

Earthworms (*Eisenia foetida*): are one of the most important organisms involved in breaking down matter in soil. They are decomposers and play a key role in nutrient recycling. They also aid in soil aeration and infiltration by increasing the soil's porosity. Earthworms have wet surface membranes and are in almost constant contact with the soil; they also often ingest soil. Since they are at the base of the food chain and are prey of many creatures, including the American robin, their relationship with the soil makes them an important link between impacted soil and wildlife species.

Vegetation: Much of the Site is paved and little vegetation is present. There are some plants (mostly grasses and shrubs) at locations in dips and cracks in the pavement and along the fence line. Complete exposure pathways are root uptake from soil and ground water, uptake from outdoor vapours, and deposition of soil particles on above-ground surfaces of plants. This SLERA does not identify specific species to represent those at the Site, but instead considers toxicity reference values (TRVs) protective of plant species in general. (See Section 6.6.)

6.1.6 Ecological Conceptual Site Model

A conceptual site model (CSM) consists of illustrations and/or narrative that describe the exposure pathways that link COPCs to each identified VEC. The CSM for this SLERA is shown in Figure 6.1.

The Site is mainly paved and is enclosed by a fence. It provides poor habitat for foraging or grazing and access is likely limited to small terrestrial mammals, birds, and soil invertebrates.

6.2 EXPOSURE ASSESSMENT

6.2.1 Pathways Analysis

Soil pathways including ingestion, dermal contact, and inhalation of soil particles - These pathways are relevant where ecological receptors can come into direct contact with impacted soil. As explained in Section 6.1.6, these pathways are assumed to be complete for soil micro-organisms and soil-dwelling invertebrates and therefore, these pathways should be evaluated further in the context of all types of terrestrial organisms. Assessing dermal contact is challenged by the roles that fur, feathers, and scales could play; however, the U.S. EPA has concluded that dermal contact likely is a small contributor to total exposure of ecological receptors (U.S. EPA, 2003). As a result, the dermal contact pathway seldom is quantified for birds and small mammals.

Inhalation and/or foliar uptake of Soil vapours – The COPCs at the Site include benzene in soil and PHC F2 in ground water. These are sufficiently volatile that they would produce vapours in soil which would then migrate to outdoor air. Therefore, the inhalation of soil vapours and outdoor air should be addressed further.

Ingestion of ground water - Soil microorganisms and invertebrates may come in contact with and ingest ground water. The average ground water table was approximately 1.2 m bgs based on measurements at four monitoring wells in 2010.

Dermal contact with ground water – Soil microorganisms and invertebrates may come in contact with ground water. The average ground water table was approximately 1.2 m bgs based on measurements at four monitoring wells in 2010.

Foliar deposition of soil particles – Much of the Site is paved. Grasses and shrubs are limited to the edges of the property and cracks in the pavement. This pathway could be completed for those plants present and should be addressed further.

Root uptake of COPCs in ground water or soil – Roots were noted in some borehole samples collected from the top 1.5 m in 2009 and 2010. COPCs were found in this part of the soil profile and this depth intersects the ground water table on the Site. Thus the pathway should be considered further.

Ingestion of ground water after it reaches a surface water feature – Surface water samples collected in 2010 did not show evidence of elevated concentrations of parameters identified as COPCs. The amount of COPCs migrating from the Site into the harbour likely occurs to such a small degree that it lacks the potential to alter water quality in the harbour. Therefore, this pathway does not need to be addressed further.

Food web considerations – It is possible for COPCs to be transferred from soil micro-organisms, to soil-dwelling invertebrates, to birds and small animals, or from plants to birds and small animals. Therefore, food web considerations need to be evaluated.

Food web-interactions can result in bioaccumulation and biomagnifications in the food chain. Food web considerations are incorporated to a lesser extent through some of the TRVs presented in Section 6.3. For example, the recent soil screening levels (SSLs) recommended by the U.S. EPA consider bioaccumulation. SSLs are among the TRVs discussed for all of the COPCs in Section 6.3.

The CSM presented in Figure 6.1 summarizes this discussion of relevant pathways.

6.2.2 Exposure Estimates

Exposures are not quantified in this SLERA. The potential risks to ecological receptors are examined by comparing measured concentrations of COPCs to ecological TRVs. This process is presented in Section 6.4.

Many of the TRVs come from agencies such as the CCME, Environment Canada, U.S. EPA, U.S. Department of Energy, and RIVM. To establish TRVs, those agencies examine numerous published studies to determine which studies warrant further consideration, and which do not. The agencies often examine studies of different species, different endpoints, different exposures or doses, different exposure mechanisms, etc. and then use combinations of calculations and professional judgment to recommend benchmarks, thresholds, guidelines, etc.

The majority of the ecological TRVs are expressed as concentrations and often are interpretations of toxicity studies for broad categories of ecological receptors. (For example, there is a screening benchmark for lead in soil of 50 μg/g to protect plants.) In Section 6.4, all measured concentrations of COPCs are considered, although emphasis is placed on the higher measured concentrations. If the maximum concentration of a COPC measured at the Site is below such benchmarks, then it can be assumed with confidence that the potential risks are acceptably low and the exposures to specific types of receptors do not need to be quantified.

6.2.3 Uncertainty in the Exposure Assessment

As noted in Section 6.2.2, exposures are not quantified in this SLERA and therefore, there are no uncertainties associated with exposure estimates *per se*; however, the SLERA uses measured concentrations as a surrogate for exposures and therefore one source of uncertainty relates to how well the measured concentrations represent the chemical quality of the environmental media that ecological receptors will contact. Two environmental media are of interest in this SLERA – soil and ground water. Soil samples from numerous locations have been analyzed. The Site is relatively small, so a low level of uncertainty is assigned to the understanding of COPCs in soil. Approximately 20 ground water samples collected from the Site have been analyzed since 2003. All samples were analyzed for inorganic parameters and BTEX. Fewer samples were analyzed for VOCs and PAHs. This is adequate to assign a low level of uncertainty to the understanding of COPCs in ground water. Surface water is not an environmental medium of concern since samples in 2010 displayed no effects of the COPCs identified in soil or ground water.

6.3 HAZARD ASSESSMENT

6.3.1 General Approach to Assessing Hazards

The potential hazards that chemicals can pose to ecological receptors typically are evaluated by exposing populations of receptors to known concentrations of chemicals under controlled conditions.

To assess the hazards a chemical poses to soil invertebrates and plants, exposure levels are simply measured as concentrations of the COPCs in the soil. Individual exposure pathways (dermal exposure, ingestion, respiration) seldom are considered. The endpoints selected for measurement of effect in soil toxicity tests vary according to the type of receptor being tested, and the purpose of the test. For example, respiration often is used as a measure to evaluate both lethal and sub-lethal impacts to microorganisms, while factors such as seedling root length and shoot height often are used to assess sub-lethal effects on plants.

One approach to interpreting the results of toxicity testing is to determine the relationship between the percentage of exposed receptors affected and the concentration of the chemical in soil. For example, a specific concentration of a chemical in soil (expressed as μg/g) might be described as the concentration that is found to be lethal to 50% of exposed organisms (the LC_{50}), or the concentration that produces sub-lethal effects (such as reduced plant growth) in 25% of the exposed organisms (the EC_{25}).

A second approach to interpreting the results is to determine the concentration at which there is no longer a measured affect (the No Observed Adverse Effect Concentration or NOAEC), or the lowest concentration at which effects were observed (the Lowest Observed Adverse Effect Concentration or LOAEC).

The results of numerous toxicity tests, usually for several organisms, can be reviewed collectively to identify a single value that is considered to be protective of most or all organisms under most or all conditions encountered. Such values may be referred to as toxicity reference values or TRVs, ecological screening benchmarks, ecological component values (this terminology appears in the former MOE Guideline and supporting documents), or ecological guidelines.

For this SLERA, the hazard assessment of the COPCs consists primarily of compiling TRVs established by regulatory agencies. All types of TRVs are documented including effect concentration (EC_x) values, NOAEC, LOAEC, No Observable Adverse Effects Levels (NOAELs), and Lowest Observable Adverse Effect Levels (LOAELs). These values are described in the following sections.

TRVs are deliberately set to be conservative (i.e. they are intended to be protective of the majority of organisms at the majority of sites). As a result, when the concentration of a COPC does not exceed a TRV it is highly probable that significant adverse effects will not occur. It is equally important to note that when a COPC concentration exceeds a TRV, this is simply an indication that a measurable effect may occur. Depending on the conditions and organisms at a specific site, it is possible that there are no observable effects even when concentrations are higher than a TRV.

For this SLERA, the more relevant TRVs are: concentrations that inhibit bacterial activity; ecological component values from the MOE (both 1996c and 2009); similar ecological guidelines from the CCME; ecological soil screening levels from the U.S. EPA; and screening benchmark values intended to be protective of plants, soil invertebrates, birds, and small mammals.

Of secondary relevance are TRVs for larger animals (including livestock), and values based simply on detection limits or background concentrations.

6.3.2 Toxicity Reference Values for Arsenic in Soil

CCME Benchmarks

The CCME has set the soil quality guideline for ecological health at 17 µg/g based on protecting organisms that have direct contact with soil (CCME, 1997). Data for plants and soil invertebrates are used if available to set such guidelines, but in the case of arsenic, it appears that only data for plants are used.

MOE Benchmarks

The ecological component value for the MOE SCS for arsenic is 20 µg/g (MOE, 2009). Values of 20 to 25 µg/g have been used by the MOE since the mid-1980s and frequently are described as intended to protect plants (for example, MOE, 1991). The recent 2009 Rationale document provides values of 20 µg/g for coarse soil, and 25 µg/g for medium-fine grained soil.

Plants

The U.S. EPA has set a soil screening level (SSL) of 18 µg/g for plants (U.S. EPA, 2005a). The value is based upon an extensive review of the literature. An older screening benchmark of 10 µg/g also is based on a review of the available literature (Efroymson *et al.*, 1997a).

Microorganisms

Toxicity data from various types of microbial processes have been used to calculate a mean NOEC of 160 µg/g, and that 5% of processes may be impacted of 25 µg/g (Verbruggen *et al.*, 2001).

An older review of the published literature recommended a screening benchmark of 100 µg/g to be protective of soil microorganisms and microbial processes (Efroymson *et al.*, 1997b).

Soil Invertebrates

A recent review of the published literature determined that there was insufficient data upon which to base a SSL for soil invertebrates (U.S. EPA, 2005a). An older review of the literature recommends a screening benchmark of 60 µg/g based on earthworms (Efroymson *et al.*, 1997b). A CCME report indicates that earthworms are not affected at 83 µg/g (CCME, 1997).

Other Receptors

Small birds and mammals often will have more stringent screening level due to the food web interactions; however, this is not the case for arsenic. The SSL of 43 µg/g for birds (specifically the woodcock, an insectivore), and the SSL of 46 µg/g for mammals (specifically the shrew, an insectivore) are less stringent than the SSL for plants (U.S. EPA, 2005a). SSLs for other types of birds and mammals (including avian herbivore, avian carnivore, and mammalian carnivore) are less stringent than those for the woodcock and shrew.

Toxicity data from various types of terrestrial organisms have been used to calculate a mean NOEC of 56 µg/g (Verbruggen *et al.*, 2001).

Preferred TRVs for this ERA

Several TRVs have been recommended for receptors that are relevant at the Site. They range from 10 to 160 µg/g. The most stringent is a screening value of 10 µg/g for plants, but it comes from a source published in 1997. Similarly, the next most stringent value is 17 µg/g from the CCME was set in 1997. More recent TRVs fall into the range of 18 to 25 µg/g. Using the low end of that range, **the preferred TRV is set to 18 µg/g.** It appears to be protective of plants, microorganisms, soil invertebrates, birds, and mammals.

6.3.3 Toxicity Reference Values for Boron (Hot Water Extractable) in Soil

CCME Benchmarks

The CCME has not set soil quality guidelines for boron.

MOE Benchmarks

The ecological component value for the MOE SCS for boron (specifically for boron that is hot water extractable or HWE) is 2 µg/g. That value applies to industrial/commercial/community land use sites with both categories of soil texture, and is unchanged in the recently revised SCS that come into effect in 2011. A slightly lower SCS of 1.5 µg/g applies to agricultural as well as residential/parkland/institutional land use sites.

Plants

The MOE SCS is based on ecological toxicity values, and specifically intended to be protective of plants. The two SCS of 1.5 and 2 µg/g are an attempt to strike a balance between plant species that are sensitive and those that are prone to displaying signs of boron deficiency.

The U.S. EPA has not set soil screening levels (SSLs) for boron.

An older screening benchmark of 0.5 µg/g also is based on a review of the available literature (Efroymson *et al.,* 1997a) but it is for total boron, not HWE boron, and was assigned a low level of confidence.

Microorganisms

An older review of the published literature recommended a screening benchmark of 20 µg/g to be protective of soil microorganisms and microbial processes (Efroymson *et al.,* 1997b), but it is for total boron, not HWE boron, and was assigned a low level of confidence.

Soil Invertebrates

The U.S. EPA has not set soil SSLs for boron.

Other Receptors

Toxicity studies involving rats, water fowl, and sheep have identified hazards from excessive exposure to boron, but the results for those studies are expressed as total boron, not HWE.

Preferred TRVs for this ERA

Very few TRVs have been recommended HWE. This is not surprising since the parameter is designed to address plant health. The only TRVS are the two SCS recommended by the MOE. Therefore, **the preferred TRV is set to 2 µg/g.** It is protective of plants and appears to be protective of soil microorganisms.

6.3.4 Toxicity Reference Values for Chromium (hexavalent) in Soil

CCME Benchmarks

The CSQG for chromium (hexavalent) for ecological health is 1.4 µg/g for commercial land-use. This is based on soil contact (CCME, 1999). The CCME describes this value as "provisional" (meaning that further information is needed before the provisional descriptor can be removed).

MOE Benchmark

The MOE ecotoxicity component value is 8 µg/g (MOEE, 1996, 1999). This value is intended to be protective of plants and soil organisms. That value is unchanged in the recently revised SCS that come into effect in 2011.

Plants

The U.S. EPA does not have enough data to recommend a SSL value for either trivalent or hexavalent chromium. Of 150 papers reviewed, 11 papers that describe 13 studies were judged to be acceptable. Toxicity values ranged from 3 µg/g for the turnip, to 138 µg/g for the carrot and pea. Information was reviewed only for plant species that are grown for consumption (U.S. EPA, 2005b).

An older screening benchmark of 1 µg/g also is based on a review of the literature (Efroymson *et al.*, 1997a). The authors assign that benchmark a low level of confidence. It is also primarily based on studies involving hexavalent chromium.

Microorganisms

Toxicity data in soil have been used to calculate that 120 µg/g is the most stringent serious risk addition (SRA) value for chromium and it is based on HC50 for species (Verbruggen *et al.*, 2001). The value of 120 µg/g is the lowest SRA for either trivalent or hexavlent chromium.

An older screening benchmark of 10 µg/g also is based on a review of the literature (Efroymson *et al.*, 1997b). The authors assign that benchmark a high level of confidence.

Soil Invertebrates

The U.S. EPA does not recommend a SSL to be protective of invertebrates due to a lack of qualified studies. The two studies that qualified recommend a toxicity value of 57 µg/g for the earthworm (U.S. EPA, 2005b).

Other references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates include a screening benchmark of 0.4 µg/g (Efroymson *et al.,* 1997b). The authors assign that benchmark a low level of confidence due to the limited number of reported concentrations causing toxicity.

Other Receptors

The U.S. EPA recommends SSL values of 26 µg/g to protect birds (the woodcock, a ground insectivore), and 34 µg/g to protect mammals based on trivalent chromium. There is not sufficient data to recommend an avian SSL for hexavalent chromium, but an SSL for mammalian receptors is recommended at 81 µg/g. These values are based upon extensive reviews of the published literature (U.S. EPA, 2005b).

Toxicity data from various types of terrestrial organisms have been used to calculate that 130 µg/g is the mean NOEC, and that 5% of organisms may be impacted of 8.5 µg/g (Verbruggen *et al.*, 2001).

Preferred TRVs for this ERA

Many TRVs have been recommended for chromium in soil. Those based mainly on trivalent chromium, and those assigned low levels of confidence by the authors are not considered further. Also not considered further is the "provisional" value from the CCME. This leaves several TRVs that have been recommended for all of the receptors of interest at the Site except plants. These range from 8 to 120 µg/g. Using the low end of that range, **the preferred TRV is set to 8 µg/g**. It appears to be protective of plants, microorganisms, soil invertebrates, birds, and mammals. It may not be protective for some types of plants (notably species grown for human consumption, but no crops are grown at the Site).

6.3.5 Toxicity Reference Values for Selenium in Soil

CCME Benchmarks

As noted in Section 3.6, the CCME SQG includes a SQG_E (soil quality guideline for environmental health) of 2.9 µg/g for selenium based on soil contact (CCME, 2009). Data for plants and soil invertebrates are used to set such guidelines if available. In the case of selenium, it appears that data for both types of receptors are used.

MOE Benchmarks

The ecotoxicity component value used by the MOE is 10 μg/g (1996). This is only slightly changed in the recently revised Rationale document (2009) which recommends an ecotoxicity value of 10 μg/g for coarse grained soil and 12.5 μg/g for medium/fine grained soil. These values are intended to be protective of plants and soil invertebrates.

Plants

The U.S. EPA recommends an SSL value of 0.52 μg/g to protect plants. That value is based upon an extensive review of the published literature (U.S. EPA, 2007c).

Other references typically consulted for benchmarks or similar values intended to be protective of plants include a screening benchmark of 1 μg/g (Efroymson *et al.*, 1997a).

Microorganisms

References typically consulted for toxicity information pertaining to microorganisms (i.e. Verbruggen, et al, 1997; Efroymson *et al.*, 1997b) have no information for selenium.

Soil Invertebrates

The U.S. EPA recommends an SSL of 4.1 μg/g to protect soil invertebrates. That value is based upon a review of the published literature (U.S. EPA, 2007c).

Other Receptors

The U.S. EPA recommends SSL values of 1.2 μg/g to protect birds, and 0.63 μg/g to protect mammals. These values are based upon extensive reviews of the published literature (U.S. EPA, 2007c).

The recently revised MOE Rationale document (2009) provides the following screening values: 5.7 μg/g for American Woodcock; 5.5 μg/g for the red-winged black bird; 26 μg/g for meadow vole; and 4.3 μg/g for sheep.

Preferred TRVs for this ERA

Several TRVs have been recommended for receptors that are relevant at the Site except microorganisms. The TRVs range from 0.52 to 26 µg/g. A few are less than background concentrations in Ontario and therefore judged to be unduly stringent for the Site. The most stringent TRV not below background is the CCME ecological value of 2.9 µg/g that is intended to be protective of plants and soil invertebrates. The **preferred TRV is set equal to the CCME ecological value of 2.9 µg/g.** It appears to be protective of all the relevant receptors with the exception of some species of plants and birds and mammals that are insectivores, but that finding needs to be tempered by the knowledge that the small size of the Site would be able to meet the dietary needs of only a few individuals.

6.3.6 Toxicity Reference Values for Electrical Conductivity in Soil

CCME Benchmarks

The CCME has not established a benchmark for electrical conductivity (EC) in soil.

MOE Benchmarks

The ecotoxicity component value used by the MOE is 1.4 mS/cm (MOE, 1996). In the recently revised Rationale document (2009), that benchmark value has not changed. The Rationale document indicates that this value is protective of plants and soil invertebrates at industrial/commercial/community land use sites with coarse grained soil.

Plants

The U.S. EPA has not published on SSL for EC (U.S. EPA, 2007b).

Other common references typically consulted for benchmarks or similar values intended to be protective of plants, such as Efroymson *et al.*, 1997a and Verbruggen *et al.*, 2001 also have not presented TRVs for EC.

Microorganisms

NOEC values for EC are not available for micro-organisms.

Soil Invertebrates

The U.S. EPA has not published on SSL for EC (U.S. EPA, 2007b).

Other common references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates, such as Efroymson *et al.*, 1997b and Verbruggen *et al.*, 2001 do don't include TRVs for EC.

Other Receptors

Benchmark values for other receptors are not available for EC.

Preferred TRVs for this ERA

The only TRV available for EC is one recommended by the MOE. Although described as being protective of plants and soil organisms it is based almost entirely on studies of plant growth. Thus, **the preferred TRV is set to 1.4 mS/cm**. Benchmarks for other receptors of interest are not available.

6.3.7 Toxicity Reference Values for Sodium Adsorption Ratio in Soil

CCME Benchmarks

The CCME has not recommended a benchmark for sodium adsorption ratio (SAR).

MOE Benchmarks

The ecotoxicity component value used by the MOE 12 μg/g (MOE, 1996). In the recently revised Rationale document (2009), the benchmark value has not been changed. The Rationale document indicates that this value is protective of plants and soil invertebrates at industrial/commercial/community land use sites with coarse grained soil.

Plants

The U.S. EPA has not published an SSL for SAR (U.S. EPA, 2007b).

Other common references typically consulted for benchmarks or similar values intended to be protective of plants, such as Efroymson *et al.*, 1997a and Verbruggen *et al.*, 2001 also have not presented TRVs for SAR.

Microorganisms

NOEC values for SAR are not available for micro-organisms.

Soil Invertebrates

The U.S. EPA has not published an SSL for SAR (U.S. EPA, 2007b).

Other common references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates, such as Efroymson *et al.*, 1997b and Verbruggen *et al.*, 2001 also have not presented TRVs for SAR.

Other Receptors

Benchmark values for other receptors are not available for SAR.

Preferred TRVs for this ERA

The only TRV available for SAR is published by the MOE (2009). The value was selected to be protective of plants and soil organisms. Thus, **the preferred TRV is set to 12 ug/g**. Benchmarks for other receptors of interest for the Site are not available.

6.3.8 Toxicity Reference Values for PHC Fraction 2 and Fraction 3 in Soil

CCME Benchmarks

The CCME Canada-Wide Standard for PHCs includes one or more ecological component values for each of the four PHC fractions. For PHC F2 at commercial and industrial sites with coarse soil, the most stringent of these is the direct soil contact value of 260 µg/g. The corresponding value for PHC F3 is 1700 µg/g. These values are based on toxicity studies conducted on behalf of CCME using plants and soil invertebrates (CCME, 2008b).

MOE Benchmarks

The ecotoxicity component values for PHC F2 and F3 in the recently revised MOE Rationale document are the same as the CCME values noted above (i.e. 260 and 1700 µg/g, respectively).

Plants

The U.S. EPA has not published on SSL for PHC fractions (U.S. EPA, 2007b).

Other common references typically consulted for benchmarks or similar values intended to be protective of plants, such as Efroymson *et al.,* 1997a and Verbruggen *et al.*, 2001 also have not presented TRVs for PHCs.

Microorganisms

NOEC values for PHCs are not available for micro-organisms.

Soil Invertebrates

The U.S. EPA has not published on SSL for PHC fractions (U.S. EPA, 2007b).

Other common references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates, such as Efroymson *et al.,* 1997b and Verbruggen *et al.*, 2001 also have not presented TRVs for PCHs.

Other Receptors

Benchmark values for other receptors are not available for PHCs.

Preferred TRVs for this ERA

The only TRVs available for PHCs in soil are those derived by the CCME and subsequently adopted by the MOE. Therefore, the **preferred TRVs are set to the CCME/MOE ecological component values of 260 µg/g for PHC F2, and 1,700 µg/g for PHC F3.**

6.3.9 Toxicity Reference Values for Sodium in Ground Water

CCME Benchmarks

The CCME has not recommended a benchmark for sodium in ground water.

MOE Benchmarks

In the recently revised MOE Rationale document (2009), the benchmark value is 490,000 µg/L. The Rationale document indicates that this value is based on Ontario background, and not based on toxicity studies.

Plants

The references typically consulted for benchmarks or similar values intended to be protective of plants (Efroymson *et al.*, 1997a; Verbruggen *et al.*, 2001; U.S. EPA, 2003) provide no such values for sodium.

There are many studies of the damage to vegetation caused by road salt along highways, parking lots, salt storage yards, etc. Salt spray often is the main source of damage.

In the assessment of road salt as a priority substance, threshold values for various types of plants are provided. These values are for sodium chloride which is approximately 40% sodium and 60% chlorides by weight. By multiplying thresholds for sodium chloride by 40% to derive threshold for sodium, the thresholds for herbaceous and woody plants range from 340 to 10,000 mg/L of sodium for various thresholds including EC_{25} values. Values also are provided for wetland species but those are not relevant in the context of the Site (Environment Canada and Health Canada, 2001).

Soil Microorganisms

In the assessment of road salt as a priority substance, reference is made to studies of the sensitivity of soil bacteria for sodium chloride. Two of 40 bacteria were moderately inhibited at 60 mg/L of sodium. One was strongly inhibited at 400 mg/L of sodium. Seventeen were strongly inhibited at 2,000 mg/L (Environment Canada and Health Canada, 2001).

Soil Invertebrates

The references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates (Efroymson *et al.,* 1997b; Verbruggen *et al.*, 2001; U.S. EPA, 2003) provide no such values for sodium.

In the assessment of road salt as a priority substance, it is reported that earthworms are sensitive to salt but the results are expressed as concentration in soil (not in water) (Environment Canada and Health Canada, 2001).

Terrestrial Animals and Birds

The references typically consulted for benchmarks or similar values intended to be protective of terrestrial animals and birds (Sample *et al.,* 1996; Verbruggen *et al.*, 2001) provide no such values for sodium in water.

Publications from the Ontario Ministry of Agriculture, Food, and Rural Affairs (OMAFRA) indicate that salinity concentrations should not exceed 3,000 mg/L for cattle and pigs, and that no health problems should occur if concentrations are less than 1,000 mg/L (OMAFRA, 1997; 2007). The publication concerning pigs indicates that sodium by itself poses little threat to a pig's health but can contribute to poor health if sulphate is elevated (> 1,000 mg/L). There is no reason to suspect that sulphate in ground water is elevated at the Site.

The OMAFRA guidelines are for salinity which includes not only sodium and chlorides, but also calcium, magnesium, potassium, sulphate, and bicarbonate. These chemicals have not been measured in ground water at the Site. To be conservative, it is assumed that sodium and chloride account for 75% of the total salinity at the Site.

Sodium chloride is approximately 40% sodium and 60% chloride by weight. That ratio of 40:60 is similar to the ratios observed in six of seven samples collected at the Site in 2010 that displayed elevated concentrations of sodium and chloride. The ratios in those six samples ranged from 35:65 to 48:52.

If sodium and chloride typically represent about 75% of the salinity at the Site and if salinity of 3,000 mg/L is safe for cattle and pigs, then about 2,250 mg/L of sodium plus chlorides should be safe for cattle and pigs, and that 2,250 mg/L should consist of approximately 900 mg/L of sodium and 1,350 mg/L of chlorides. Water of excellent quality for cattle and pigs would have not more than 300 mg/L for sodium and 450 mg/L for chlorides.

Aquatic Receptors

No regulatory agencies in Canada have established limits for sodium in water to be protective of aquatic habitat. One frequently cited TRV is 680 mg/L (Suter and Tsao, 1996). It is based upon preventing impacts to daphnia chronically exposed to sodium in water. In the assessment of road salt as a priority substance, toxicity values including EC_{50} and LC_{50} values for various aquatic organisms including frogs, trout, and daphnia are all higher than 900 mg/L (Environment Canada and Health Canada, 2001).

Preferred TRVs for this ERA

The reviewed literature provides TRVs (of 680 mg/L or higher) intended to protect aquatic organisms. These are not well suited to this ERA since sodium is a COPC only in ground water. The salinity guidelines from OMAFRA can be converted into a maximum acceptable concentration of approximately 900 mg/L for watering cattle and pigs, but that TRV also is not well suited to this ERA since the ground water at the Site is not consumed by any animals. Information concerning herbaceous and woody plants suggests that TRVs are in the range of approximately 340 to 10,000 mg/L. Such receptors are or could be present at the Site. Information concerning the sensitivity of soil bacteria suggests that the TRV should be in the range of 60 to 2,000 mg/L. Such receptors are present at the Site.

Based on the information for plants and microorganisms, the preferred TRV should be in the range of 60 to 10,000 mg/L. By interpolating between the published values, 500 mg/L could be detrimental to less than 10% of bacteria species. (Since this condition likely has existed for many years, the bacterial population at the Site likely has adapted to the sodium present.) The value of 500 mg/L could be detrimental to less than 25% of herbaceous plants, and detrimental to about 25% of woody species. Water with 500 mg/L of sodium would be acceptable for livestock to drink (although this does not occur) and it would not be detrimental to any aquatic organisms in the Oshawa Harbour (assuming that undiluted ground water reaches the harbor). These considerations suggest that the preferred TRV should be approximately 500 mg/L. That value is very similar to the MOE standard of 490 mg/L (490,000 μg/L), therefore, **the preferred TRV for sodium in ground water is 490 mg/L.**

6.3.10 Toxicity Reference Values for Chlorides in Ground Water

CCME Benchmarks

The CCME has not recommended a benchmark for chlorides in ground water.

MOE Benchmarks

In the recently revised MOE Rationale document (2009), the benchmark value is 2,300,000 µg/L. The Rationale document indicates that this value is protective of aquatic life (assuming that the ground water is diluted before entering the surface water habitat).

Plants

The references typically consulted for benchmarks or similar values intended to be protective of plants (Efroymson *et al.,* 1997a; Verbruggen *et al.*, 2001; U.S. EPA, 2003) provide no such values for chlorides.

The CCME has recommended ranges of chlorides in water used for irrigation based upon susceptibility to foliar damage when plants are spray irrigated (CCME, 2003). The most sensitive (at 100 to 200 mg/L) are fruits and nuts including peaches, plums, apricots, almonds, and strawberries. Moderately sensitive crops (350 to 700 mg/L) include alfalfa, barley, corn, and cucumbers. The least sensitive crops (at more than 700 mg/L) include cauliflower, cotton, sorghum, sugar beets, and sunflowers. (All values are from CCME, 1987.)

In the assessment of road salt as a priority substance, threshold values for various types of plants are provided. These values are for sodium chloride which is approximately 40% sodium and 60% chlorides by weight. By multiplying thresholds for sodium chloride by 60% to derive threshold for chlorides, the thresholds for herbaceous and woody plants range from 510 to 15,000 mg/L of chlorides for various thresholds including EC_{25} values. Values also are provided for wetland species but those are not relevant in the context of the Site (Environment Canada and Health Canada, 2001).

Soil Microorganisms

In the assessment of road salt as a priority substance, reference is made to studies of the sensitivity of soil bacteria for sodium chloride. Two of 40 bacteria were moderately inhibited at 90 mg/L of chlorides. One of 40 was strongly inhibited at 600 mg/L of chlorides. Seventeen of 40 were strongly inhibited at 3,000 mg/L (Environment Canada and Health Canada, 2001).

Soil Invertebrates

The references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates (Efroymson *et al.,* 1997b; Verbruggen *et al.*, 2001; U.S. EPA, 2003) provide no such values for chlorides.

Terrestrial Animals and Birds

The references typically consulted for benchmarks or similar values intended to be protective of terrestrial animals and birds (Sample *et al.,* 1996; Verbruggen *et al.*, 2001) provide no such values for chlorides in water.

The same OMAFRA publications noted in Section 6.3.9 can be used to derive maximum acceptable concentrations of chlorides in water consumed by cattle and pigs. Water should be safe if chlorides do not exceed 1,350 mg/L. Water of excellent quality for cattle and pigs would have not more than 450 mg/L for chlorides.

Aquatic Receptors

While considerable research has been published on the potential risks that chloride can pose to aquatic organisms in freshwater habitat, no regulatory agencies in Canada have established limits for chlorides in water to be protective of aquatic habitat.

A review of laboratory studies using various types of aquatic receptors produced the following ranges of TRVs (Evans and Frick, 2002):

- LC_{50} values of 1,400 to 13,085 mg/L
- EC_{50} values (conducted over seven days) of 874 to 3,330 mg/L
- Chronic toxicity values of 150 to 1,402 mg/L

The authors also note that concentrations in the latter two ranges are observed in creeks, rivers, ponds, and lakes in urban areas and near highways.

Similar ranges have been reported by others:

- LC_{50} values of 2,724 to 14,100 mg/L based on one day exposures to six freshwater fish and crustacean species (Cowgill *et al.*, 1990)
- LC_{50} values of 1,440 to 6,031 mg/L based on seven day exposures to 17 species of fish, amphibians and crustaceans (Environment Canada and Health Canada, 2001).

Preferred TRVs for this ERA

The reviewed literature provides TRVs (of 874 mg/L or higher) intended to protect aquatic organisms. These values are not well suited to this ERA since chlorides is a COPC only in ground water. The salinity guidelines from OMAFRA can be converted into a maximum acceptable concentration of approximately 1,350 mg/L for watering cattle and pigs, but that TRV also is not well suited to this ERA since the ground water is not consumed by any animals until it surfaces on other blocks. Information concerning herbaceous and woody plants suggests that TRVs are in the range of approximately 510 to 15,000 mg/L. Such receptors are or could be present at the Site.

The CCME has recommended a range of 100 to 700 mg/L for irrigation water. That range is not well suited to this ERA since it is based largely on commercial crop species that are not the types of plants that will grow at the Site, and the range is based upon foliar damage due to sprinkling which is not how contact could occur at the Site.

Information concerning the sensitivity of soil bacteria suggests that the TRV should be in the range of 90 to 3,000 mg/L. Such receptors are present at the Site.

Based on the information for plants and microorganisms, the preferred TRV should be in the range of 90 to 15,000 mg/L. By interpolating between the published values, 700 mg/L could be detrimental to approximately 5% of bacteria species. (Since this condition likely has existed for many years, the bacterial population at the Site likely has adapted to the chlorides present.) The value of 700 mg/L could be detrimental to less than 25% of herbaceous plants, and detrimental to approximately 25% of woody species. If sprayed on sensitive or moderately sensitive crop species, it could cause damage, but such crops will not be grown at the Site.

Water with 700 mg/L of chlorides would be acceptable for livestock to drink (although this does not occur) and it would be less than any of the TRVs for aquatic organisms even if undiluted ground water was to reach the Oshawa Harbour. Therefore, **the preferred TRV for chlorides in ground water is 700 mg/L.**

6.3.11 Toxicity Reference Values for PHC F2, F3, and F4 in Ground Water

CCME Benchmarks

The CCME undertook a thorough review of ecological information when it set the Canada-Wide Standards for PHCs (CCME, 2000) and in the update (CCME, 2008b). Those CCME documents are the main source of ecological information for PHCs in soil, but provide much less guidance for PHCs in ground water. There are estimations of reference concentrations for crude oil in water ingested by cattle. The estimated reference concentration is 230 mg/L for fresh crude. By making assumptions about composition, the CCME estimates that the RfCs are: 49 mg/L for PHC F2; 79 mg/L for PHC F3; and is 42 mg/L for Fraction 4 (CCME, 2008b).

MOE Benchmarks

In the recently revised MOE Rationale document (2009), the ecological value is 970 µg/L. The Rationale document indicates that this value is protective of aquatic life (assuming that the ground water is diluted before entering the surface water habitat).

The recently revised MOE Rationale document provides no ecological values for PHC F3 or F4. The standards for those two parameters (each set at 500 µg/L) is set at the routinely achievable detection limit and the assumption that these substances should not be detectable at background locations (MOE, 2009).

Plants

The references typically consulted for benchmarks or similar values intended to be protective of plants (Efroymson *et al.,* 1997a; Verbruggen *et al.*, 2001; U.S. EPA, 2003) provide no such values for PHC fractions in ground water.

Soil Invertebrates

The references typically consulted for benchmarks or similar values intended to be protective of soil invertebrates (Efroymson *et al.,* 1997b; Verbruggen *et al.*, 2001; U.S. EPA, 2003) provide no such values for PHC fractions in ground water.

Other Receptors

Other sources of ecological benchmarks including U.S. EPA Region 5, U.S. EPA Region 6, and Sample *et al.*, 1996 provide no such values for PHC fractions in ground water.

Preferred TRVs for this ERA

Microorganisms are the only type of receptor likely to come into contact with PHC fractions in ground water at the Site. For PHC F2, the only candidate that is relevant in the context of the Site is the 970 µg/L recommended by the MOE. Therefore, **the preferred TRV for PHC F2 is 970 µg/L.** For PHC F3 and PHC F4, no TRVs are relevant in the context of the Site. As a result, there is an inadequate basis for selecting a preferred TRV for either of these two parameters.

6.3.12 Uncertainty in the Hazard Assessment

For many of the COPCs, numerous toxicity studies have been conducted on many species. Some are not considered further when selecting a Preferred TRV for each COPC because the originating sources assign them a low level of confidence, or the TRVs have become "stale" relative to more recent reviews of the literature, or they reflect toxicity tests on species not found or expected to be present at the site, or they advocate values that are lower than background concentrations in Ontario. Even when those TRVs are not used to assess ecological risks at the Site, there remain TRVs appropriate for most of the COPCs in soil. Electrical conductivity and SAR in soil are two exceptions were TRVs are limited to plants and soil invertebrates. For both parameters the MOE is the only source of benchmark values and these Preferred TRVs are assigned a medium level of uncertainty.

TRVs are limited for the COPCs in ground water. A medium level of uncertainly is assigned to the Preferred TRVs for sodium, chlorides, and PHC F2. There is inadequate information to identify Preferred TRVs for PHC F3 and PHC F4 were not available.

6.4 ECOLOGICAL RISK CHARACTERIZATION

6.4.1 General Approach to Risk Characterization

One method used to interpret the ecological risks posed by a COPC is to determine how often its Preferred TRV is exceeded in the samples from the Site. If the Preferred TRV is not exceeded (or seldom exceeded or exceeded by only small margins), then ecological risks should be acceptable for all of the receptor types considered when the Preferred TRV is selected.

Another method is to divide measured concentrations of a COPC by the Preferred TRV or the relevant TRV for a specific type of receptor to calculate environmental hazard quotients (or EHQs). This is similar to the way that Hazard Quotients are calculated in the human health risk assessment (see Section 5). When EHQs are always less than one, adverse effects are unlikely and the potential risk is acceptable.

When EHQs are > 1, impacts are possible. It also may indicate that further evaluation of Site specific factors should be undertaken. The likelihood of impacts increases in proportion to the magnitude of the EHQ. When the EHQ is > 10, impacts are likely if the receptors used to set the corresponding TRV are the same or similar to those that might spend time at the Site and if those receptors have frequent access to the COPC.

6.4.2 Risk Characterization for Arsenic in Soil

The concentrations of arsenic measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/g)	Basis and Source of TRV
BH09-03A4 (0-0.30m)	110	
	100	Screening benchmark, microorganisms (Efroymson *et al.*, 1997b)
MW09-04A5 (0.76-1.37m)	91	
	60	Screening benchmark, earthworm (Efroymson *et al.*, 1997b)
	46	SSL, mammalian insectivore (U.S. EPA, 2005a)
	43	SSL, avian insectivore (U.S. EPA, 2005a)
	25	5% microbial processes (Verbruggen, *et al.*, 2001)
BH-308-1 (0-0.61m)	24	
	40	Ecotox value (MOE, 2009)
Preferred TRV	**18**	SSL, plants (U.S. EPA, 2005a)
	17	SQG_E based on soil contact (CCME, 1997)
MW4 SS2 (DCS, 0.61-1.22m)	14.6	
Dup of BH-308-1 (AQT, 0-0.61m)	13	
	10	Screening benchmark, plants (Efroymson *et al.*, 1997a)
MW09-04B5 (1.91-2.49m)	8	
MW6 SS2 (0.61-1.22m)	5.2	
14 samples	<1 to 4	
MW09-01B4 (GENIVAR, 2.59-3.20m)	4	
BH-306-4 (AQT, 2.13-2.90m)	4	
MW09-01A4 (GENIVAR, 0.08-0.61m)	3	
MW09-02A4 (GENIVAR, 0.30-1.37m)	3	
(MW09-02A Dup)4 (GENIVAR, 0.30-1.37m)	3	
MW09-02B4 (GENIVAR, 3.05-3.50m)	3	
BH09-03B4 (GENIVAR, 2.74-3.35m)	3	
BH7 SS1 (DCS, 0-0.61m)	2.4	
BH5 SS2 (DCS, 0.61-1.22m)	2.1	
BH-304-4 (AQT, 2.13-2.90m)	2	
BH-305-2 (AQT, 0.61-1.37m)	2	
BH-309-5 (AQT, 2.90-3.66m)	2	
BH26 SS6 (DCS, 3.05-3.66m)	1.7	
BH-310-4 (AQT, 2.13-2.90m)	<1	

Three (of 22) samples exceeds the Preferred TRV. These samples come from BH09-03, MW09-04, and BH-308. All three locations are in the west part of the Site. The samples with arsenic concentrations exceeding the TRV were collected from the top 1.37 m of fill. This suggests that the receptors of interest that are most likely to be at risk are plants and soil organisms inhabiting these soils. This part of the Site is near Oshawa Creek, a denning area for various small mammals. These mammals may be at risk as they would access this part of the Site when foraging.

The numbers of measured concentrations that exceed the most stringent TRVs for specific types of relevant receptors and the resulting EHQs include:

- Three samples exceed the most stringent TRV for plants. The corresponding EHQs are approximately 1.3, 5.1 and 6.1.
- One sample exceeds the most stringent TRV for soil micro-organisms. The corresponding EHQ is approximately 1.1.
- Two samples exceed the most stringent TRV for earthworms. The corresponding EHQ is approximately 1.5 and 1.8.
- Two samples exceed the most stringent TRV for mammalian insectivores. The corresponding EHQ is approximately 2.0 and 2.4.
- Two samples exceed the most stringent TRV for avian insectivores. The corresponding EHQ are approximately 2.1 and 2.6.

That few samples produce HQs higher than 1 and produce no HQs higher than 6.1 demonstrates that the receptors of interest should not experience adverse effects in most areas of the Site. Overall, the ecological risks posed by arsenic in soil are found to be acceptable at all locations except at BH09-03, MW09-04, and BH-308.

6.4.3 Risk Characterization for Boron in Soil

The concentrations of HWE boron measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/g)	Basis and Source of TRV
	20	Benchmark, microorganisms (Efroymson et *al.*, 1997a)
MW09-04A5 (0.76-1.37m)	4.17	
MW09-04B5 (1.91-2.49m)	2.17	
Preferred TRV	**2**	Plant and soil invertebrates at sites with coarse grained soil (MOE, 2009)
BH09-03A4 (0-0.30m)	1.57	
BHX1 (MW09-02A Dup)4 (0.30-1.37m)	1.55	
BH09-03B4 (2.74-3.35m)	1.5	
MW09-02A4 (0.30-1.37m)	1.46	
	0.5	Benchmark, plants (Efroymson et *al.*, 1997a)
3 samples	< 0.5	

Two samples exceed the Preferred TRV of 2 µg/g. Both samples come from soil between 0.7 and 2.5 mbgs in MW09 located in the west part of the Site. This suggests that the receptors of interest may experience adverse effects in one portion of the Site.

The numbers of measured concentrations that exceed the most appropriate TRVs for specific types of relevant receptors and the resulting EHQs include:

- Two results exceed the appropriate TRV for plants and soil invertebrates. The corresponding EHQs are in the range of 1.09 to 2.08.
- Remaining results were below the preferred TRV.

Overall, the ecological risks posed by HWE boron in soil are found to be acceptable at all locations except at MW09-04.

6.4.4 Risk Characterization for Chromium (hexavalent) in Soil

The concentrations of hexavalent chromium measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/g)	Basis and Source of TRV
	120	SRA microorganisms, based on HC50 (Verbruggen *et al.*, 2001)
	81	SSL, mammalian insectivore (U.S. EPA, 2005b)
	57	SSL, invertebrates (U.S. EPA, 2005b)
	26	SSL, avian insectivore (U.S. EPA, 2005b)
	10	Screening benchmark, microorganisms (Efroymson *et al.*, 1997b)
	8.5	5% microbial processes (Verbruggen, *et al.*, 2001)
Preferred TRV	**8**	Ecotox value (MOE, 1996, 1999)
BH-304-4 (2.13-2.90m)	<2	
BH-309-5 (2.90-3.66m)	<2	
BH-310-4 (2.13-2.90m)	<2	
	1.4	SQG_E for ecological health, commercial land use, based on soil contact (CCME, 1999)
	1	Screening benchmark, plants (Efroymson *et al.*, 1997a)
BH-306-4 (2.13-2.90m)	<1	
	0.4	Screening benchmark, earthworm (Efroymson *et al.*, 1997b)
12 samples	<0.4	

None of the soil results exceeded the Preferred TRV of 8 µg/g. Three results had elevated detection limits that exceeded the CCME SQG_E soil contact value. There is a possibility that these samples have concentrations of hexavalent chromium exceeding that benchmark; however, they were all collected at depth greater than 2 mbgs where plant roots and soil organisms are limited. The remaining samples had non-detectable results (<1 µg/g) and were below relevant benchmarks.

No EHQs exceed 1. This suggests that the receptors of interest are not at risk of adverse effects from exposure to hexavalent chromium throughout the Site.

6.4.5 Risk Characterization for Selenium in Soil

The concentrations of selenium measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/g)	Basis and Source of TRV
	100	Benchmark, microorganisms (Efroymson et *al.*, 1997b)
	26	Herbivorous mammal (MOE, 2009)
	10	Ecotox value (MOE, 1996c)
	10	Plant and soil invertebrates coarse grained soil (MOE, 2009)
	5.7	Omnivorous bird (MOE, 2009)
	5.5	Herbivorous bird (MOE, 2009)
	4.1	SSL, soil invertebrates (U.S. EPA, 2007c)
MW4 SS2 (0.61-1.22m)	3.1	
Preferred TRV	**2.9**	SQG_E based on soil contact (CCME, 2002)
MW09-04A5 (0.76-1.37m)	2.7	
BH09-03A4 (0-0.30m)	2.2	
BH-308-1 (0-0.61m)	1.6	
MW6 SS2 (0.61-1.22m)	1.5	
	1.2	SSL, avian insectivore (U.S. EPA, 2007c)
	1.0	Benchmark, plants (Efroymson et *al.*, 1997a)
BH-999 Field Dup of BH-308-1 (0-0.61m)	1.0	
17 samples	<0.8	

One sample exceeds the Preferred TRV of 2.9 µg/g. This suggests that plants, birds, and mammals may experience adverse effects in one small area at the Site.

The numbers of measured concentrations that exceed the TRVs for specific types of relevant receptors and the resulting EHQs include:

- One result exceeded the TRV based on soil contact. The corresponding EHQs is in the range of 1.1.
- Four results exceed the appropriate TRV for avian insectivores. The corresponding EHQs range from 1.25 to 1.8.

- No results exceed the appropriate TRV for microorganisms, herbivorous mammals, omnivorous birds or herbivorous birds.
- Although some of the measured concentrations exceed the Preferred TRV and the appropriate TRVs for specific types of receptors, the highest EHQ is only 1.8.

That few samples produce HQs higher than 1 and produce no HQs higher than 1.8 demonstrates that the receptors of interest should not experience adverse effects in most areas of the Site. Overall, the ecological risks posed by selenium in soil are found to be acceptable.

When compared to the PSS for human health (in Section 5.8), this Preferred TRV is more stringent. Given that only one sample (at 3.1 μg/g) marginally exceeds the Preferred TRV of 2.9 μg/g, there is no meaningful increase in risks to ecological receptors if the Preferred TRV is increased to 3.1 μg/g. That value is used later to set the ecological PSS.

6.4.6 Risk Characterization for Electrical Conductivity in Soil

The electrical conductivity (EC) measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (mS/cm)	Basis and Source of TRV
BH-307-6 (3.66-4.42m)	12	
BH-303-5 (2.90-3.66m)	11	
MW09-01B4 (2.59-3.20m)	9.05	
BH-997 Field Dup of BH-303-5 (2.90-3.66m)	8.4	
BH-302-7 (4.42-5.18m)	5.4	
BH09-03A4 (0-0.30m)	2.94	
MW09-02B4 (3.05-3.50m)	2.52	
MW09-04B5 (1.91-2.49m)	2.51	
MW09-04A5 (0.76-1.37m)	2.32	
MW6 SS2 (0.61-1.22m)	2.12	
BH-301-8 (5.18-5.94m)	1.8	
BH09-03B4 (2.74-3.35m)	1.71	
Preferred TRV	**1.4**	Ecotox value (MOE, 1996, 2009)
8 samples	<1.0	

Twelve (of 20 samples) exceed the Preferred TRV of 1.4 μg/g. This suggests that plants may experience adverse effects across much of the Site.

The numbers of measured concentrations that exceed the TRVs for specific types of relevant receptors and the resulting EHQs include:

- More than half the results exceed the TRV for plants. The corresponding EHQs are in the range of 1.1 to 9.
- There are no TRVs for other types of receptors of interest.

Overall, the ecological risks posed by EC in soil may be unacceptable for plants. This finding should be tempered knowing that much of the Site is paved with asphalt, it is an operating commercial facility, and few plants grow at the Site.

6.4.7 Risk Characterization for Sodium Adsorption Ratio in Soil

The measured soil adsorption ratio (SAR), and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (μg/g)	Basis and Source of TRV
BH-307-6 (3.66-4.42m)	150	
BH-303-5 (2.90-3.66m)	140	
Dup BH-303-5 (2.90-3.66m)	100	
MW09-01B4 (2.59-3.20m)	85.8	
BH-302-7 (4.42-5.18m)	77	
BH-301-8 (5.18-5.94m)	33	
MW09-04B5 (1.91-2.49m)	27.2	
BH57 SS4 (2.29-3.05m)	21.8	
MW09-02B4 (3.05-3.50m)	14.7	
BH09-03B4 (2.74-3.35m)	13	
Preferred TRV	**12**	Ecotox value (MOE, 1996, 2009)
MW09-04A5 (0.76-1.37m)	11.2	
BH57 SS3 (1.52-2.29m)	3.92	
BH09-03A4 (0-0.30m)	2.52	
MW6 SS7 (3.66-4.27m)	2.34	
6 samples	<2.0	

Ten (of 20) results exceed the Preferred TRV of 12 µg/g. There was only one benchmark for SAR and it is based on plant growth (more specifically the growth of various commercial crops). This suggests that plants would experience adverse effects across much of the Site.

The numbers of measured concentrations that exceed the TRVs for specific types of relevant receptors and the resulting EHQs include:

- One-half the results exceed the TRV for plants. The corresponding EHQs are in the range of 1.1 to 12.5.
- There are no TRVs for other types of receptors of interest.

Overall, the ecological risks posed by SAR in soil may be unacceptable for plants. This finding should be tempered knowing that much of the Site is paved with asphalt, it is an operating commercial facility, and few plants grow at the Site.

6.4.8 Risk Characterization for PHC Fraction 2 in Soil

The concentrations of PHC Fraction 2 measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/g)	Basis and Source of TRV
MW17 SS2 (0.61-1.22m)	7440	
BH-999 Field Dup of BH-308-1 (0-0.61m)	2700	
BH-308-1 (0-0.61m)	2600	
Preferred TRV	**260**	SQG_E based on soil contact (CCME, 2002) and MOE ecotox value
MW4 SS2 (0.61-1.22m)	60	
BH09-03A4 (0-0.30m)	53	
MW17 SS4 (1.83-2.44m)	50	
BH10 SS6 (3.05-3.66m)	30	
MW6 SS2 (0.61-1.22m)	20	
BH54 SS4 (2.29-3.05m)	20	
BH-309-5 (2.90-3.66m)	11	
BH-310-4 (2.13-2.90m)	11	
BH09-03B4 (2.74-3.35m)	<20	
11 samples	<10	

One result from MW17 and two from BH308 exceed the Preferred TRV of 260 µg/g. This suggests that plants and soil organisms may experience adverse effects in the west part of the Site where these samples were collected.

The numbers of measured concentrations that exceed the TRVs for specific types of relevant receptors and the resulting EHQs include:

- Three results exceed the TRV for plants and soil organisms. The corresponding EHQs are in the range of 10 to 28.6.
- There are no TRVs for other receptors of interest.

These comparisons indicate that risks to plants and soil organisms may be unacceptable at MW17 and BH 308. Although TRVs are not available for other receptors of interest, the relatively low concentrations measured elsewhere at the Site suggest that conditions are acceptable at all locations.

6.4.9 Risk Characterization for PHC Fraction 3 in Soil

The concentrations of PHC Fraction 3 measured in soil, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth m bgs)	Measured Concentration or TRV (µg/g)	Basis and Source of TRV
MW17 SS2 (0.61-1.22m)	4,250	
Preferred TRV	**1,700**	SQG_E based on soil contact (CCME, 2002) and MOE ecotox value
BH-308-1 (0-0.61m)	1,700	
BH-999 Field Dup of BH-308-1 (0-0.61m)	1,600	
MW17 SS4 (1.83-2.44m)	470	
BH09-03A4 (0-0.30m)	370	
BH09-03B4 (2.74-3.35m)	320	
MW4 SS2 (0.61-1.22m)	270	
BH10 SS6 (3.05-3.66m)	250	
MW6 SS2 (0.61-1.22m)	140	
BH54 SS4 (2.29-3.05m)	110	
13 samples	<50	

One result from MW17 exceeds the Preferred TRV of 1700 µg/g. This suggests that plants and soil invertebrates may experience adverse effects in one small area on the west side of the Site.

The numbers of measured concentrations that exceed the TRVs for specific types of relevant receptors and the resulting EHQs include:

- One result exceeds the TRV for plants and soil organisms. The corresponding EHQ is approximately 2.5.
- There are no TRVs for the other receptors of interest.

These comparisons indicate that risks to plants and soil organisms may be unacceptable at MW17. Although TRVs are not available for other receptors of interest, the relatively low concentrations measured elsewhere at the Site suggest that conditions are acceptable at all of those locations.

6.4.10 Risk Characterization for Sodium in Ground Water

The concentrations of sodium measured in ground water, and the TRVs described in Section 6.3 are summarized below:

Sample Location	Measured Concentration or TRV (µg/L)	Basis and Source of TRV
MW09-01	17,800,000	
MW09-04	8,240,000	
MW-302	3,400,000	
MW09-2i	1,100,000	
MW09-100 (MW09-2i Dup)	1,100,000	
MW302	1,040,000	
MW-308	650,000	
Preferred TRV	**490,000**	Benchmark, aquatic life (MOE, 2009)
MW-996 (MW-307 Field Dup)	440,000	
MW-307	420,000	
MW6	350,000	
MW-309	280,000	
MW308	234,000	
4 samples	<70,000	

Seven (of 19) samples exceed the Preferred TRV. The samples were collected from five locations across the Site. This suggests that aquatic receptors (in Oshawa Harbour) may experience adverse effects if ground water from the Site is not diluted substantially upon its entry into the harbour. As explained in Section 6.3.9, the Preferred TRV also is intended to be protective of the terrestrial receptors of interest at the Site. Since the majority of the Site is paved, soil micro-organisms and soil invertebrates also might be at risk, while mammals and birds would have very limited to no exposure to ground water.

The numbers of measured concentrations that exceed the most stringent TRVs for specific types of relevant receptors and the resulting EHQs include:

- Seven results exceed the TRV, which as explained in Section 6.3.9 should be protective of all the receptors of interest. The corresponding EHQs range from 1.3 to 36.3.

Overall, it appears that ecological risks posed by sodium in ground water are higher than acceptable at: MW09-01, MW09-02, MW09-04, MW302, and MW308. These locations are scattered across much of the Site.

6.4.11 Risk Characterization for Chlorides in Ground Water

The concentrations of chloride measured in ground water, and the TRVs described in Section 6.5 are summarized below:

Sample Location	Measured Concentration or TRV (µg/L)	Basis and Source of TRV
MW09-01	33,300,000	
MW09-04	6,740,000	
	2,300,000	Benchmark, aquatic receptors (MOE, 2009)
MW302	1,860,000	
MW09-2i	1,650,000	
MW09-100 (MW09-02i Dup)	1,600,000	
Preferred TRV	**700,000**	Derived in Section 6.3.10
MW6	455,000	
MW308	254,000	
MW09-2ii	66,200	
MW310	20,300	

Five (of nine) samples exceed the Preferred TRV. The samples were collected from four locations across the Site. This suggests that aquatic receptors (in Oshawa Harbour) may experience adverse effects if ground water from the Site is not diluted substantially upon its entry into the harbour. As explained in Section 6.3.10, the Preferred TRV also is intended to be protective of the terrestrial receptors of interest at the Site. Since the majority of the Site is paved, soil micro-organisms and soil invertebrates also might be at risk, while mammals and birds would have very limited to no exposure to ground water.

The numbers of measured concentrations that exceed the most stringent TRVs for specific types of relevant receptors and the resulting EHQs include:

- Five results exceed the TRV, which as explained in Section 6.3.10 should be protective of all the receptors of interest. The corresponding EHQs range from 1.3 to 47.

Overall, it appears that ecological risks posed by chlorides in ground water are higher than acceptable at: MW09-01, MW09-02, MW09-04, and MW302. These locations are scattered across much of the Site.

6.4.12 Risk Characterization for PHC Fraction 2 in Ground Water

The concentrations of PHC Fraction 2 measured in ground water, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/L)	Basis and Source of TRV
MW-308	2,600	
MW-310	1,300	
Preferred TRV	**970**	Benchmark, aquatic receptors (MOE, 2009)
MW310	430	
MW309	330	
MW305	290	
12 samples	<100	

Two (of 17) samples exceed the Preferred TRV. The samples were collected from two locations at the north end of the Site. This suggests that aquatic receptors (in Oshawa Harbour) may experience adverse effects if ground water from that portion of the Site is not diluted before entering the harbour. There are no TRVs for the terrestrial receptors of interest at the Site. Since the majority of the Site is paved, soil micro-organisms and soil invertebrates also might be at risk, while mammals and birds would have very limited to no exposure to ground water.

The numbers of measured concentrations that exceed the most stringent TRVs for specific types of relevant receptors and the resulting EHQs include:

- Two results exceed the TRV protective of aquatic receptors. The corresponding EHQs range from 1.3 to 2.7.

That only two samples exceed the Preferred TRV and produce HQs no higher than 2.7 demonstrates that the receptors of interest should not experience adverse effects in most areas of the Site. Overall, the ecological risks posed by PHC Fraction 2 in ground water are found to be acceptable.

6.4.13 Risk Characterization for PHC Fraction 3 in Ground Water

The concentrations of PHC Fraction 3 measured in ground water, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/L)	Basis and Source of TRV
MW-310	1,200	
MW-308	1,100	
MW310	500	
MW-302	170	
MW-307	130	
MW-996 (MW-307 Field Dup)	130	
11 samples	<100	

Although there is insufficient information upon which to select a Preferred TRV, the maximum measured concentration (1,200 µg/L) is only slightly higher than the Ontario background concentration of 500 µg/L and only slightly higher than the current MOE standard for potable ground water of 1,000 µg/L for PHC Fraction 3 + Fraction 4. On that basis, the ecological risks posed by PHC Fraction 3 in ground water are found to be acceptable.

6.4.14 Risk Characterization for PHC Fraction 4 in Ground Water

The concentrations of PHC Fraction 4 measured in ground water, and the TRVs described in Section 6.3 are summarized below:

Sample Location (depth mbgs)	Measured Concentration or TRV (µg/L)	Basis and Source of TRV
MW-310	620	
MW-302	320	
13 samples	<100	

Although there is insufficient information upon which to select a Preferred TRV, the maximum measured concentration (620 µg/L) is only slightly higher than the Ontario background concentration of 500 µg/L and less than the current MOE standard for potable ground water of 1,000 µg/L for PHC Fraction 3 + Fraction 4. On that basis, the ecological risks posed by PHC Fraction 4 in ground water are found to be acceptable.

6.4.15 Interpretation of Off-Site Ecological Risks

The Site is relatively small and surrounded by a fence. Nevertheless, small mammals and birds would be able to access the Site and could be exposed to the COPCs found in soil. A further barrier to exposure is the fact that much of the surface is paved, preventing direct access to any impacted soil below the asphalt. The largest component of exposure to off-Site receptors would be from ingesting plants and invertebrates that have originated from the Site. Due to its size, the Site would likely make up only part of an off-Site receptor's foraging range, further reducing exposure.

Impacted soils are relatively well contained under the pavement and/or contained behind the break walls of the wharf. Relatively mobile COPCs such as sodium and chloride in ground water, are not elevated in concentrations of surface water collected from the harbor. Therefore, conditions on the Site are not migrating in sufficient amounts to modify water quality in the harbor.

Overall, the potential for off-Site ecological receptors to receive doses of COPCs high enough to cause adverse effects is minimal, and those exposures do not need to be quantified or assessed further.

6.4.16 Uncertainty in the Risk Characterization

In this ecological risk characterization, measured concentrations are compared to various types of ecological TRVs. The resulting EHQs assume that the TRVs are appropriate for the types of ecological receptors that live or visit the Site. Many of the TRVs designated as screening levels or screening values reflect reviews of the available literature, and therefore likely include receptors similar to those that would spend time at the Site; however, many ecological toxicity studies will expose organisms to metals in chemical forms that are known or thought to be relatively bioavailable and those may not be the chemical forms actually present in the natural environment. This tends to overstate risks. Such studies also cannot compensate for the adaptations that species and ecological communities will make over time in response to conditions including soil chemistry.

That the published studies tend to overstate ecological risks is evident in that some of the TRVs (particularly the relatively recent SSLs recommended by the U.S. EPA) are similar to or even less than background concentrations in soil in Ontario, and ecotoxicity values set by the MOE and CCME.

The overall uncertainty in the risk characterization is low when there are adequate numbers of measured samples and TRVs for most or all of the ecological receptors of interest. That is the case for arsenic and hexavalent chromium in soil, as well as sodium and chlorides in ground water.

The overall uncertainty in the risk characterization is medium where either there are few samples or the TRVs are missing for most of the receptors of interest. This is the case for boron, EC, SAR, PHC Fraction 2, and PHC Fraction 3 in soil as well as for PHC Fraction 3 in ground water. In each case, there are TRVs for less than half the receptors of interest.

The overall uncertainty in the risk characterization is high where either there are too few samples or TRVs are missing. This is the case for PHC Fraction 3 and PHC Fraction 4 in ground water.

6.5 UNCERTAINTY IN THE SLERA

One source of uncertainty in the exposure assessment revolves upon how well the measured concentrations of COPCs represent the conditions that ecological receptors encounter. Numerous samples have been analyzed and this aspect of the exposure assessment is assigned a low level of uncertainty.

As noted in Section 6.3.12, the amount of published information is sufficient to assign a low level of uncertainty in the hazard assessments of the COPCs in soil. Electrical conductivity and SAR in soil are two exceptions where TRVs are limited to plants and soil invertebrates. For both parameters the MOE is the only source of benchmark values and these Preferred TRVs are assigned a medium level of uncertainty.

TRVs are limited for the COPCs in ground water. A medium level of uncertainly is assigned to the Preferred TRVs for sodium, chlorides, and PHC F2. There is inadequate information to identify Preferred TRVs for PHC F3 and PHC F4 were not available.

More than 350 EHQs are calculated in Section 6.4. Of those, 59 (about 17%) exceed 1. Of those, eight (about 2%) exceed 10. None exceed 100. The eight EHQs greater than 10 are due to the highest concentrations of PHC Fraction 2 in soil, SAR in soil, sodium in ground water, and chlorides in ground water. Overall, a low level of uncertainty is assigned to the SLERA. The interpretation of the information demonstrates that ecological risks are generally acceptable except at locations with the highest concentrations of PHC Fraction 2 in soil, the highest SRA concentrations in soil, and the highest concentrations of sodium and chloride in ground water.

6.6 SUMMARY FOR THE SLERA

Ecological risks have been estimated for five broad categories of receptors: plants, soil microorganisms, soil invertebrates, birds, and mammals. In addition, aquatic receptors have been considered in the assessment of ground water quality. The COPCs in soil are arsenic, HWE boron, hexavalent chromium, selenium, EC, SAR, PHC Fraction 2, and PHC Fraction 3. The COPCs in ground water are sodium, chlorides, PHC Fraction 2, PHC Fraction 3, and PHC Fraction 4.

Risks are estimated to be higher than acceptable for the following combinations of locations and COPCs:

- BH301 – EC and SAR in soil (relatively deep)
- BH302 – EC and SAR in soil (relatively deep) and sodium and chloride in ground water
- BH303 – EC and SAR in soil
- BH307 – EC and SAR in soil
- BH308 – arsenic, PHC Fraction 2 in soil and ground water, sodium in ground water
- BH310 – PHC Fraction 2 in ground water
- BH09-03 – arsenic, EC, and SAR in soil
- BH57 – SAR in soil
- MW09-01 – EC and SAR in soil, sodium and chlorides in ground water

- MW09-02 – EC and SAR in soil, sodium and chlorides in ground water
- MW09-04 – arsenic, HWE boron, EC, and SAR in soil and sodium and chlorides in ground water
- MW6 – EC in soil
- MW17 – PHC Fraction 2 and PHC Fraction 3 in soil

EC and SAR in soil, and sodium and chlorides in ground water are all associated with the use and former storage of road salt. These four COPCs account for approximately three-quarters of instances were ecological risks are estimated to be higher than acceptable.

Tables 6.2 and 6.3 summarize the proposed specific standards (PSS) based on protection of ecological health.

Table 6.2 Proposed Standards in Soil Based on Protection of Ecological Health

COPC in Soil	PSS (µg/g)	Basis for PSS	Number of Samples that exceed PSS
Arsenic	18	SSL for plants (U.S. EPA, 2005a)	3 samples
Boron (hot water soluble)	2	Plant and soil organisms at sites with coarse grained soil (MOE, 2009)	2 samples
Chromium (hexavalent)	8	Plants and soil organisms for sites with coarse grained soil(MOE, 1996, 1999)	0 samples
Selenium	3.1	SQG_E based on soil contact (CCME, 2002) + 10% as described in Section 6.4.5	0 samples
EC	1.4	Plants and soil organisms for industrial/commercial sites (MOE, 1996, 1999)	12 samples
SAR	12	Plants and soil organisms for industrial/commercial sites (MOE, 1996, 1999)	9 samples
PHC Fraction 2	260	SQG_E based on soil contact (CCME, 2002) and MOE ecotox value	3 samples
PHC Fraction 3	1,700	SQG_E based on soil contact (CCME, 2002) and MOE ecotox value	1 sample

Table 6.3 Proposed Standards in Ground Water Based on Protection of Ecological Health

COPC in Ground Water	PSS (µg/L)	Basis for PSS	Number of Samples that exceed PSS
Sodium	490,000	Benchmark, aquatic life (MOE, 2009)	7 samples
Chlorides	700,000	Derived in Section 6.3.10 to take into account all receptors of interest at the Site	6 samples
PHC F2	970	Benchmark, aquatic receptors (MOE, 2009)	2 samples
PHC F3	1,200*	No ecological basis for setting a Preferred TRV	0 samples
PHC F4	620*	No ecological basis for setting a Preferred TRV	0 samples

Notes:

* Where there is inadequate information for identifying a Preferred TRV, the PSS is set equal to the maximum measured concentration after considering other factors such as Ontario background concentrations and regulatory values for the COPC in potable ground water.

7.0 SSRA AND SLERA CONCLUSIONS/RECOMMENDATIONS

7.1 RECOMMENDED STANDARDS

Tables 7.1 and 7.2 provide a summary of the proposed human health standards (from Section 5.6), the proposed ecological standards (from Section 6.6), and the final standards recommended in this SSRA for soil and ground water, respectively. If the more stringent of the two proposed standards for a COPC is substantially higher than measured concentrations on the Site, then the final standard is set equal to the maximum measured concentration of the COPC.

For arsenic in soil, the final standard is 18 μg/g. It is equal to the ecological health PSS. Although the human health PSS is lower (at 6.3 μg/g), that value is less than the Ontario background and therefore frequently exceeded at locations remote from contaminating activities. It is not practical to set a final PSS below a background concentration. The CCME SQG is slightly lower at 17 μg/g, but was set in 1997 and several recently set ecological benchmarks are higher.

For boron (hot water extractable) in soil, the final standard is 2 μg/g. It is equal to the ecological PSS. This parameter is not relevant in the context of human health.

For chromium (hexavalent) in soil, the final standard is 2 μg/g. Hexavalent chromium was not detected in samples from the Site. The "highest" reported value was <2 μg/g. That concentration is less than the most stringent human health component value (therefore hexavalent chromium is not a COPC for human heath), and less than the ecological PSS.

For selenium in soil, the final standard is 3.1 μg/g. It is equal to the ecological PSS, and less than the most stringent human health component value (therefore selenium is not a COPC for human heath).

For electrical conductivity in soil, the final standard is 1.4 mS/cm. It is equal to the ecological PSS. This parameter is not relevant in the context of human health.

For sodium absorption ratio in soil, the final standard is 12 μg/g. It is equal to the ecological PSS. This parameter is not relevant in the context of human health.

For benzene in soil, the final standard is 0.33 μg/g. It is equal to the human health PSS, and less than the most stringent ecological component value (therefore benzene is not a COPC for ecological heath).

For toluene in soil, the final standard is 4.1 μg/g. In Chapter 3, it was determined that toluene did not warrant further assessment from the perspectives of human health and the environment. It is appropriate to set the final PSS equal to the maximum concentration that has been measured on the Site.

For ethylbenzene in soil, the final standard is 2.1 μg/g. In Chapter 3, it was determined that ethylbenzene did not warrant further assessment from the perspectives of human health and the environment. It is appropriate to set the final PSS equal to the maximum concentration that has been measured on the Site.

For xylenes in soil, the final standard is 13 μg/g. In Chapter 3, it was determined that xylenes did not warrant further assessment from the perspectives of human health and the environment. It is appropriate to set the final PSS equal to the maximum concentration that has been measured on the Site.

For PHC Fraction 2 in soil, the final standard is 260 μg/g. It is equal to the ecological PSS, and less than the human health PSS (4,941 μg/g). Although it reflects information for only a few of the ecological receptors of interest, the final PSS should not be detrimental to the broader ecological community at the Site.

For PHC Fraction 3 in soil, the final standard is 1,700 μg/g. It is equal to the ecological PSS, and less than the human health PSS (10,308 μg/g). Although it reflects information for only a few of the ecological receptors of interest, the final PSS should not be detrimental to the broader ecological community at the Site.

For acenaphthylene in soil, the final standard is 0.16 μg/g. In Chapter 3, it was determined that acenaphthylene did not warrant further assessment from the perspectives of human health and the environment. It is appropriate to set the final PSS equal to the maximum concentration that has been measured on the Site.

For anthracene in soil, the final standard is 1 μg/g. In Chapter 3, it was determined that anthracene did not warrant further assessment from the perspectives of human health and the environment. It is appropriate to set the final PSS equal to the maximum concentration that has been measured on the Site.

For sodium in ground water, the final standard is 490,000 μg/L. It is equal to the ecological PSS, and less than the most stringent human health component value (therefore sodium is not a COPC for human heath).

For chlorides in ground water, the final standard is 700,000 μg/L. It is equal to the ecological PSS, and less than the most stringent human health component value (therefore chlorides is not a COPC for human heath).

For PHC Fraction 2 in ground water, the final standard is 970 μg/L. It is equal to the ecological PSS, and less than the human health PSS (1,037 μg/L). Although it reflects information for only a few of the ecological receptors of interest, the final PSS should not be detrimental to the broader ecological community at the Site.

For PHC Fraction 3 in ground water, the final standard is 484 μg/L. It is equal to the human health PSS, and less than the ecological PSS (1,200 μg/g). Although there is very little information for the ecological receptors of interest, the final PSS should not be detrimental to the broader ecological community at the Site.

For PHC Fraction 4 in ground water, the final standard is 620 μg/L. It is equal to the ecological PSS, which in turn, was set equal to the maximum measured concentration due to the lack of information for the ecological receptors of interest. The final PSS is less than the most stringent human health component value (therefore PHC Fraction 4 is not a COPC for human heath). Despite the lack of information for the ecological receptors of interest, the final PSS should not be detrimental to the broader ecological community at the Site.

For indeno(1,2,3-cd)pyrene in ground water, the final standard is 0.27 μg/L. In Chapter 3, it was determined that indeno(1,2,3-cd)pyrene did not warrant further assessment from the perspectives of human health and the environment. It is appropriate to set the final PSS equal to the maximum concentration that has been measured on the Site.

Locations where risks are estimated to be greater than acceptable are shown in Figure 7.1 for soil, and 7.2 for ground water. Risk management measures are required at locations where concentrations in soil and ground water exceed acceptable risk levels.

Table 7.1 Summary of Proposed Standards for Soil

COC	Proposed Human Health Standard	Proposed Ecological Standard	Maximum Measured Concentration	Final Site Standard
Arsenic	6.3*	18	110	18
Boron (Hot Water Extractable)	Not Relevant	2	4.17	2
Chromium (hexavalent)	Not a COPC	8	<2	2
Selenium	Not a COPC	3.1	3.1	3.1
Electrical Conductivity	Not Relevant	1.4	12.0	1.4
Sodium Adsorption Ratio	Not Relevant	12	150	12
Benzene	0.33	Not a COPC	1.5	0.33
Toluene	Not Needed	Not Needed	4.1	4.1
Ethylbenzene	Not Needed	Not Needed	2.1	2.1
Xylenes	Not Needed	Not Needed	13	13
PHC Fraction 2	4,941	260	7,440	260
PHC Fraction 3	10,308	1,700	4,250	1,700
Acenaphthylene	Not Needed	Not Needed	0.16	0.16
Anthracene	Not Needed	Not Needed	1	1

Notes:

- All values are shown in µg/g except electrical conductivity which is in mS/cm.
- The * indicates that the human health PSS for arsenic is less than Ontario background.
- "Not Relevant"- Parameters such as HWE boron, electrical conductivity, and sodium adsorption ratio apply to ecological receptors (specifically plants) only.
- "Not Needed" – Section 3.4 provides the basis for these decisions.

Table 7.2 Summary of Proposed Standards for Ground Water

COC	Proposed Human Health Standard	Proposed Ecological Standard	Maximum Measured Concentration	Final Site Standard
Sodium	Not a COPC	490,000	17,800,000	490,000
Chlorides	Not a COPC	700,000	33,300,000	700,000
PHC F2	1,037	970	2,600	970
PHC F3	484	1,200	1,200	484
PHC F4	Not a COPC	620	620	620
Indeno(123-cd)pyrene	Not Needed	Not Needed	<0.27	0.27

Notes:

- All values are shown in μg/L.
- As noted in Table 6.3, where there is inadequate information for identifying a Preferred TRV, the PSS is set equal to the maximum measured concentration after considering other factors such as Ontario background concentrations and regulatory values for the COPC in potable ground water. This is the case of the ecological PSS for PHC Fraction 3 and PHC Fraction 4.
- "Not Needed" – Section 3.4 provides the basis for these decisions.

8.0 STATEMENT OF LIMITING CONDITIONS

This SSRA and SLERA was prepared to meet the intent of the document entitled *Procedures for the Use of Risk Assessment under Part XV.1 of the Environmental Protection Act* published by the Ontario Ministry of the Environment in 2005, documents from Health Canada on conducting human health risk assessments (2004a), and the CCME document entitled *A Framework for Ecological Risk Assessment* (1996).

The findings presented in this report are based on conditions observed by others at the specified dates and locations, and on the analysis of samples for the specified parameters. Unless otherwise stated, the findings cannot be extended to previous or future Site conditions, portions of the Site that were not investigated directly, or types of analysis not performed. The conclusions presented herein are based on information obtained up to and including the submission date of this document. Any Site operations or land uses that may have changed since this submission may render the conclusions invalid.

WESA makes no warranty as to the accuracy or completeness of the information provided by others, or of conclusions and recommendations predicated on the accuracy of that information.

Nothing in this report is intended to constitute or provide a legal opinion. WESA makes no representation as to compliance with environmental laws, rules, regulations or policies established by regulatory agencies.

This report has been prepared for GENIVAR Consultants LP and Public Works and Government Services Canada and Transportation Canada. Any use a third party makes of this report, any reliance on the report, or decisions based upon the report, are the responsibility of those third parties unless authorized by WESA in writing. WESA accepts no responsibility for damages suffered by any unauthorized third party as a result of decisions made or actions taken based upon this report.

This report has been written by Paul Bandler, Brett Ibbotson and Simone Smith of WESA.

Sincerely yours,

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FIGURES

Legend

Site Locations

N

0 400 800

(meters)

PROJECT NUMBER: WB8604	DRAWN BY: KC	DESIGNED BY: CMR
DATE: 17 JUNE 2010	CHECKED BY: KSS	
SCALE: As Shown	CAD FILE NO.: B8604-FIG1.1	

FIGURE: 1.1

Oshawa Harbour Lands, West Wharf

Site Location Map

WESA
A Better Environment For Business

Legend

Approximate Property Boundary

N

0 50 100

(meters)

PROJECT NUMBER: WB8604	DRAWN BY: KC	DESIGNED BY: CMR
DATE: May 17, 2010	CHECKED BY: KSS	
SCALE: As Shown	CAD FILE NO.: B8604-FIG1.2-WW	

FIGURE: 1.2

Oshawa Harbour Lands
West Wharf

Site Plan

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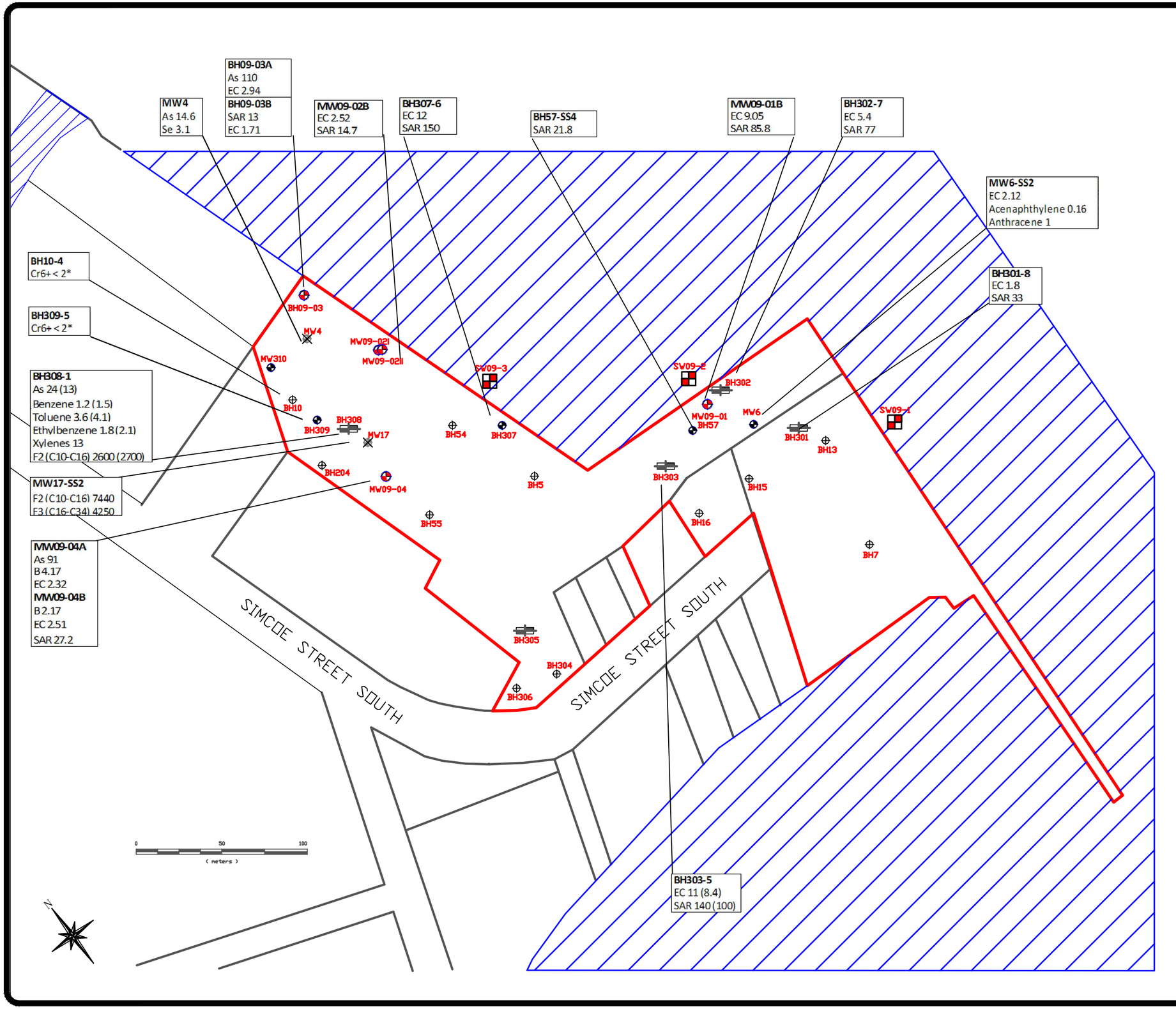


Legend

- Genivar Samples
- DCS Samples
- No longer on-site / accessible
- AQT Samples
- Approximate Property Boundary
- MW01 Pb 1600 — Sample Location and Parameter concentration in excess of guideline
  Values in brackets ( ) are duplicate samples
- * Elevated detection limits

Parameter	CCME (Industrial/Commercial)
Arsenic (As)	12
Boron (B)	2**
Chromium (hexavalent Cr6+)	1.4
Selenium (Se)	2.9**
Electrical Conductivity (EC) (2:1)	1.4**
Sodium Adsorption (SAR) (2:1)	12**
Benzene	0.030
Toluene	0.37
Ethylbenzene	0.082
Xylenes (Total)	11
F2 (C10-C16)	260
F3 (C16-C34)	1700
Acenaphthylene	0.15**
Anthracene	0.67**

All values are in ug/g
** Signifies MOE SCS

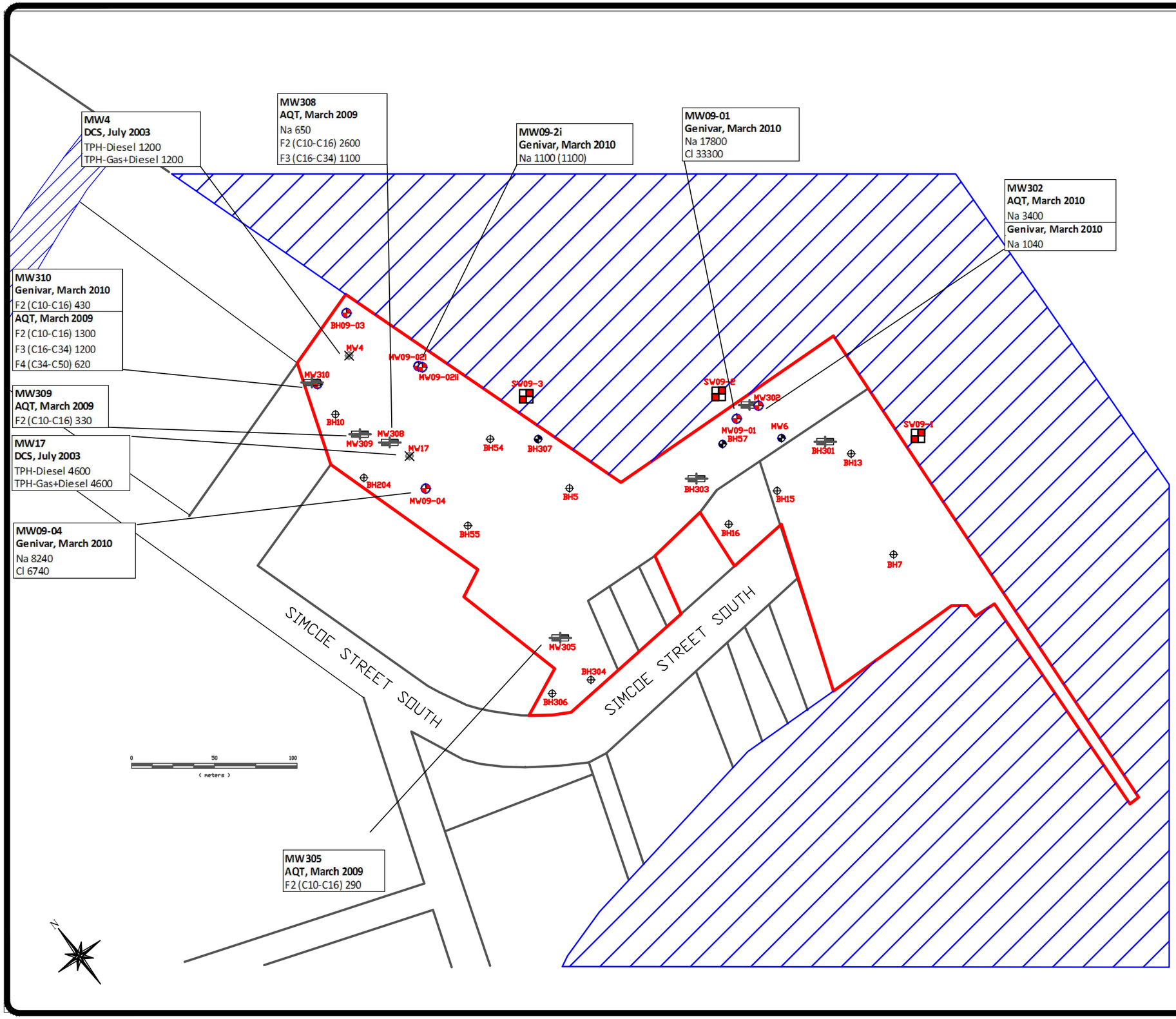
PROJECT NUMBER: WB8604	DRAWN BY: KC	DESIGNED BY: CMR
DATE: May 17, 2010	CHECKED BY: KSS	
SCALE: As Shown	CAD FILE NO.:	

FIGURE: 3.1

Oshawa Harbour Lands
Southern Part of West Wharf

Soil samples that exceed guidelines

WESA
A Better Environment For Business



Legend

- Genivar Samples
- DCS Samples
- No longer on-site / accessible
- AQT Samples
- Approximate Property Boundary
- MW01 Pb 1600 — Sample Location and Parameter concentration in excess of guideline

Values in brackets ( ) are duplicate samples

Parameter	MOE Table 3 SCS (2009)
Sodium (Na)	490 mg/L
Chloride (Cl)	≤2700+mg/L
F2 (C10-C16)	150 ug/L
F3 (C16-C34)	500 ug/L
F4 (C34-C50)	500 ug/L

Units in figure are those in the legend for each respective parameter

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FIGURE: 3.2

Oshawa Harbour Lands Southern Part of West Wharf

Ground water samples that exceed guidelines

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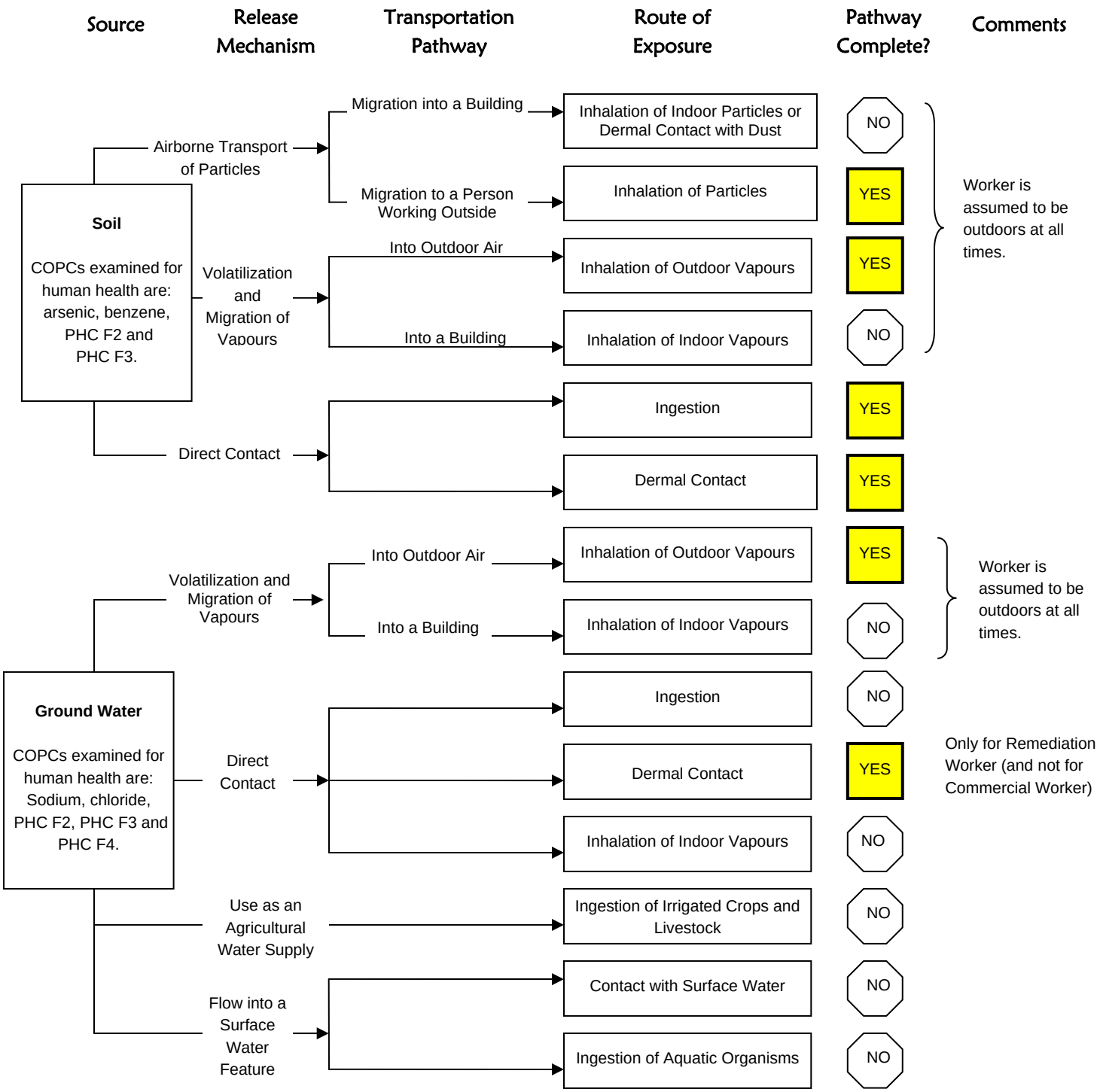


Figure 5.1 Human Health Conceptual Site Model for the Oshawa Harbour Lands West Wharf (Remediation Worker and Commercial Worker)

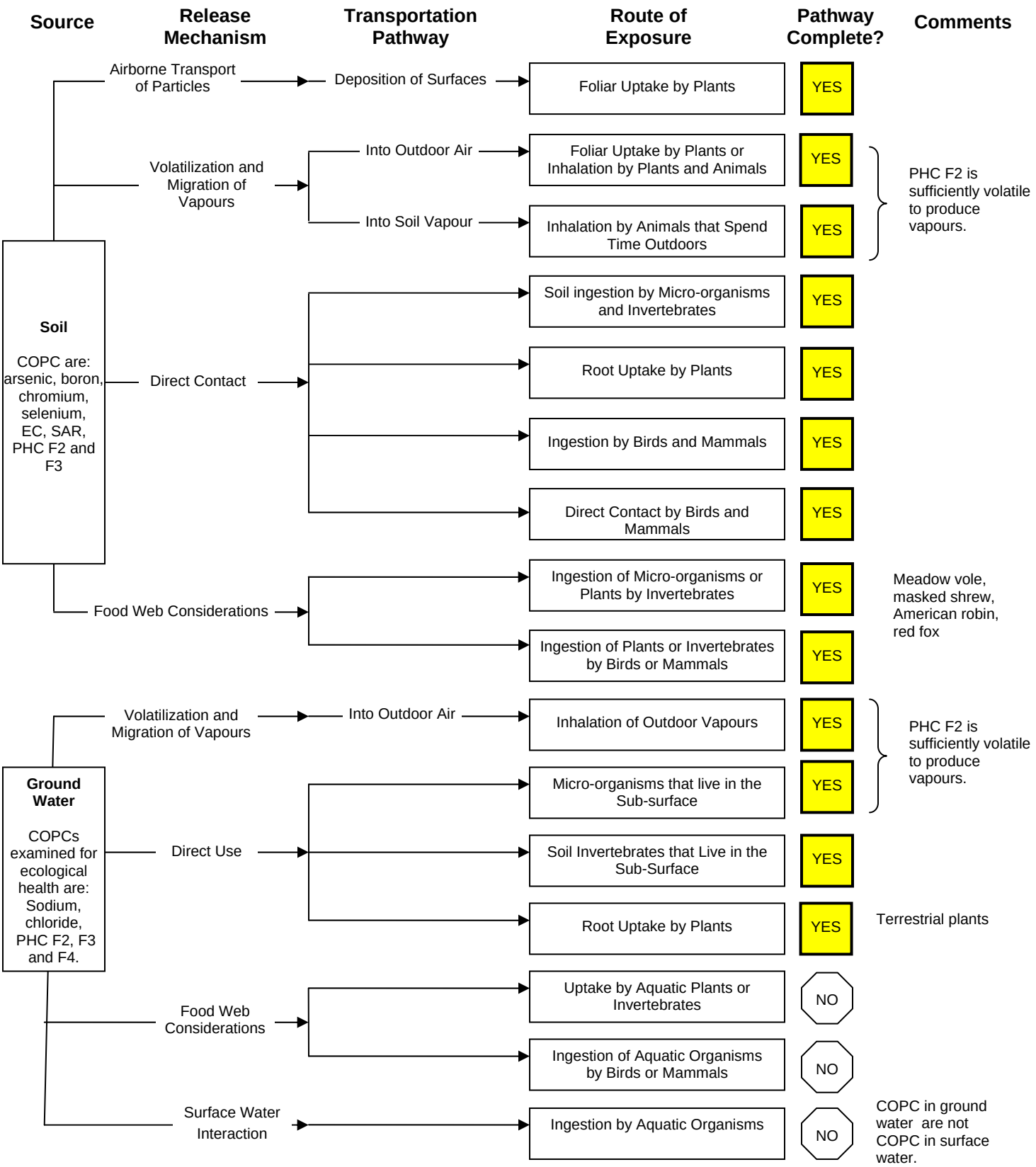
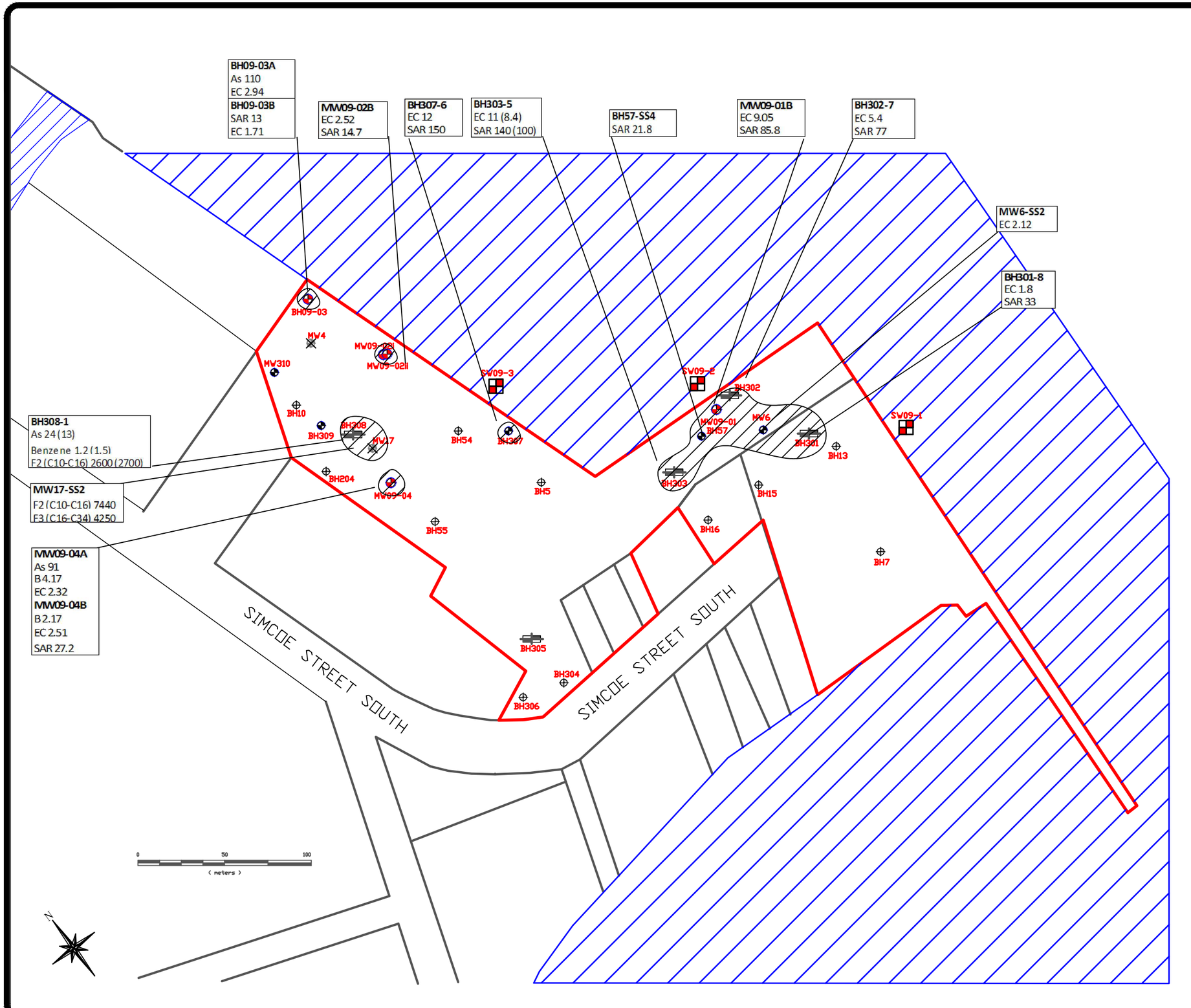


Figure 6.1 Ecological Conceptual Site Model for the Oshawa Harbour Lands West Wharf



Legend

- Genivar Samples
- DCS Samples
- No longer on-site / accessible
- AQT Samples
- Approximate Property Boundary
- MW01 Pb 1600 — Sample Location and Parameter concentration in excess of guideline
  Values in brackets ( ) are duplicate samples
- Elevated detection limits
- Locations where estimated risks are greater than acceptable and risk management measures are required

Parameter	CCME (Industrial/Commercial)	Final Site Standard
Arsenic (As)	12	18
Boron (B)	2**	2
Chromium (hexavalent Cr6+)	1.4	2
Selenium (Se)	2.9**	3.1
Electrical Conductivity (EC) (2:1)	1.4**	1.4
Sodium Adsorption (SAR) (2:1)	12**	12
Benzene	0.030	0.33
Toluene	0.37	4.1
Ethylbenzene	0.082	2.1
Xylenes (Total)	11	13
F2 (C10-C16)	260	260
F3 (C16-C34)	1700	1700
Acenaphthylene	0.15**	0.16
Anthracene	0.67**	1

All values are in ug/g
** Signifies MOE SCS

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FIGURE: 7.1

Oshawa Harbour Lands
Southern Part of West Wharf

Locations in Soil Where Risk Management Measures are Required

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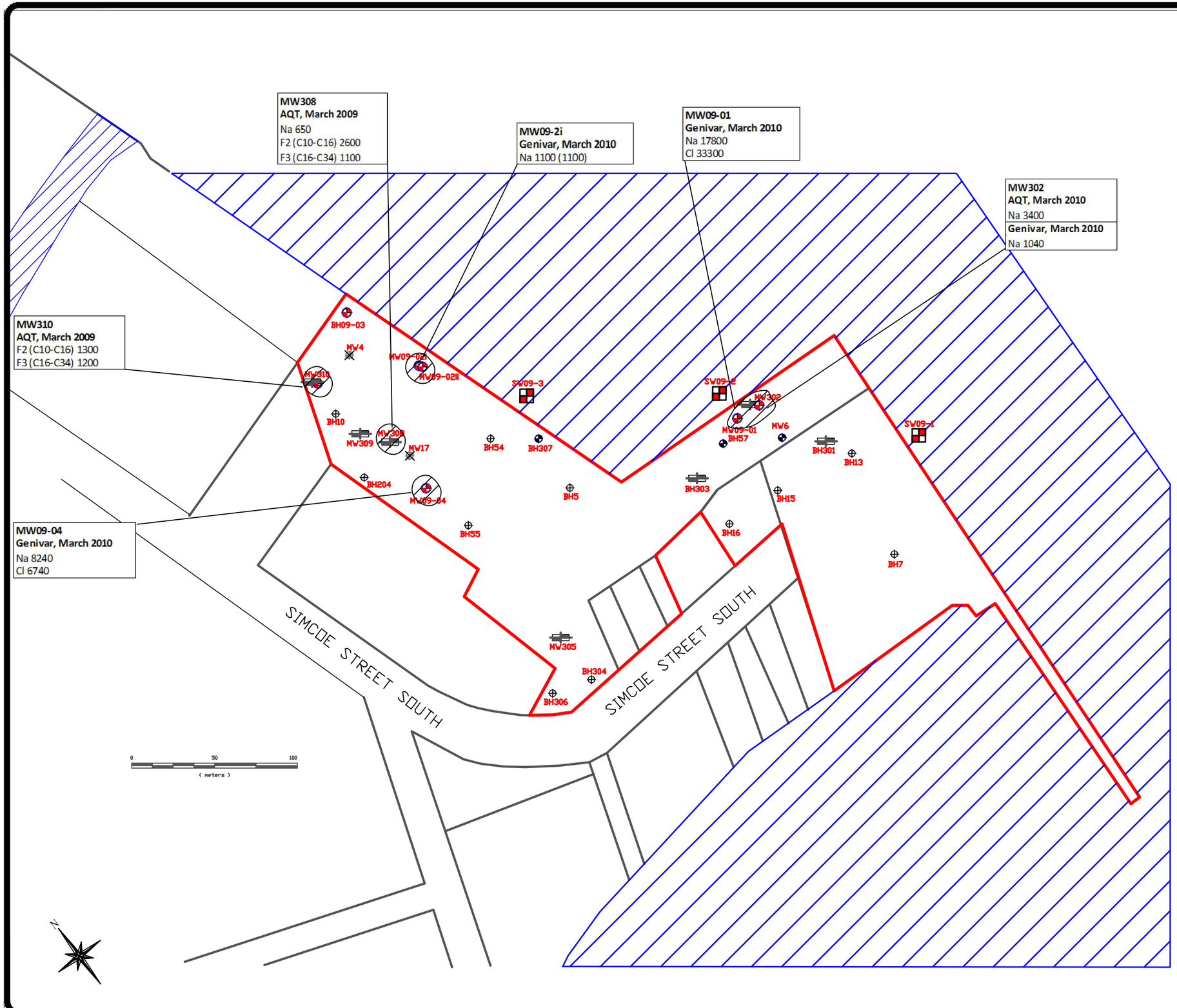

Legend

- Genivar Samples
- DCS Samples
- No longer on-site / accessible
- AQT Samples
- Approximate Property Boundary
- MW01 Pb 1600 — Sample Location and Parameter concentration in excess of guideline
  Values in brackets ( ) are duplicate samples
- Locations where estimated risks are greater than acceptable and risk management measures are required

Parameter	MOE Table 3 SCS (2009)	Final Site Standard
Sodium (Na)	490 mg/L	490 mg/L
Chloride (Cl)	≤2700+ mg/L	700 mg/L
F2 (C10-C16)	150 ug/L	970 ug/L
F3 (C16-C34)	500 ug/L	484 ug/L
F4 (C34-C50)	500 ug/L	620 ug/L

Units in figure are those in the legend for each respective parameter

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FIGURE: 7.2

Oshawa Harbour Lands Southern Part of West Wharf

Locations in Ground Water Where Risk Management Measures are Required

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APPENDIX A SUMMARY OF DATA

Table A1
Oshawa West Wharf Soil Chemistry
West Wharf

Parameters	CCME, 1999 revised 2008	O. Reg. 153 Table 3 Commercial/ Industrial/ Community	Total	Min	Max	Exceeds CCME comm	Exceeds O.Reg. Table 3	Units	RDL	GENIVAR MW09-01A[4]	GENIVAR MW09-01B[4]	GENIVAR MW09-01 SS3	GENIVAR MW09-02A[4]	GENIVAR BHX1 (MW09-02A Dup)[4]	GENIVAR MW09-02B[4]	GENIVAR BH09-03A[4]	GENIVAR BH09-03B[4]	GENIVAR MW09-03 SS2	GENIVAR MW09-04A[5]	GENIVAR MW09-04B[5]	DCS MW4 SS2	DCS MW6 SS2	DCS MW6 SS7	DCS MW17 SS2	DCS MW17 SS4	DCS BH5 SS2
Depth										0.08-0.61m	2.59-3.20m	1.52-2.13m	0.30-1.37m	0.30-1.37m	3.05-3.50m	0-0.30m	2.74-3.35m	0.76-1.37m	0.76-1.37m	1.91-2.49m	0.61-1.22m	0.61-1.22m	3.66-4.27m	0.61-1.22m	1.83-2.44m	0.61-1.22m
Date Sampled										4-Mar-10	4-Mar-10	4-Mar-10	4-Mar-10	4-Mar-10	4-Mar-10	5-Mar-10	5-Mar-10	5-Mar-10	4-Mar-10	4-Mar-10	23-Apr-03	23-Apr-03	23-Apr-03	23-Apr-03	23-Apr-03	23-Apr-03
Metals								ug/g		MW09-01A 0.08-0.61m	MW09-01B 2.59-3.20m	SS3 1.52-2.13m	MW09-02A 0.30-1.37m	MW09-02A 0.30-1.37m	MW09-02B 3.05-3.50m	BH09-03A 0-0.30m	BH09-03B 2.74-3.35m	SS2 0.76-1.37m	MW09-04A 0.76-1.37m	MW09-04B 1.91-2.49m	SS2 0.61-1.22m	SS2 0.61-1.22m	SS7 3.66-4.27m	SS2 0.61-1.22m		SS2 0.61-1.22m
Antimony	40		21	0.20	1.50	0		ug/g	0.8	<0.8	<0.8		<0.8	<0.8	<0.8	<0.8	<0.8		1.5	<0.8	<1.6	<1.6				<1.6
Arsenic	12		21	1.70	110.00	5		ug/g	1	3	4		3	3	3	*110*	3		*91*	8	14.6	5.2				2.1
Barium	2000		21	16.00	202.00	0	0	ug/g	2	36	108		64	67	83	79	81		202	40	37.4	27.2				63.2
Beryllium	NV	8	21	0.30	2.80		0	ug/g	0.5	<0.5	0.6		<0.5	<0.5	<0.5	0.9	<0.5		*2.8*	<0.5	<0.9	0.9				<0.9
Boron	NV	120	9	6.00	22.00		0	ug/g	5	6	8		8	8	7	22	9		16	8						
Boron (Hot Water Extractable)	NV	2	9	0.19	4.17		2	ug/g	0.10	0.19	0.43		1.46	1.55	0.5	1.57	1.5		4.17	2.17						
Cadmium	22		21	0.10	0.70	0	0	ug/g	0.5	<0.5	<0.5		<0.5	<0.5	<0.5	<0.5	<0.5		<0.5	<0.5	0.7	<0.4				<0.4
Chromium	87		21	4.00	31.00	0	0	ug/g	2	10	31		18	25	26	12	28		15	9	19.8	6				22.7
Cobalt	NV	80	21	1.70	12.10	0	0	ug/g	0.5	3	7.2		3.6	4.2	4.9	7.7	4.7		7.9	4.7	12.1	4				3
Copper	91		21	2.70	38.00	0	0	ug/g	1	9	15		8	8	11	16	12		38	12	17.4	8.2				8.2
Lead	260		21	2.00	44.00	0	0	ug/g	1	13	12		6	6	8	9	9		21	17	8.2	12.8				5.9
Molybdenum		40	21	0.60	8.50		0	ug/g	0.5	0.6	0.6		<0.5	<0.5	<0.5	1.1	<0.5		8.5	0.7	0.7	1.2				<0.5
Nickel	50	270	21	2.60	28.00	0	0	ug/g	1	8	14		7	8	10	18	9		20	12	28.0	11.7				9.3
Selenium	2.9	5.5	21	0.50	3.10	1	0	ug/g	0.4	<0.4	0.7		0.6	0.5	<0.4	*2.2*	0.6		2.7	0.7	3.1	1.5				<0.8
Silver		40	21	-	-		0	ug/g	0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2		<0.2	<0.2	<0.4	<0.4				<0.4
Thallium	1	3.3	21	0.10	0.70	0	0		0.4	<0.4	<0.4		<0.4	<0.4	<0.4	<0.4	<0.4		0.7	<0.4	<0.4	<0.4				<0.4
								ug/g																		
Uranium	33	NV	9	0.50	1.50	0	0	ug/g	0.5	0.5	0.9		0.6	0.8	0.8	0.7	0.8		1.5	0.6						
Vadium	130	200	21	7.00	31.00	0	0	ug/g	1	11	30		17	17	23	20	22		30	11	12.9	12.2				14.7
Zinc	360	600	21	15.00	79.90	0	0	ug/g	5	53	56		27	30	40	46	40		36	50	79.9	60.5				34.1
Chromium, Hexavalent	1.4	8	16	-	2.00	3	0	ug/g	0.2	<0.2	<0.2		<0.2	<0.2	<0.2	<0.2	<0.2		<0.2	<0.2						
Cyanide, Free	8	0.051	14	-	-	0	0	ug/g	0.05	<0.05	<0.05		<0.05	<0.05	<0.05	<0.05	<0.05		<0.05	<0.05						
Mercury	24	3.9	17	0.02	0.35	0	0	ug/g	0.01	0.02	0.054		0.03	0.03	0.04	0.069	0.058		0.353	0.052						
Electrical Conductivity (2:1)		1.4	19	0.18	12.00		12	mS/cm	0.002	0.179	*9.05*		*0.7*	*0.763*	*2.52*	*2.94*	*1.71*		*2.32*	*2.51*		2.12	0.494			
Sodium Adsorption Ratio (2:1)		12	19	0.02	150.00		10	N/A	N/A	0.491	*85.8*		1.49	1.38	*14.7*	*2.52*	*13*		*11.2*	*27.2*		0.02	2.34			
pH, 2:1 CaCl2 Extraction	6 to 8	5 to 9	9	7.22	7.84	0	0	ug/g		7.84	7.6		7.22	7.27	7.29	7.33	7.3		7.73	7.62						
Chloride (2:1)	NV	NV	14	16.00	15,000.00	0	0	ug/g	2	16	*5310*		16	21	*1010*	140	*504*		*978*	*1160*						
Nitrate + Nitrite	NV	NV	9	-	-	0	0	%	1	<1	<10		<1	<1	<1	<1	<1		<1	<1						
Total Organic Carbon	NV	NV	2	0.93	2.10	0	0		0.15			0.93						2.1								
Petroleum Hydrocarbons								µg/g		MW09-01A 0.08-0.61m	MW09-01B 2.59-3.20m		MW09-02A 0.30-1.37m	MW09-02A 0.30-1.37m	MW09-02B 3.05-3.50m	BH09-03A 0-0.30m	BH09-03B 2.74-3.35m		MW09-04A 0.76-1.37m	MW09-04B 1.91-2.49m	SS2 0.61-1.22m	SS2 0.61-1.22m		SS2 0.61-1.22m	SS4 1.83-2.44m	
Benzene	0.030	0.32	23	0.00	1.50	2	2	µg/g	0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.005	0.008		0.009	<0.005	
Toluene	0.37	68	23	0.01	4.10	2	0	µg/g	0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.005	0.03		0.018	0.005	
Ethylbenzene	0.082	9.5	23	0.01	2.10	2	0	µg/g	0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.005	0.008		0.051	<0.005	
Xylenes (Total)	11	26	23	0.00	13	1	0	ug/g	0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.005	0.061		0.086	<0.005	
F1 (C6-C10)	320	55	23	0.15	280	0	2		5	<5	<5		<5	<5	<5	<5	<10		<5	<5	<0.05	0.72		25.8	0.32	
F1 PHC (C6-C10) - BTEX			7	0.15	25.60	0	0	ug/g													<0.05	0.61		25.6	0.32	
F2 (C10-C16)	260	230	23	11	7,440	3	3	ug/g	10	<10	<10		<10	<10	<10	53	<20		<10	<10	60	20		7440	50	
F3 (C16-C34)	1700	1700	23	24	4,250	1	1	ug/g	50	<50	<50		<50	<50	<50	370	320		<50	<50	270	140		4250	470	
F4 (C34-C50)	3300	3300	23	10.00	400	0	0		50	<50	<50		<50	<50	<50	130	<100		<50	<50	210	150		170	400	
Total C6-C50 (F1 to F4)			7	40.00	11,890	0	0														540	310		11890	920	
Polycyclic Aromatic Hydrocarbons								µg/g					MW09-02A 0.30-1.37m	MW09-02A 0.30-1.37m	MW09-02B 3.05-3.50m	BH09-03A 0-0.30m	BH09-03B 2.74-3.35m		MW09-04A 0.76-1.37m	MW09-04B 1.91-2.49m	SS2 0.61-1.22m	SS2 0.61-1.22m				
Naphthalene	22	9.6	12	0.07	4.50	0		µg/g	0.03				0.07	<0.03	<0.03	*0.41*	<0.06		0.22	<0.03	0.08	4.5				
Acenaphthylene		0.15	12	0.02	0.16		1	µg/g	0.02				<0.02	<0.02	<0.02	0.02	<0.04		<0.02	<0.02	<0.03	0.16				
Acenaphthene		96	12	0.04	0.05		0	µg/g	0.03				<0.03	<0.03	<0.03	0.05	<0.06		<0.03	<0.03	<0.04	0.05				
Fluorene		62	12	0.06	0.41		0	µg/g	0.02				<0.02	<0.02	<0.02	0.11	<0.04		<0.02	<0.02	<0.04	0.41				
Phenanthrene		12	12	0.03	4.30		0	µg/g	0.02				0.04	<0.02	<0.02	1.1	<0.04		0.76	0.03	0.08	4.3				
Anthracene		0.67	12	0.04	1.00		1	µg/g	0.02				<0.02	<0.02	<0.02	0.12	<0.04		<0.02	<0.02	<0.03	1				
Fluoranthene		9.6	12	0.02	0.90		0	µg/g	0.02				0.02	<0.02	<0.02	0.15	<0.04		0.12	<0.02	<0.04	0.90				
Pyrene		96	12	0.02	1.40		0	µg/g	0.02				0.02	<0.02	<0.02	0.25	<0.04		0.15	<0.02	<0.03	1.4				
Benzo(a)anthracene		0.96	12	0.08	0.96		0	µg/g	0.02				<0.02	<0.02	<0.02	0.13	<0.04		0.08	<0.02	<0.03	0.96				
Chrysene		9.6	12	0.02	0.75		0	µg/g	0.02				0.03	<0.02	<0.02	0.21	<0.04		0.19	0.02	<0.04	0.75				
Benzo(b)fluoranthene		0.96	12	0.05	0.30		0	µg/g	0.02				<0.02	<0.02	<0.02	0.06	<0.04		0.05	<0.02	<0.03	0.30				
Benzo(k)fluoranthene		0.96	12	0.02	0.09		0	µg/g	0.02				<0.02	<0.02	<0.02	0.02	<0.04		<0.02	<0.02	<0.04	0.09				
Benzo(a)pyrene	0.7	0.3	12	0.04	0.33	0		µg/g	0.02				<0.02	<0.02	<0.02	0.1	<0.04		0.04	<0.02	<0.05	0.33				
Indeno(1,2,3-cd)pyrene		0.76	12	0.03	0.07		0	µg/g	0.02				<0.02	<0.02	<0.02	0.03	<0.04		<0.02	<0.02	<0.05	0.07				
Dibenz(a,h)anthracene		0.1	12	-	-		0	µg/g	0.02				<0.02	<0.02	<0.02	<0.02	<0.04		<0.02	<0.02	<0.04	<0.04				
Benzo(g,h,i)perylene		96	12	0.03	0.13		0	µg/g	0.02				<0.02	<0.02	<0.02	0.08	<0.04		0.04	<0.02	<0.02	0.13				
2-and 1-methyl phthalene		76	7	0.09	1.60		0		0.05				0.09	<0.05	<0.05	1.6	<0.10		1.1	<0.05						
								ug/g																		
Benzo(a)pyrene TPE**			10				0		-					-	-		-		0.0553	0.0002	0.05	0.5				
Volatiles								µg/g					MW09-02A 0.30-1.37m	MW09-02A 0.30-1.37m	MW09-02B 3.05-3.50m	BH09-03A 0-0.30m	BH09-03B 2.74-3.35m		MW09-04A 0.76-1.37m	MW09-04B 1.91-2.49m				SS2 0.61-1.22m		
Dichlorodifluoromethane		16.00	7	-	<0.010	0	0	µg/g	0.005				<0.005	<0.005	<0.005	<0.005	<0.010		<0.005	<0.005						
Chloromethane		NV	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.01		
Vinyl Chloride		0.032	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.003		
Bromomethane		0.05	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.009		
Chloroethane		NV	8	-	<0.010	0	0	µg/g	0.005				<0.005	<0.005	<0.005	<0.005	<0.010		<0.005	<0.005				<0.01		
Trichlorofluoromethane		4	8	-	<0.008	0	0	µg/g	0.004				<0.004	<0.004	<0.004	<0.004	<0.008		<0.004	<0.004				<0.003		
Acetone		16	8	0.22	<0.260	0	0	µg/g	0.130				<0.130	<0.130	<0.130	0.22	<0.260		<0.130	<0.130				<0.074		
1,1-Dichloroethylene		0.064	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.002		
Methylene Chloride		1.6	8	-	<0.006	0	0	µg/g	0.003				<0.003	<0.003	<0.003	<0.003	<0.006		<0.003	<0.003				<0.007		
TRANS-1,2-Dichloroethylene		1.3	8	-	<0.006	0	0	µg/g	0.003				<0.003	<0.003	<0.003	<0.003	<0.006		<0.003	<0.003				<0.005		
Methyl tert-butyl Ether		11	8	-	<0.008	0	0	µg/g	0.004				<0.004	<0.004	<0.004	<0.004	<0.008		<0.004	<0.004				<0.005		
1,1-Dichloroethane		17	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.006		
Methyl Ethyl Ketone		70	8	-	<0.20	0	0	µg/g	0.10				<0.10	<0.10	<0.10	<0.10	<0.20		<0.10	<0.10				<0.044		
CIS 1,2-Dichloroethylene		55	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.006		

Table A1
Oshawa West Wharf Soil Chemistry
West Wharf

Parameters	CCME, 1999 revised 2008	O. Reg. 153 Table 3 Commercial/ Industrial/ Community	Total	Min	Max	Exceeds CCME comm	Exceeds O.Reg. Table 3	Units	RDL	GENIVAR MW09-01A[4]	GENIVAR MW09-01B[4]	GENIVAR MW09-01 SS3	GENIVAR MW09-02A[4]	GENIVAR BHX1 (MW09-02A Dup)[4]	GENIVAR MW09-02B[4]	GENIVAR BH09-03A[4]	GENIVAR BH09-03B[4]	GENIVAR MW09-03 SS2	GENIVAR MW09-04A[5]	GENIVAR MW09-04B[5]	DCS MW4 SS2	DCS MW6 SS2	DCS MW6 SS7	DCS MW17 SS2	DCS MW17 SS4	DCS BH5 SS2
Chloroform		0.47	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.009		
1,2- Dichloroethane		0.05	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.003		
1,1,1-Trichloroethane		6.1	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.003		
Carbon Tetrachloride		0.21	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Benzene	0.0068	0.32	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
1,2-Dichloropropane		0.16	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Trichloroethylene	0.01	0.91	8	-	<0.004	0	0	µg/g	0.004				<0.004	<0.004	<0.004	<0.004	<0.008		<0.004	<0.004				<0.005		
Bromodichloromethane		18	8	-	<0.006	0	0	µg/g	0.003				<0.003	<0.003	<0.003	<0.003	<0.006		<0.003	<0.003				<0.004		
CIS-1,3-Dichloropropene		0.18	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Methyl Isobutyl Ketone		31	8	-	<0.20	0	0	µg/g	0.10				<0.10	<0.10	<0.10	<0.10	<0.20		<0.10	<0.10				<0.018		
TRANS-1,3-Dichloropropene		0.18	8	-	<0.006	0	0	µg/g	0.003				<0.003	<0.003	<0.003	<0.003	<0.006		<0.003	<0.003				<0.002		
1,1,2-Trichloroethane		0.05	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.005		
Toluene	0.08	68	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.001		
2-Hexanone		NV	8	-	<0.940	0	0	µg/g	0.470				<0.470	<0.470	<0.470	<0.470	<0.940		<0.470	<0.470				<0.021		
Dibromochloromethane		13	8	-	<0.006	0	0	µg/g	0.003				<0.003	<0.003	<0.003	<0.003	<0.006		<0.003	<0.003				<0.004		
Ethylene Dibromide		0.05	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Tetrachloroethylene	0.5	4.5	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
1,1,1,2-Tetrachloroethane		0.087	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Chlorobenzene		2.4	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Ethylbenzene		9.5	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.003		
m & p-Xylene		NV	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.006		
Bromoform		0.61	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
Styrene		34	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.002		
1,1,2,2- Tetrachloroethane		0.05	8	-	<0.008	0	0	µg/g	0.004				<0.004	<0.004	<0.004	<0.004	<0.008		<0.004	<0.004				<0.002		
o-Xylene		NV	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.005		
1,3-Dichlorobenzene		9.6	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
1,4-Dichlorobenzene		0.2	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.005		
1,2-Dichlorobenzene		6.8	8	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002				<0.004		
1,2,4-Trichlorobenzene		NV	8	-	<0.014	0	0	µg/g	0.007				<0.007	<0.007	<0.007	<0.007	<0.014		<0.007	<0.007				<0.007		
Xylene Mixture (Total)	2.4	26	7	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002						
1,3-Dichloropropene (Cis + Trans)		0.18	7	-	<0.004	0	0	µg/g	0.002				<0.002	<0.002	<0.002	<0.002	<0.004		<0.002	<0.002						
n-Hexane		46.00	7	-	<0.010	0	0		0.005				<0.005	<0.005	<0.005	<0.005	<0.010		<0.005	<0.005						

Table A1
Oshawa West Wharf Soil Chemistry
West Wharf

Parameters	DCS	DCS	DCS	DCS	DCS	DCS	DCS	DCS	DCS	DCS	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT
	BH5 SS4	BH7 SS1	BH10 SS2	BH10 SS6	BH26 SS6	BH54 SS4	BH55 SS3	BH57 SS1	BH57 SS3	BH57 SS4 2.29-3.05m	BH-301-8	BH-302-7	BH-303-5	BH-997 Field Dup of BH-303-5	BH-304-4	BH-305-2	BH-306-4	BH-307-6	BH-308-1	BH-999 Field Dup of BH-308-1	BH-309-5	BH-310-4
Depth	1.83-2.44m	0-0.61m	0.61-1.22m	3.05-3.66m	3.05-3.66m	2.29-3.05m	1.52-2.29m	0-0.76m	1.52-2.29m	2.29-3.05m	5.18-5.94m	4.42-5.18m	2.90-3.66m	2.90-3.66m	2.13-2.90m	0.61-1.37m	2.13-2.90m	3.66-4.42m	0-0.61m	0-0.61m	2.90-3.66m	2.13-2.90m
Date Sampled	23-Apr-03	23-Apr-03	24-Apr-03	24-Apr-03	5-May-03	28-Jul-03	28-Jul-03	28-Jul-03	28-Jul-03	28-Jul-03	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09	24-Mar-09	25-Mar-09	25-Mar-09	25-Mar-09	25-Mar-09	25-Mar-09	25-Mar-09
Metals		SS1 0-0.61m			SS6 3.05-3.66m			SS1 0-0.76m	SS3 1.52-2.29m	SS4 2.29-3.05m	SS8 5.18-5.94m	SS7 4.42-5.18m	SS5 2.90-3.66m	SS5 2.90-3.66m	SS4 2.13-2.90m	SS2 0.61-1.37m	SS4 2.13-2.90m	SS6 3.66-4.42m	SS1 0-0.61m	SS-1 0-0.61m	SS5 2.90-3.66m	SS4 2.13-2.90m
Antimony		<1.6			<1.6										<	<	<		<	0.2	<	<
Arsenic		2.4			1.7										2	2	4		24	13	2	<
Barium		28.3			70.1										94	61	130		27	27	16	32
Beryllium		<0.9			<0.9										0.3	0.4	0.7		0.3	0.3	<	<
Boron																						
Boron (Hot Water Extractable)																						
Cadmium		<0.4			<0.4										0.2	0.2	0.3		0.1	0.2	<	<
Chromium		4.1			13.6										18	14	27		5	4	7	6
Cobalt		2.0			5.8										5.7	5.4	7.9		3.5	3.3	3.8	1.7
Copper		5.2			11										14	13	20		11	10	12	2.7
Lead		10.1			5.8										44	14	16		12	11	6	2
Molybdenum		<0.5			<0.5										0.6	<	0.7		1.1	1.0	0.7	<
Nickel		6.4			17.1										11	12	15		7.2	6.6	5.7	2.6
Selenium		<0.8			<0.8										<	<	0.5		1.6	1.0	<	<
Silver		<0.4			<0.4										<	<	<		<	<	<	<
Thallium		<0.4			<0.4										0.11	0.1	0.18		0.19	0.12	<	<
Uranium																						
Vadium		7.1			19.5										24	24	31		9	9	9	7
Zinc		26.2			48.3										49	48	67		23	22	41	15
Chromium, Hexavalent															<2	<	<1		<0.4	<0.4	<2	<2
Cyanide, Free											<0.01	<0.01	<0.01	<0.01				<0.01				
Mercury					<0.0011										<	<	0.06		0.13	0.10	<	<
Electrical Conductivity (2:1)								0.207	0.989	0.540	1.8	5.4	11	8.4				12				
Sodium Adsorption Ratio (2:1)								0.44	3.92	21.8	33	77	140	100				150				
pH, 2:1 CaCl2 Extraction																						
Chloride (2:1)											800	1900	4600	4300				15000				
Nitrate + Nitrite																						
Total Organic Carbon																						
Petroleum Hydrocarbons				SS6 3.05-3.66m		SS4 2.29-3.05m	SS3 1.52-2.29m								SS4 2.13-2.90m	SS2 0.61-1.37m	SS4 2.13-2.90m		SS1 0-0.61m	SS-1 0-0.61m	SS5 2.90-3.66m	SS4 2.13-2.90m
Benzene				<0.005		<0.005	<0.005								0.002	<0.1	0.003		1.2	1.5	0.003	<0.1
Toluene				<0.005		0.009	0.007								0.007	<0.1	0.013		3.6	4.1	0.013	<0.1
Ethylbenzene				<0.005		<0.005	<0.005								<	<0.1	<		1.8	2.1	<	<0.1
Xylenes (Total)				<0.005		0.005	<0.005								0.007	<0.1	0.0014		11	13	0.012	<0.1
F1 (C6-C10)				0.15		<0.05	<0.05								<	<	<		250	280	<	<
F1 PHC (C6-C10) - BTEX				0.15		<0.05	<0.05															
F2 (C10-C16)				30		20	<10								<	<	<		2600	2700	11	11
F3 (C16-C34)				250		110	30								48	<	24		1700	1600	25	<
F4 (C34-C50)				230		70	10								130	<	<		160	230	<	<
Total C6-C50 (F1 to F4)				510		200	40															
Polycyclic Aromatic Hydrocarbons	SS4 1.83-2.44m	SS1 0-0.61m	SS2 0.61-1.22m																			
Naphthalene	<0.04	<0.04	0.17																			
Acenaphthylene	<0.03	<0.03	0.03																			
Acenaphthene	<0.04	<0.04	0.04																			
Fluorene	<0.04	<0.04	0.06																			
Phenanthrene	<0.03	0.04	0.38																			
Anthracene	<0.03	<0.03	0.04																			
Fluoranthene	<0.04	<0.04	<0.04																			
Pyrene	<0.03	<0.03	0.16																			
Benzo(a)anthracene	<0.03	<0.03	0.11																			
Chrysene	<0.04	<0.04	0.26																			
Benzo(b)fluoranthene	<0.03	<0.03	0.06																			
Benzo(k)fluoranthene	<0.04	<0.04	<0.04																			
Benzo(a)pyrene	<0.05	<0.05	<0.05																			
Indeno(1,2,3-cd)pyrene	<0.05	<0.05	<0.05																			
Dibenz(a,h)anthracene	<0.04	<0.04	<0.04																			
Benzo(g,h,i)perylene	<0.02	<0.02	0.03																			
2-and 1-methyl phthalene																						
Benzo(a)pyrene TPE**	0.05	0.05	0.07																			
Volatiles																						
Dichlorodifluoromethane																						
Chloromethane																						
Vinyl Chloride																						
Bromomethane																						
Chloroethane																						
Trichlorofluoromethane																						
Acetone																						
1,1-Dichloroethylene																						
Methylene Chloride																						
TRANS-1,2-Dichloroethylene																						
Methyl tert-butyl Ether																						
1,1-Dichloroethane																						
Methyl Ethyl Ketone																						
CIS 1,2-Dichloroethylene																						

Table A1
Oshawa West Wharf Soil Chemistry
West Wharf

Parameters	DCS	DCS	DCS	DCS	DCS	DCS	DCS	DCS	DCS	DCS	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT
	BH5 SS4	BH7 SS1	BH10 SS2	BH10 SS6	BH26 SS6	BH54 SS4	BH55 SS3	BH57 SS1	BH57 SS3	BH57 SS4 2.29-3.05m	BH-301-8	BH-302-7	BH-303-5	BH-997 Field Dup of BH-303-5	BH-304-4	BH-305-2	BH-306-4	BH-307-6	BH-308-1	BH-999 Field Dup of BH-308-1	BH-309-5	BH-310-4
Chloroform																						
1,2- Dichloroethane																						
1,1,1-Trichloroethane																						
Carbon Tetrachloride																						
Benzene																						
1,2-Dichloropropane																						
Trichloroethylene																						
Bromodichloromethane																						
CIS-1,3-Dichloropropene																						
Methyl Isobutyl Ketone																						
TRANS-1,3-Dichloropropene																						
1,1,2-Trichloroethane																						
Toluene																						
2-Hexanone																						
Dibromochloromethane																						
Ethylene Dibromide																						
Tetrachloroethylene																						
1,1,1,2-Tetrachloroethane																						
Chlorobenzene																						
Ethylbenzene																						
m & p-Xylene																						
Bromoform																						
Styrene																						
1,1,2,2- Tetrachloroethane																						
o-Xylene																						
1,3-Dichlorobenzene																						
1,4-Dichlorobenzene																						
1,2-Dichlorobenzene																						
1,2,4-Trichlorobenzene																						
Xylene Mixture (Total)																						
1,3-Dichloropropene (Cis + Trans)																						
n-Hexane																						

Table A2
Oshawa West Wharf Ground Water Chemistry
West Wharf

Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1 All Other Property Uses[3]	O. Reg. 153 Table 3 All Property Uses[4]	Units	RDL	Total Number Samples	Num Exceed MOE T3	Max	GENIVAR MW09-01[5]	GENIVAR MW09-2i[5]	GENIVAR MW09-100 (MW09-02i Dup)[5]	GENIVAR MW09-2ii[5]	GENIVAR MW09-04[6]	GENIVAR MW302[5]	GENIVAR MW308[6]	GENIVAR MW6[5]	GENIVAR MW310[6]	DCS MW4
Water Level(m)										**1.23**	**1.74**	**1.74**	**0.86**	**0.15**	**1.23**	**0.38**	**1.51**	**1.92**	**1.32**
Date Sampled										**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	**12-Mar-2010**	
Metals and Inorganics																			
Antimony	6	NV	6.0	20,000	ug/L	0.5	20	0	2.8	2.8	<0.5	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	<1.53
Arsenic	10	5	25	1900	ug/L	1.0	20	0	73.2	3.3	4.5	4.4	<1.0	73.2	3.6	1.7	1.8	3.3	1.4
Barium	1000	NV	NV	29,000	ug/L	2.0	20	0	1540	1540	90.9	91.6	40.7	102	122	97.6	157	91.2	44.5
Beryllium	NV	NV	4.0	67	ug/L	0.5	20	0	0	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<1.84
Boron	5000	NV	200	45000	ug/L	10.0	17	0	1230	17.1	190	182	59.1	1230	48.2	145	97.9	89.1	
Cadmium	5	0.017	0.5	2.7	ug/L	0.2	20	0	0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.67
Chromium	50	8.9	8.9	810	ug/L	2.0	20	0	18.3	2.5	<2.0	<2.0	<2.0	2	4.3	5.2	9.7	2.1	12.8
Cobalt	NV	NV	0.9	66	ug/L	0.5	20	0	42	4.2	1	0.8	0.7	15.8	1	2.7	0.7	2.1	<0.96
Copper	1000	2 to 4[a]	2.5	87	ug/L	1.0	20	0	5.03	4.7	1.4	1.1	2.4	4.4	1.8	1.4	1.5	1.1	5.03
Lead	10	1 to 7[b]	1	25	ug/L	0.5	20	0	1.2	<0.5	1.2	<0.5	<0.5	0.5	<0.5	<0.5	<0.5	<0.5	0.73
Molybdenum	NV	73	40	9200	ug/L	0.5	20	0	15.1	1.7	<0.5	<0.5	0.9	15.1	1.8	1.1	0.8	1	<0.47
Nickel	NV	25 to 150[c]	25	490	ug/L	1.0	20	0	28.4	<1.0	<1.0	<1.0	3.3	21.2	2.7	3.2	3.2	5.4	6.47
Selenium	10	1	5.0	63	ug/L	1.0	20	0	9.06	<1.0	<1.0	2	2	3.6	<1.0	1.5	2.4	<1.0	1.69
Silver	NV	0.1	0.25	1.5	ug/L	0.2	20	0	0	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.7
Thallium	1	NV	0.5	510	ug/L	0.3	19	0	0	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3	<0.36
Uranium	20*	NV	NV	420	ug/L	0.5	10	0	1.5	0.8	<0.5	<0.5	0.9	1	0.6	1.5	<0.5	1.4	
Vanadium	130	NV	6.0	250	ug/L	0.4	20	0	5.65	<0.4	2.9	3.5	<0.4	0.5	2.8	0.4	2.3	0.6	4.20
Zinc	5000	30	20	1100	ug/L	5.0	20	0	366	15.9	<5.0	<5.0	<5.0	16.5	7.2	6.2	<5.0	<5.0	99.5
Mercury	0.001	0.026	0.02	0.29	ug/L	0.02	12	0	0	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.1
Chromium VI	NV	1	10	140	ug/L	5	11	0	0	<5	<5	<5	<5	<5	<5	<5	<5	<5	
Cyanide, Free	0.2	5	5.0	66	ug/L	2	9	0	15	<2	<2	<2	<2	<2	15	<2	2	<2	
Sodium	NV	NV	NV	4.90E+05	ug/L	50	16	7	17,800,000	17,800,000	1,100,000	1,100,000	67,400	8,240,000	1,040,000	234,000	350,000	54,200	
Chloride	≤250000+	NV	NV	2.30E+07	ug/L	2000	9	1	33300000	33300000	1650000	1600000	66200	6740000	1860000	254000	455000	20300	
Nitrate as N	45000	13000	NV	NV	ug/L	1000	9	0	940	<1000	<50	<50	940	<500	<50	<50	<50	<50	
Nitrite as N	NV	60	NV	NV	ug/L	1000	9	0	0	<1000	<50	<50	<50	<500	<50	<50	<50	<50	
Electrical Conductivity	NV	NV	NV	NA	uS/cm	2	9	0	72500	72500	6390	6290	1650	20600	5700	2560	3740	1070	
pH	6.5 to 8.5 +	NV	NV	NA	NA	NA	9	0	7.97	7.15	7.76	7.73	7.89	7.51	7.97	7.7	7.91	7.59	
Other																			
Total Suspended Solids	NV	NV	NV	NV	mg/L	10				16800	5020	3820	378	7420	6840	1800	1640	1210	
Volatile Organic Compounds																			
Dichlorodifluoromethane	NV	NV	NV	4400	µg/L		6	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Chloromethane	NV	NV	NV	NV	µg/L		7	0	0		<0.80	<0.80	<0.40	<0.80		<0.80		<0.80	
Vinyl Chloride	2	NV	0.5	0.5	µg/L		7	0	0		<0.34	<0.34	<0.17	<0.34		<0.34		<0.34	
Bromomethane	NV	NV	0.9	5.6	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Chloroethane	NV	NV	NV	NV	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Trichlorofluoromethane	NV	NV	NV	2500	µg/L		7	0	0		<0.80	<0.80	<0.40	<0.80		<0.80		<0.80	
Acetone	NV	NV	NV	130000	µg/L		7	0	55		<2.0	<2.0	<1.0	<2.0		<2.0		<2.0	
1,1 Dichloroethene	NV	NV	0.66	320	µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
Methylene Chloride	NV	98.1	50	610	µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
trans- 1,2-dichloroethylene	NV	100-	100	1.6	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Methyl tert-butyl ether	15	10000	200	190	µg/L		7	0	23		<0.40	<0.40	<0.20	<0.40		23		<0.40	
1,1-Dichloroethane	5	NV	70	320	µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
Methyl Ethyl Ketone	NV	NV	350	470,000	µg/L		7	0	7.4		<2.0	<2.0	<1.0	<2.0		<2.0		<2.0	
cis-1,2-Dichloroethylene	NV	100-	70	1.6	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Chloroform	NV	NV	0.5	2.4	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
1,2 - Dichloroethane	5	100	5.0	1.6	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
1,1,1-Trichloroethane	NV	NV	10	640	µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
Carbon Tetrachloride	5	13.3	0.5	0.79	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Benzene	5	370	5.0	44	µg/L		7	0	8.7		<0.40	<0.40	<0.20	<0.40		<0.40		8.7	
1,2-Dichloropropane	NV	NV	0.7	16	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Trichloroethylene	NV	21	20	1.6	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Bromodichloromethane	16	NV	5.0	85,000	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
cis-1,3-Dichloropropene	NV	NV	NV	5.2	ug/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Methyl Isobutyl Ketone	NV	NV	NV	140,000	µg/L		7	0	0		<2.0	<2.0	<1.0	<2.0		<2.0		<2.0	
trans-1,3-Dichloropropene	NV	NV	NV	5.2	µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
1,1,2-Trichloroethane	NV	NV	5	4.7	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	

Table A2
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Parameters	CCME, 1999 revised 2008[1]	CCME, 1999 revised 2007[2]	O. Reg. 153 Table 1 All Other Property Uses[3]	O. Reg. 153 Table 3 All Property Uses[4]	Units	RDL	Total Number Samples	Num Exceed MOE T3	Max	GENIVAR MW09-01[5]	GENIVAR MW09-2i[5]	GENIVAR MW09-100 (MW09-02i Dup)[5]	GENIVAR MW09-2ii[5]	GENIVAR MW09-04[6]	GENIVAR MW302[5]	GENIVAR MW308[6]	GENIVAR MW6[5]	GENIVAR MW310[6]	DCS MW4
Toluene	24	2	0.8	18,000	µg/L		7	0	7.2		<0.40	<0.40	<0.20	<0.40		<0.40		7.2	
2-Hexanone	NV	NV	NV	NV	µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
Dibromochloromethane	NV	NV	0.5	82,000	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
Ethylene Dibromide	NV	NV	1.0	0.25	µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
Tetrachloroethene	5	111	5.0		µg/L		7	0	0		<0.40	<0.40	<0.20	<0.40		<0.40		<0.40	
1,1,1,2-Tetrachloroethane	NV	NV	5.0	3.4	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
Chlorobenzene	NV	1.3	15	630	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
Ethylbenzene	2.4	90	2.4	2,300	µg/L		7	0	69		<0.20	<0.20	<0.10	<0.20		<0.20		69	
m & p-Xylene	NV	NV	NV		µg/L		7	0	17		<0.40	<0.40	<0.20	<0.40		<0.40		17	
Bromoform	NV	NV	5.0	380	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
Styrene	NV	72	4.0	1300	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
1,1,2,2-Tetrachloroethane	NV	NV	1.0	3.2	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
o-Xylene	NV	NV	NV		µg/L		7	0	2.4		<0.20	<0.20	<0.10	<0.20		<0.20		2.4	
1,3-Dichlorobenzene	NV	150	2.5	9,600	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
1,4-Dichlorobenzene	5	26	1.0	8	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
1,2-Dichlorobenzene	200	0.7	2.5	4,600	µg/L		7	0	0		<0.20	<0.20	<0.10	<0.20		<0.20		<0.20	
1,2,4-Trichlorobenzene	NV	24	0.5		µg/L		7	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
1,3-Dichloropropene (Cis + Trans)	NV	NV	1.4	5.2	µg/L		6	0	0		<0.60	<0.60	<0.30	<0.60		<0.60		<0.60	
Xylenes (Total)	300	NV	72	4,200	µg/L		6	0	19		<0.40	<0.40	<0.20	<0.40		<0.40		19	
n-Hexane	NV	NV	NV		µg/L		6	0	1.5		<0.40	<0.40	<0.20	<0.40		<0.40		1.5	
Petroleum Hydrocarbons																			
Benzene	5	370	5	44	ug/L	0.2	20	0	8.7	<0.2	<0.40	<0.40	<0.20	<0.40	<0.2	<0.40	<0.2	8.7	<0.04
Toluene	24	2	0.8	18000	ug/L	0.2	20	0	7.2	<0.2	<0.40	<0.40	<0.20	<0.40	<0.2	<0.40	<0.2	7.2	0.33
Ethylbenzene	2.4	90	2.4	2300	ug/L	0.1	20	0	69	<0.1	<0.20	<0.20	<0.10	<0.20	<0.1	<0.20	<0.1	69	<0.05
Xylenes (total)	300	NV	72	4200	ug/L	0.2	20	0	19	<0.2	<0.40	<0.40	<0.20	<0.40	<0.2	<0.40	<0.2	19	0.53
F1 (C6-C10)	NV	NV	NV	750	ug/L	25	17	0	610	<25	<25	<25	<25	<25	<25	27	<25	610	
F2 (C10-C16)	NV	NV	NV	150	ug/L	100	17	5	2600	<100	<100	<100	<100	<100	<100	<100	<100	430	
F3 (C16-C34)	NV	NV	NV	500	ug/L	100	17	2	1200	<100	<100	<100	<100	<100	<100	<100	<100	500	
F4 (C34-C50)	NV	NV	NV	500	ug/L	100	17	1	620	<100	<100	<100	<100	<100	<100	<100	<100	<100	
TPH-Gas																			13
TPH-Diesel																			1200
TPH-Gas+Diesel																			1200
Polycyclic Aromatic Hydrocarbons																			
Naphthalene	NV	1.1	7.0	1400	µg/L	0.12	6	0	0		<0.12	<0.12	<0.12	<0.12					<0.3
Acenaphthylene	NV	NV	1.0	1.8	µg/L	0.11	6	0	0		<0.11	<0.11	<0.11	<0.11					<0.31
Acenaphthene	NV	5.8	1.0	600	µg/L	0.10	6	0	0		<0.10	<0.10	<0.10	<0.10					<0.3
Fluorene	NV	3	1.0	400	µg/L	0.09	6	0	0		<0.09	<0.09	<0.09	<0.09					<0.31
Phenanthrene	NV	0.4	1.0	580	µg/L	0.10	6	0	0.22		<0.10	<0.10	0.22	<0.10					<0.32
Anthracene	NV	0.012	0.05	2.4	µg/L	0.07	6	0	0		<0.07	<0.07	<0.07	<0.07					<0.3
Fluoranthene	NV	0.04	1.0	130	µg/L	0.12	6	0	0		<0.12	<0.12	<0.12	<0.12					<0.27
Pyrene	NV	0.025	0.05	68	µg/L	0.12	6	0	0		<0.12	<0.12	<0.12	<0.12					<0.27
Benzo(a)anthracene	NV	0.018	0.1	4.7	µg/L	0.08	6	0	0		<0.08	<0.08	<0.08	<0.08					<0.2
Chrysene	NV	NV	0.05	1	µg/L	0.05	6	0	0		<0.05	<0.05	<0.05	<0.05					<0.27
Benzo(b)fluoranthene	NV	NV	0.05	0.75	µg/L	0.05	6	0	0		<0.05	<0.05	<0.05	<0.05					<0.2
Benzo(k)fluoranthene	NV	NV	0.05	0.4	µg/L	0.06	6	0	0		<0.06	<0.06	<0.06	<0.06					<0.2
Benzo(a)pyrene	0.01	0.015	0.005	0.81	ug/L	0.01	6	0	0		<0.01	<0.01	<0.01	<0.01					<0.24
Indeno(1,2,3-cd)pyrene	NV	NV	0.1	0.2	µg/L	0.03	6	2	0		<0.03	<0.03	<0.03	<0.03					<0.27
Dibenzo(a,h)anthracene	NV	NV	0.1	0.52	µg/L	0.09	6	0	0		<0.09	<0.09	<0.09	<0.09					<0.2
Benzo(g,h,i)perylene	NV	NV	0.10	0.2	µg/L	0.06	6	0	0		<0.06	<0.06	<0.06	<0.06					<0.2
2-and 1-methyl Napthalene	NV	NV	2.5	1800	µg/L	0.20	4	0	0		<0.20	<0.20	<0.20	<0.20					

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Oshawa West Wharf Ground Water Chemistry
West Wharf

Parameters	DCS	DCS	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT
	MW6	MW17	MW6 Mar. 27 2009	MW-302	MW-305	MW-307	MW-996 Field Dup of MW-307	MW-308	MW-309	MW-310
Water Level(m)	**1.26**	**1.70**		**0.78**	**0.36**	**1.09**	**1.09**	**0.24**	**0.31**	**0.51**
Date Sampled			**26-Mar-09**	**26-Mar-09**	**26-Mar-09**	**26-Mar-09**	**26-Mar-09**	**26-Mar-09**	**26-Mar-09**	**26-Mar-09**
Metals and Inorganics										
Antimony	<1.53	<1.53	<	<5	<	<	<	<	<	<
Arsenic	2.10	1.60	2	<10	1	2	2	<5	3	2
Barium	117	356	160	1100	490	130	130	500	320	94
Beryllium	<1.84	<1.84	<	<5	<	<	<	<	<	<
Boron			140	130	84	49	44	160	170	83
Cadmium	<0.67	<0.67	<	<1	<	<	<	<	<	<
Chromium	8.08	18.3	<	<50	<	<	<	<	<	<
Cobalt	<0.96	2.99	<	17	42	5.0	5.2	18	20	5.3
Copper	3.70	4.26	<	<10	4	2	2	2	1	3
Lead	0.73	<0.44	<	<5	<	<	<	<	<	<
Molybdenum	2.62	3.31	<	<10	2	2	2	2	2	4
Nickel	6.98	28.4	<	<10	7	2	2	<	<	1
Selenium	1.26	9.06	<	<20	<	<	<	<	<	<
Silver	<0.7	<0.7	<	<1	<	<	<	<	<	<
Thallium	<0.36	<0.36	<	<0.5	<		<	<	<	<
Uranium							<			
Vanadium	5.65	4.24	4	<10	<	<	<	<5	<	<
Zinc	26.2	366	13	<50	9	<	9	8	9	12
Mercury	<0.1	<0.1								
Chromium VI			<5		<5					
Cyanide, Free										
Sodium			35,000	3,400,000		420,000	440,000	650,000	280,000	14,000
Chloride										
Nitrate as N										
Nitrite as N										
Electrical Conductivity										
pH										
Other										
Total Suspended Solids										
Volatile Organic Compounds										
Dichlorodifluoromethane										
Chloromethane		<0.4								
Vinyl Chloride		<0.3								
Bromomethane		<0.2								
Chloroethane		<0.2								
Trichlorofluoromethane		<0.4								
Acetone		55								
1,1 Dichloroethene		<0.2								
Methylene Chloride		<0.3								
trans- 1,2-dichloroethylene		<0.2								
Methyl tert-butyl ether		<0.2								
1,1-Dichloroethane		<0.3								
Methyl Ethyl Ketone		7.4								
cis-1,2-Dichloroethylene		<0.2								
Chloroform		<0.2								
1,2 - Dichloroethane		<0.2								
1,1,1-Trichloroethane		<0.3								
Carbon Tetrachloride		<0.2								
Benzene		<0.2								
1,2-Dichloropropane		<0.2								
Trichloroethylene		<0.2								
Bromodichloromethane		<0.2								
cis-1,3-Dichloropropene		<0.2								
Methyl Isobutyl Ketone		<0.3								
trans-1,3-Dichloropropene		<0.3								
1,1,2-Trichloroethane		<0.2								

Table A2
Oshawa West Wharf Ground Water Chemistry
West Wharf

Parameters	DCS	DCS	AQT	AQT	AQT	AQT	AQT	AQT	AQT	AQT
	MW6	MW17	MW6 Mar. 27 2009	MW-302	MW-305	MW-307	MW-996 Field Dup of MW-307	MW-308	MW-309	MW-310
Toluene		<0.2								
2-Hexanone		<0.3								
Dibromochloromethane		<0.1								
Ethylene Dibromide		<0.2								
Tetrachloroethene		<0.1								
1,1,1,2-Tetrachloroethane		<0.1								
Chlorobenzene		<0.1								
Ethylbenzene		<0.1								
m & p-Xylene		<0.2								
Bromoform		<0.1								
Styrene		<0.1								
1,1,2,2-Tetrachloroethane		<0.1								
o-Xylene		<0.1								
1,3-Dichlorobenzene		<0.1								
1,4-Dichlorobenzene		<0.1								
1,2-Dichlorobenzene		<0.1								
1,2,4-Trichlorobenzene		<0.3								
1,3-Dichloropropene (Cis + Trans)										
Xylenes (Total)										
n-Hexane										
Petroleum Hydrocarbons										
Benzene	0.14	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	2.9
Toluene	0.41	<0.2	<0.2	0.9	1.3	0.4	0.3	1.5	1.9	2.1
Ethylbenzene	<0.05	<0.1	<0.2	<0.2	0.4	<0.2	<0.2	0.3	0.4	4.5
Xylenes (total)	0.36	–	<0.4	1.3	1.9	<0.4	<0.4	1.8	2.4	6.5
F1 (C6-C10)			<100	<100	<100	<100	<100	<100	<100	38
F2 (C10-C16)			<100	<100	290	<100	<100	2600	330	1300
F3 (C16-C34)			<100	170	<100	130	130	1100	<100	1200
F4 (C34-C50)			<100	320	<100	<100	<100	<100	<100	620
TPH-Gas	<8	10								
TPH-Diesel	240	4600								
TPH-Gas+Diesel	240	4600								
Polycyclic Aromatic Hydrocarbo										
Naphthalene	<0.3									
Acenaphthylene	<0.31									
Acenaphthene	<0.3									
Fluorene	<0.31									
Phenanthrene	<0.32									
Anthracene	<0.3									
Fluoranthene	<0.27									
Pyrene	<0.27									
Benzo(a)anthracene	<0.2									
Chrysene	<0.27									
Benzo(b)fluoranthene	<0.2									
Benzo(k)fluoranthene	<0.2									
Benzo(a)pyrene	<0.24									
Indeno(1,2,3-cd)pyrene	<0.27									
Dibenzo(a,h)anthracene	<0.2									
Benzo(g,h,i)perylene	<0.2									
2-and 1-methyl Napthalene										

APPENDIX B VAPOUR EXPOSURE MODELLING

B.1 JOHNSON AND ETTINGER MODEL

The Johnson and Ettinger (J-E) model is used frequently to simulate the migration of vapours from the subsurface into buildings. Named for the authors of a 1991 article that describes this approach, aspects of the model were used by the MOE in 1996 to assess acceptable soil and ground water concentrations of volatile compounds.

The J-E model predicts the migration of vapours from underlying soil and/or ground water into buildings by both convective and diffusive mechanisms. Key aspects in this regard are the presence of cracks and other openings through which vapours can enter the building, the presence of pressure differentials which tend to draw vapours from the subsurface into a building, the rate at which vapours in the building are diluted by mixing with "fresh" air, the permeability of the soil, and the distance that the vapours must travel from the source to the building.

In the 1991 article, Johnson and Ettinger examine vapour migration into a typical house with a full basement. They also assign various characteristics of the house and the surrounding soil. In the process of setting generic criteria, the MOE examined the same residential scenario and used the same characteristics as those picked by Johnson and Ettinger. Since that time, improvements have been made to the model and to the parameters used as inputs. To accommodate some of the model improvements, "new" parameters have been added.

The following discussion presents many of the parameters that are inputs to the model and notes those parameters that differ in this application from those used by Johnson and Ettinger and/or differ from the values that the MOE used in the criteria setting process in 1996. The differences are summarized in Table B1.

The version of the J-E model used in this risk assessment has been created by the U.S. EPA and is available at www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm.

Temperature Below Ground Surface - Although not explicitly stated in the earlier versions of the J-E model, the temperature is assumed to be 20°C because various chemical properties commonly are expressed at that temperature (including diffusivity in air, diffusivity in water, and Henry's Law Constant); however, the average temperature in soil 3 m below the surface will be less than 20 °C which will have the net effect of reducing vapour migration. A map of average shallow ground water temperatures shows the area around the top of Lake Superior to be approximately 37 °F or 3 °C (EQM, 2003).

Shallow ground water temperatures can be used to approximate subsurface soil temperatures greater than one to 2 m below the surface (EQM, 2003). To be conservative a temperature of 10°C is used in this risk assessment

.

Diffusivity of Vapours in Air - The original J-E paper uses a value of 0.087 cm^2/s (for benzene at 20 °C). No such value is provided in the MOE Guideline or supporting documents. The U.S. EPA version of the model includes a data base of numerous characteristics for many chemicals including BTEX. Those values are used in this SSRA. TPHCWG (1997a) states that diffusivity does not vary significantly from fraction to fraction and that "a conservative, reasonable assumption would be to set $D_{air} = 10^{-1}$ cm^2/s for all fractions with little loss in accuracy". That value is used in this risk assessment for PHC fractions.

Dry Bulk Soil Density - The value of 1.7 g/cm^3 is used in the original J-E paper and by the MOE. This is a commonly used value. The latest version of the J-E model prepared for the U.S. EPA recommends a default value of 1.66 g/cm^3 for medium sand unless site specific data are available (EQM, 2003).

Total Porosity - The original J-E paper uses a value of 0.38. This is the mid-range value cited by Freeze and Cherry (1979) for sandy soil. The default value for sand in the U.S EPA version of the model is 0.375 (EQM, 2003). That value is used in this SSRA.

Water-Filled Porosity (Moisture Content) - The original J-E paper uses a moisture content value of 0.07 g of water/g of soil (for sandy soil) to calculate a moisture-filled porosity of 0.12 g/cm^3 which is approximately equal to 0.12 cm^3/ cm^3. The default value for medium sand in the U.S EPA version of the model is a water-filled porosity of 0.053 cm^3/cm^3 (EQM, 2003). That value is used in this SSRA.

Gas-Filled (or Air-Filled) Porosity - The value of this parameter is equal to the total porosity minus the water-filled porosity. The original J-E paper calculates a value of 0.26 for sandy soil. The default value for sand in the U.S. EPA version of the model is 0.322 cm^3/cm^3 (EQM, 2003). That value is used in this SSRA.

Soil Vapour Permeability - The original J-E paper provides ranges of values for vapour permeability based on soil type. The authors use values in the range of 1×10^{-6} to 1×10^{-7} cm^2 to illustrate medium sandy soils. The value of this parameter is calculated using the formula:

$$\text{permeability to vapours} = \frac{(\text{hydraulic conductivity} \times \text{dynamic viscosity of water} \times 100)}{(\text{density of water} \times \text{gravitational constant}}$$

In the U.S. EPA version of the model, intrinsic permeability values are assigned for each soil. For sand, the intrinsic permeability is 9.92×10^{-8} cm^2 (EQM, 2003) and is calculated using the above equation. The model then calculates an effective permeability by taking into account the degree of water saturation in the soil. The effective permeability for sand is calculated to be 9.91×10^{-8} cm^2. In this SSRA, the model is left to calculate this parameter.

Organic Carbon in Soil - The original J-E paper does not use organic carbon content as a parameter. The default value for all soil types in 0.002 in the U.S. EPA version of the model (EQM, 2003). That value is used in this SSRA.

Vapour Viscosity - The original J-E paper uses a value of 1.8×10^{-4} g/cm·s. In the most recent U.S. EPA version of the model, this is calculated to be 1.75×10^{-4} g/cm·s. That value is used in this SSRA.

Building Dimensions –The original J-E paper and the MOE use a house with the following dimensions: length and width of 10 m and 7 m; basement height of 3 m; and 2 m of the basement walls are below grade. For this SSRA, this is not applicable not applicable. Buildings are not modeled on site as they are temporary types where vapours would not migrate through floors into indoor air. The model is left with default parameters, which will not affect coefficients modeling to outdoor air.

Air Change Rate - The original J-E paper uses a value of 0.5 air changes per hour and that value also is used by the MOE. In the most recent U.S. EPA version of the model, the default value has been adjusted slightly to 0.45 (EQM, 2003).

Area of Cracks and Openings - The area of all openings divided by the total area of surfaces in contact with soil is identified as η. The original J-E paper cites a range of 0.01 to 0.001, and assigns a value of 0.01 to η. The MOE uses the same value in the process of setting generic criteria. For this SSRA, this is not applicable not applicable. Buildings are not modeled on site as they are temporary types where vapours would not migrate through floors into indoor air. The model is left with default parameters, which will not affect coefficients modeling to outdoor air.

Crack Length - In the original J-E paper, the value of this parameter (identified as L_{crack}) is equal to the thickness of the floor slab. The value of 15 cm is used in the original paper, by the MOE, and in this SSRA. Furthermore, for this SSRA, this is not applicable not applicable. Buildings are not modeled on site as they are temporary types where vapours would not migrate through floors into indoor air. The model is left with default parameters, which will not affect coefficients modeling to outdoor air.

Vapour Travel Distance - This parameter (identified as L_T) is examined in the original J-E paper at values ranging from 0 to 10 m. For the Outdoor Worker (Remediation or Commercial), impacts in soil are 0.3 m below the surface which results in a travel distance of 0.30 m (30 cm). This corresponds to the shallowest, and therefore most conservative, depth of EPC concentrations used in this SSRA.

Pressure Differential - In the original J-E paper, a value of 1 Pa is used as a reasonable long-term average value for screening calculations. Health Canada has suggested that the vapour flow rate be set to 5 L/min and that meant the pressure differential no longer is used in the calculation.

TABLE B1 SITE SPECIFIC MODEL INPUTS USED IN THIS RISK ASSESSMENT

soil temperature	10°C C
diffusivity of vapours in air	0.1 cm^2/s for TPH fractions (TPHCWG, 1997a)
dry bulk density	1.66 (in EQM, 2003) instead of the J-E value of 1.7
total porosity	0.375 for sand used (EQM, 2003) versus J-E value of 0.38 for sand
soil-water filled porosity	0.053 cm^3/cm^3 used for sand (EQM, 2003) versus the J-E value of approximately 0.12
gas-filled or air-filled porosity	0.321 calculated for sand (EQM, 2003) versus the J-E value of 0.26 for sand
soil vapour permeability	effective permeability of 9.91×10^{-8} cm^2 is calculated for sand versus soil vapour permeability values in the range of 1×10^{-6} to 1×10^{-7} provided by J-E to illustrate medium sandy soils

building dimensions	10 m by 7 m although not relevant in this SSRA
vapour flow rate	set at 5 L/min as suggested by Health Canada; this eliminates the need to set the air change rate, areas of cracks and opening in the basement, and pressure differential
vapour travel distance	for building without a basement, set at 0.3 m for impacted soil and 1.2 metre for ground water to reflect likely minimum distances at this Site

B.2 J-E MODEL RESULTS

This Appendix includes the output produced by the U.S. EPA version of the J-E model. Each model run produces four pages of output. The total number of model runs for the Site can be estimated from the total number of COPCs at that Site.

Attached are the outputs for the following model runs only:

- **Benzene in Soil** - This is included to illustrate the vapour concentrations to outdoor air that subsequently are used to estimate exposures and risks.
- **PHC F2 (aromatic $C_{>10}$ – C_{12}) in Ground water** - This is included to illustrate the vapour concentrations to outdoor air that subsequently are used to estimate exposures and risks.

One of the prime outputs of the J-E model is a parameter referred to as the Attenuation Factor (α). Using the J-E article as a basis, the MOE selected an Attenuation Factor of 5×10^{-4} for all coarse-textured soils and 8×10^{-5} for all medium-to-fine textured soils.

For the Worker, the Attenuation Factors for the COPCs are approximately 2.9×10^{-3} when soil is the source. The soil on Site is modelled as a medium textured sand.

B.3 OUTDOOR VAPOUR MODEL

The inhalation of vapours that migrate to outdoor air is identified as a potentially complete exposure pathway for both the Outdoor Worker receptor.

The Remediation Worker is assumed to spend all of their time outside and therefore, is assumed to breathe outdoor air for 8 h/d, 5 d/w, 18.4 w/y = 736 h/y, for 7 years.

The Commercial Worker is assumed to spend all of their time outside and therefore, is assumed to breathe outdoor air for 8 h/d, 5 d/w, 48 w/y = 1920 h/y, for 25 years.

The concentrations of vapours in outdoor air caused by impacted soil or ground water tend to be substantially lower than those in indoor air. Vapours that migrate from the subsurface to outdoor air are rapidly diluted and degraded.

Concentrations in outdoor air can be modelled as a flux of vapours from the subsurface into the air that the receptor then breathes. The flux rate can be estimated from two parameters calculated in the J-E model. These parameters are the vapour concentration in soil (described as the "source" vapour concentration in J-E model output) and the effective diffusion coefficient. Both parameters are chemical specific.

When the source is impacted soil, it is assumed that the vapours need to travel 0.30 m through sand to reach the surface. The distance of 0.3 m corresponds to the minimum shallow depth of the highest COPC concentrations measured in 2010.

When the source is impacted ground water, it is assumed that the vapours need to travel 1.20 m through sand to reach the surface. The distance of 1.2 m corresponds to the minimm depth to ground water of the highest COPC concentrations measured in 2010.

The Outdoor Worker (Commercial and Remediation) receptor is assumed to breathe air at a distance of 1.5 m above the ground surface. It is assumed that the receptor stands at the down wind end of an impacted area that is 80 m long. Virtually all of the "worst case" concentrations in soil and ground water come from locations that would "fit" within a rectangular area with sides of approximately 80 m.

The following spreadsheets show the results of these calculations for soil and ground water as a source for both the Outdoor Worker.

The equation described at the top of the spreadsheet is recommended by Health Canada for PQRAs (Health Canada, 2004a).

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Reset to Defaults

Benzene in Soil

CALCULATE RISK-BASED SOIL CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL SOIL CONCENTRATION (enter "X" in "YES" box and initial soil conc. below)

YES [X]

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial soil conc., C_R (µg/kg)	Chemical
71432	1.50E+03	Benzene

MORE ↓

ENTER Average soil temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to top of contamination, L_t (cm)	ENTER Depth below grade to bottom of contamination, (enter value of 0 if value is unknown) L_b (cm)	ENTER Totals must add up to value of L_t (cell G28) Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
10	15	30	0	30			S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum A soil organic carbon fraction, f_{oc}^A (unitless)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum B soil organic carbon fraction, f_{oc}^B (unitless)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)	ENTER Stratum C soil organic carbon fraction, f_{oc}^C (unitless)
S	1.66	0.375	0.054	0.002										

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	20	1000	700	244	0.1	1.24	5

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
75	75	75	365	1.0E-06	1
				Used to calculate risk-based soil concentration.	

END

CHEMICAL PROPERTIES SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)	Physical state at soil temperature, (S,L,G)
8.80E-02	9.80E-06	5.54E-03	25	7,342	353.24	562.16	5.89E+01	1.79E+03	7.8E-06	0.0E+00	L

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Floor-wall seam perimeter, X_{crack} (cm)	Initial soil concentration used, C_R (μg/kg)	Bldg. ventilation rate, $Q_{building}$ (cm^3/s)
2.37E+09	15	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	3,400	1.50E+03	5.88E+04

Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. soil temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. soil temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. soil temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)	Convection path length, L_p (cm)
7.00E+05	4.86E-04	15	8,122	2.68E-03	1.15E-01	1.75E-04	1.42E-02	0.00E+00	0.00E+00	1.42E-02	15	15

Soil-water partition coefficient, K_d (cm^3/g)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source β term (unitless)	Finite source ψ term $(sec)^{-1}$	Time for source depletion, τ_D (sec)	Exposure duration > time for source depletion (YES/NO)
1.18E-01	1.00E+06	0.10	8.33E+01	1.42E-02	3.40E+02	1.72E+112	1.26E-03	1.26E+03	NA	NA	NA	NA

Finite source indoor attenuation coefficient, <α> (unitless)	Mass limit bldg. conc., $C_{building}$ ($\mu g/m^3$)	Finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Final finite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
NA	NA	NA	NA	7.8E-06	NA

END

RESULTS SHEET

RISK-BASED SOIL CONCENTRATION CALCULATIONS:

Indoor exposure soil conc., carcinogen (µg/kg)	Indoor exposure soil conc., noncarcinogen (µg/kg)	Risk-based indoor exposure soil conc., (µg/kg)	Soil saturation conc., C_{sat} (µg/kg)	Final indoor exposure soil conc., (µg/kg)
NA	NA	NA	3.09E+05	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
9.8E-03	NA

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

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Version 3.0; 02/03

Reset to Defaults

CALCULATE RISK-BASED GROUNDWATER CONCENTRATION (enter "X" in "YES" box)

YES [ ]

OR

CALCULATE INCREMENTAL RISKS FROM ACTUAL GROUNDWATER CONCENTRATION (enter "X" in "YES" box and initial groundwater conc. below)

YES [X]

J-E OUTPUT FOR PHC F2 (Aromatic $C_{>10}$ to C_{12})

ENTER Chemical CAS No. (numbers only, no dashes)	ENTER Initial groundwater conc., C_W (µg/L)	Chemical
2	1.57E+03	TPH Aromatic C10 to C12

MORE ↓

ENTER Average soil/ groundwater temperature, T_S (°C)	ENTER Depth below grade to bottom of enclosed space floor, L_F (cm)	ENTER Depth below grade to water table, L_{WT} (cm)	ENTER Thickness of soil stratum A, h_A (cm)	ENTER Thickness of soil stratum B, (Enter value or 0) h_B (cm)	ENTER Thickness of soil stratum C, (Enter value or 0) h_C (cm)	ENTER Soil stratum directly above water table, (Enter A, B, or C)	ENTER SCS soil type directly above water table	ENTER Soil stratum A SCS soil type (used to estimate soil vapor permeability)	OR	ENTER User-defined stratum A soil vapor permeability, k_v (cm^2)
			Totals must add up to value of L_{WT} (cell G28)							
10	15	120	120	0	0	A	S	S		

MORE ↓

ENTER Stratum A SCS soil type (Lookup Soil Parameters)	ENTER Stratum A soil dry bulk density, ρ_b^A (g/cm^3)	ENTER Stratum A soil total porosity, n^A (unitless)	ENTER Stratum A soil water-filled porosity, θ_w^A (cm^3/cm^3)	ENTER Stratum B SCS soil type (Lookup Soil Parameters)	ENTER Stratum B soil dry bulk density, ρ_b^B (g/cm^3)	ENTER Stratum B soil total porosity, n^B (unitless)	ENTER Stratum B soil water-filled porosity, θ_w^B (cm^3/cm^3)	ENTER Stratum C SCS soil type (Lookup Soil Parameters)	ENTER Stratum C soil dry bulk density, ρ_b^C (g/cm^3)	ENTER Stratum C soil total porosity, n^C (unitless)	ENTER Stratum C soil water-filled porosity, θ_w^C (cm^3/cm^3)
S	1.66	0.375	0.054								

MORE ↓

ENTER Enclosed space floor thickness, L_{crack} (cm)	ENTER Soil-bldg. pressure differential, ΔP ($g/cm\text{-}s^2$)	ENTER Enclosed space floor length, L_B (cm)	ENTER Enclosed space floor width, W_B (cm)	ENTER Enclosed space height, H_B (cm)	ENTER Floor-wall seam crack width, w (cm)	ENTER Indoor air exchange rate, ER (1/h)	ENTER Average vapor flow rate into bldg. OR Leave blank to calculate Q_{soil} (L/m)
15	40	1000	1000	244	0.2	0.35	5

MORE ↓

ENTER Averaging time for carcinogens, AT_C (yrs)	ENTER Averaging time for noncarcinogens, AT_{NC} (yrs)	ENTER Exposure duration, ED (yrs)	ENTER Exposure frequency, EF (days/yr)	ENTER Target risk for carcinogens, TR (unitless)	ENTER Target hazard quotient for noncarcinogens, THQ (unitless)
75	56	56	365	1.0E-06	1

Used to calculate risk-based groundwater concentration.

END

DATA ENTRY SHEET

Diffusivity in air, D_a (cm^2/s)	Diffusivity in water, D_w (cm^2/s)	Henry's law constant at reference temperature, H (atm-m^3/mol)	Henry's law constant reference temperature, T_R (^oC)	Enthalpy of vaporization at the normal boiling point, $\Delta H_{v,b}$ (cal/mol)	Normal boiling point, T_B (^oK)	Critical temperature, T_C (^oK)	Organic carbon partition coefficient, K_{oc} (cm^3/g)	Pure component water solubility, S (mg/L)	Unit risk factor, URF ($(\mu g/m^3)^{-1}$)	Reference conc., RfC (mg/m^3)
1.00E-01	1.00E-05	3.37E-03	25	11,000	473.00	700.00	2.51E+03	2.50E+01	0.0E+00	2.0E-01

END

Exposure duration, τ (sec)	Source-building separation, L_T (cm)	Stratum A soil air-filled porosity, θ_a^A (cm^3/cm^3)	Stratum B soil air-filled porosity, θ_a^B (cm^3/cm^3)	Stratum C soil air-filled porosity, θ_a^C (cm^3/cm^3)	Stratum A effective total fluid saturation, S_{te} (cm^3/cm^3)	Stratum A soil intrinsic permeability, k_i (cm^2)	Stratum A soil relative air permeability, k_{rg} (cm^2)	Stratum A soil effective vapor permeability, k_v (cm^2)	Thickness of capillary zone, L_{cz} (cm)	Total porosity in capillary zone, n_{cz} (cm^3/cm^3)	Air-filled porosity in capillary zone, $\theta_{a,cz}$ (cm^3/cm^3)	Water-filled porosity in capillary zone, $\theta_{w,cz}$ (cm^3/cm^3)	Floor-wall seam perimeter, X_{crack} (cm)
1.77E+09	105	0.321	ERROR	ERROR	0.003	9.92E-08	0.998	9.91E-08	17.05	0.375	0.122	0.253	4,000

Bldg. ventilation rate, $Q_{building}$ (cm^3/s)	Area of enclosed space below grade, A_B (cm^2)	Crack-to-total area ratio, η (unitless)	Crack depth below grade, Z_{crack} (cm)	Enthalpy of vaporization at ave. groundwater temperature, $\Delta H_{v,TS}$ (cal/mol)	Henry's law constant at ave. groundwater temperature, H_{TS} (atm-m^3/mol)	Henry's law constant at ave. groundwater temperature, H'_{TS} (unitless)	Vapor viscosity at ave. soil temperature, μ_{TS} (g/cm-s)	Stratum A effective diffusion coefficient, D^{eff}_A (cm^2/s)	Stratum B effective diffusion coefficient, D^{eff}_B (cm^2/s)	Stratum C effective diffusion coefficient, D^{eff}_C (cm^2/s)	Capillary zone effective diffusion coefficient, D^{eff}_{cz} (cm^2/s)	Total overall effective diffusion coefficient, D^{eff}_T (cm^2/s)	Diffusion path length, L_d (cm)
2.37E+04	1.00E+06	8.00E-04	15	13,892	9.73E-04	4.19E-02	1.75E-04	1.62E-02	0.00E+00	0.00E+00	6.58E-04	3.35E-03	105

Convection path length, L_p (cm)	Source vapor conc., C_{source} ($\mu g/m^3$)	Crack radius, r_{crack} (cm)	Average vapor flow rate into bldg., Q_{soil} (cm^3/s)	Crack effective diffusion coefficient, D^{crack} (cm^2/s)	Area of crack, A_{crack} (cm^2)	Exponent of equivalent foundation Peclet number, $\exp(Pe^f)$ (unitless)	Infinite source indoor attenuation coefficient, α (unitless)	Infinite source bldg. conc., $C_{building}$ ($\mu g/m^3$)	Unit risk factor, URF $(\mu g/m^3)^{-1}$	Reference conc., RfC (mg/m^3)
15	6.57E+04	0.20	8.33E+01	1.62E-02	8.00E+02	9.47E+41	9.72E-04	6.39E+01	NA	2.0E-01

END

DATA ENTRY SHEET

RISK-BASED GROUNDWATER CONCENTRATION CALCULATIONS:

Indoor exposure groundwater conc., carcinogen (µg/L)	Indoor exposure groundwater conc., noncarcinogen (µg/L)	Risk-based indoor exposure groundwater conc., (µg/L)	Pure component water solubility, S (µg/L)	Final indoor exposure groundwater conc., (µg/L)
NA	NA	NA	2.50E+04	NA

INCREMENTAL RISK CALCULATIONS:

Incremental risk from vapor intrusion to indoor air, carcinogen (unitless)	Hazard quotient from vapor intrusion to indoor air, noncarcinogen (unitless)
NA	3.2E-01

MESSAGE AND ERROR SUMMARY BELOW: (DO NOT USE RESULTS IF ERRORS ARE PRESENT)

SCROLL DOWN TO "END"

END

OUTDOOR WORKER

Parameter	Units	Commercial Worker Receptor Characteristics Adult	Remediation Worker Receptor Characteristics Adult
Age		20+ years	20+ years
Age range duration	y	55	55
Body weight (BW)	kg	70.7	70.7
Breathing height	cm	150	150
Inhalation rate (IRair)	m3/h	1.5	1.5
Inhalation rate (IRair)	m3/d	15.8	15.8
Time spent outdoors	h/d	8	8
	d/week	5	5
	w/y	48	19
non-winter weeks/year	w/y	35	NA
Exposure Duration (ED)	y	25	7
Averaging Time (NTT)	y	75	75
Averaging Time (NTT)	d	27,375	27,375
Averaging Time (TT)	d	9,125	2,555
AFinh	unitless	1	1
SA (hands and arms)	cm2	3,390	3,390
SL (hands)	kg/cm2	1.0E-07	1.0E-06
SL (arms)	kg/cm2	1.0E-08	1.0E-07
IRsoil	kg/d	2.0E-05	1.0E-04
IRground water	L/d	0.0	1.5
TEV	h/event	0.0	4.0

INHALATION OF OUTDOOR VAPOURS (from Soil)

$$V_{air} = \frac{\left(Civ \times \frac{Div}{H}\right)}{\left(BH \times \frac{WS}{L}\right)}$$

$$Avg.Exposure = \frac{V_{air} \times IR \times AFinh \times D1 \times D2 \times D3 \times D4}{AT}$$

where,

Civ	=	soil vapour concentration in equilibrium with impacted soil ($\mu g/cm^3$)
Div	=	effective vapour diffusion coefficient (cm^2/d)
H	=	depth to water table (cm)
L	=	longest lateral dimension for high impact area (cm)
BH	=	breathing height for the receptor (cm above ground surface)
WS	=	average wind speed (cm/d)
Vair	=	concentration of vapours in outdoor air ($\mu g/m^3$)
IR	=	receptor inhalation rate (m^3/h)
Afinh	=	inhalation absorption factor (unitless)
D1	=	hours per day of exposure (h/d)
D2	=	days per week of exposure (d/w)
D3	=	weeks per year of exposure (w/y)
D4	=	duration of exposure (y)
AT	=	averaging time (days over which exposure is averaged)

For the Worker

Civ	=	see over	$\mu g/cm^3$ (J-E Model)
Div	=	see over	cm^2/d (J-E Model)
H_1	=	30	cm (depth to soil impacts)
L_1	=	8,000	cm (longest dimension of impact area))
WS	=	1.70E+07	cm/d (wind speed = 2.2 m/s)
s/d		86400	

Note: HQ = Dose /InhR /TRV
ILCR = Dose / InhR x TRV

COPC	Civ ($\mu g/cm^3$)	Div (cm^2/d)	RfC or IUR $(mg/m^3)^{-1}$		Commercial Worker	Remediation Worker
Arsenic (TT)			3.0E-05	Vair (mg/m^3)	0.0E+00	0.0E+00
				Avg. Exposure (mg/d)	0.0E+00	0.0E+00
				HQ - indiv	0.0E+00	0.0E+00
Arsenic (NTT)			6.4	Vair (mg/m^3)	0.0E+00	0.0E+00
				Avg. Exposure (mg/d)	0.0E+00	0.0E+00
				ILCR - indiv	0.0E+00	0.0E+00
Benzene (NTT)	14.76	1,229	0.0033	Vair ($\mu g/m^3$)	1.9E-03	1.9E-03
				Avg. Exposure ($\mu g/d$)	1.1E+02	2.2E+02
				ILCR - indiv	**2.3E-05**	**4.5E-05**
Aliphatic C>10 to C12 (F2)	2.75	1,397	1.0	Vair ($\mu g/m^3$)	4.0E-04	4.0E-04
				Avg. Exposure ($\mu g/d$)	2.3E+01	4.6E+01
				HQ - indiv	1.5E-03	2.9E-03
Aliphatic C>12 to C16 (F2)	0.24	1,397	1.0	Vair ($\mu g/m^3$)	3.5E-05	3.5E-05
				Avg. Exposure ($\mu g/d$)	2.1E+00	4.0E+00
				HQ - indiv	1.3E-04	2.5E-04
Aromatic C>10 to C12 (F2)	2.36	1,397	0.2	Vair ($\mu g/m^3$)	3.4E-04	3.4E-04
				Avg. Exposure ($\mu g/d$)	2.0E+01	3.9E+01
				HQ - indiv	6.4E-03	1.2E-02
Aromatic C>12 to C16 (F2)	0.18	1,397	0.2	Vair ($\mu g/m^3$)	2.7E-05	2.7E-05
				Avg. Exposure ($\mu g/d$)	1.6E+00	3.0E+00
				HQ - indiv	4.9E-04	9.5E-04
				F2 SUM:	0.008	0.016

OUTDOOR WORKER

Parameter	Units	Commercial Worker Receptor Characteristics Adult	Remediation Worker Receptor Characteristics Adult
Age		20+ years	20+ years
Age range duration	y	55	55
Body weight (BW)	kg	70.7	70.7
Breathing height	cm	150	150
Inhalation rate (IRair)	m3/h	1.5	1.5
Inhalation rate (IRair)	m3/d	15.8	15.8
Time spent outdoors	h/d	8	8
	d/week	5	5
	w/y	48	19
non-winter weeks/year	w/y	35	NA
Exposure Duration (ED)	y	25	7
Averaging Time (NTT)	y	75	75
Averaging Time (NTT)	d	27,375	27,375
Averaging Time (TT)	d	9,125	2,555
AFinh	unitless	1	1
SA (hands and arms)	cm2	3,390	3,390
SL (hands)	kg/cm2	1.0E-07	1.0E-06
SL (arms)	kg/cm2	1.0E-08	1.0E-07
IRsoil	kg/d	2.0E-05	1.0E-04
IRground water	L/d	0.0	1.5
TEV	h/event	0.0	4.0

INHALATION OF OUTDOOR VAPOURS (from Ground Water)

$$V_{air} = \frac{\left(Civ \times \frac{Div}{H}\right)}{\left(BH \times \frac{WS}{L}\right)}$$

$$Avg.Exposure = \frac{V_{air} \times IR \times AFinh \times D1 \times D2 \times D3 \times D4}{AT}$$

where,

Civ	=	soil vapour concentration in equilibrium with impacted soil ($\mu g/cm^3$)
Div	=	effective vapour diffusion coefficient (cm^2/d)
H	=	depth to water table (cm)
L	=	longest lateral dimension for high impact area (cm)
BH	=	breathing height for the receptor (cm above ground surface)
WS	=	average wind speed (cm/d)
Vair	=	concentration of vapours in outdoor air (kg/m^3)
IR	=	receptor inhalation rate (m^3/h)
Afinh	=	inhalation absorption factor (unitless)
D1	=	hours per day of exposure (h/d)
D2	=	days per week of exposure (d/w)
D3	=	weeks per year of exposure (w/y)
D4	=	duration of exposure (y)
AT	=	averaging time (days over which exposure is averaged)

For the Worker

Civ	=	see over	$\mu g/cm^3$ (J-E Model)
Div	=	see over	cm^2/d (J-E Model)
H_1	=	120	cm (depth to water table)
L_1	=	8,000	cm (longest dimension of gw impact area))
WS	=	1.70E+07	cm/d (wind speed = 2.2 m/s)
s/d		86400	

COPC	Civ ($\mu g/cm^3$)	Div (cm^2/d)	RfC or IUR $(mg/m^3)^{-1}$		Commercial Worker	Remediation Worker
Aliphatic C>10 to C12 (F2)	2.7E+00	2.8E+02	1.0	Vair ($\mu g/m^3$)	2.0E-05	2.0E-05
				Avg. Exposure ($\mu g/d$)	1.2E+00	2.3E+00
				HQ - indiv	7.5E-05	1.5E-04
Aliphatic C>12 to C16 (F2)	2.4E-01	2.8E+02	1.0	Vair ($\mu g/m^3$)	1.8E-06	1.8E-06
				Avg. Exposure ($\mu g/d$)	1.0E-01	2.0E-01
				HQ - indiv	6.6E-06	1.3E-05
Aromatic C>10 to C12 (F2)	1.5E-01	2.9E+02	0.2	Vair ($\mu g/m^3$)	1.1E-06	1.1E-06
				Avg. Exposure ($\mu g/d$)	6.5E-02	1.3E-01
				HQ - indiv	2.0E-05	4.0E-05
Aromatic C>12 to C16 (F2)	3.1E-02	2.9E+02	0.2	Vair ($\mu g/m^3$)	2.4E-07	2.4E-07
				Avg. Exposure ($\mu g/d$)	1.4E-02	2.7E-02
				HQ - indiv	4.4E-06	8.6E-06
				F2 SUM:	1.1E-04	2.1E-04

APPENDIX C TOXICITY INFORMATION

C.1 GENERAL NOTES ON TOXICITY

Assessing Risks from Non-threshold Toxicants

Some chemicals are thought to pose a possibility of adverse effects at any level of exposure. For some of these chemicals, an estimated concentration can be compared to a Tumorigenic Concentration 05 (TC_{05}), the concentration in air associated with a 5% increase in incidence or mortality due to tumours, or some fraction of the TC_{05}. Alternatively, for these **non-threshold toxicants**, equations can be used to link risk levels to doses. This is commonly done using slope factors (usually expressed in units of $(mg/kg\text{-}bw/d)^{-1}$. The slope factor (SF) times the dose equals the lifetime incremental risk of an adverse health effect.

A third type of toxicity value for non-threshold toxicants is the Unit Risk (UR) which is multiplied by the estimated concentration in a particular environmental medium to calculate a risk value. For example, if the Inhalation Unit Risk (IUR) for a chemical in air is 4×10^{-7} $(\mu g/m^3)^{-1}$ and the concentration of that chemical in air is 3 $\mu g/m^3$, the risk level is approximately 1.2×10^{-6}.

The human health or laboratory animal information used to characterize these types of health effects typically occur at relatively high doses and equations are used to extrapolate to lower doses. The models used for extrapolation are intended to overestimate health risks.

Assessing Risks from Threshold Toxicants

Risks can be evaluated in several ways. One common approach is to compare the intake or dose estimates to "acceptable" doses. For chemicals considered to have thresholds below which adverse effects do not occur, the comparison is relatively straightforward. For these **threshold toxicants**, regulatory agencies establish toxicity values such as a reference dose (RfD) or tolerable daily intake (TDI). For each chemical to be assessed as a threshold toxicant, a Hazard Index is determined by dividing the estimated intake or dose by the benchmark value for that chemical. The Hazard Indices for individual chemicals can be summed to calculate an overall Hazard Index. Some regulatory agencies consider an overall Hazard Index greater than 1 to indicate a potential risk to the health of the exposed population.

While some toxicity values apply to total exposure, others apply to specific exposure pathways. For example, reference concentration (RfC) values for inhalation have been established for some chemicals. If the estimated concentration in air at the point of contact is less than the RfC, then adverse health effects should not occur.

The toxicity values for many chemicals are based on studies of laboratory animals. Both RfDs and RfCs are set at a fraction of the highest dose level that did no cause observable adverse effects.

This is called the No Observed Adverse Effect Level (NOAEL). The NOAEL is then divided by one or more factors to determine the RfD.

For example, the NOAEL often is divided by a factor of ten to account for variations between laboratory animals and people, and another factor of ten to account for sensitive people in the general population. Another factor of ten may be used if there are uncertainties about the laboratory data.

Information in These Profiles

The remainder of this Appendix presents brief toxicity profiles. For each COPC, there is a discussion of its potential to be a non-threshold toxicant, followed by a discussion of its potential to be a threshold toxicant. (Several of the COPCs subsequently are assessed for both types of toxicity.)

Each profile addresses exposures via oral routes, via inhalation, and via dermal contact (although the latter is not needed for this risk assessment).

The types of toxicity reference values (TRVs) used to describe the potential for non-threshold toxicity effects include:

- slope factors (SF)
- unit risk (UR) values
- risk based concentrations (RBC) for air

The types of TRVs used to describe the potential for threshold toxicity effects include:

- reference dose (RfD)
- reference concentration (RfC) in air
- tolerable concentration (TC) in air

In most cases, the most recently published values are used. If there are two or more values and it is not clear whether one reflects a more recent assessment than the other, then the more stringent value (the one that will produce the higher risk estimates) is used.

The main sources of the TRVs are: the MOE Guideline (and supporting documents), Health Canada, the U.S. EPA Integrated Risk Information System (IRIS), the Risk Assessment Information System (RAIS) maintained by Oak Ridge National Laboratory for the U.S. government, and the RBC Table prepared for Region III of the U.S. EPA. Full references are provided in at the end of this appendix.

The TRVs reflect assessments of toxicity information by scientists in the originating agencies. The details of those assessments are not repeated in the profiles.

Some of the TRVs are denoted as "provisional". These are used in this risk assessment if they are the most stringent and are likely to be adopted broadly.

C.2 BENZENE

As a Non-Threshold Toxicant

Benzene is classified as a non-threshold toxicant or carcinogen on the basis of occupational data and laboratory studies. Occupational exposures via inhalation have been associated with various types of leukemias. Studies in animals have demonstrated the development of various types of tumours by inhalation and by oral ingestion.

Being used in relatively large quantities in commerce, the toxicity of benzene has been assessed frequently. This has resulted in various modifications to toxicity values, although in recent years these modifications have been relatively few and relatively minor.

Toxicity reference values for oral ingestion include:

Value Type	Value	Reference
oral SF	0.31 $(mg/kg\text{-}bw/d)^{-1}$	Health Canada, 2004b from drinking water guideline
	0.00292 $(mg/kg\text{-}bw/d)^{-1}$	RAIS in 2003; used in MOE Guideline
	0.015 to 0.055 $(mg/kg\text{-}bw/d)^{-1}$	U.S. EPA IRIS since 2000

For this SSRA, the oral slope factor of 0.0292 $(mg/kg\text{-}bw/d)^{-1}$ was used. This value has been used by the MOE and is in the middle of the range currently cited by the U.S. EPA. The Health Canada value is not used. It was established as support for a drinking water guideline in 1986 using publications from 1978 to 1984. Considerable review and reassessment of the toxicity of benzene has taken place in the past 25 years.

Toxicity reference values for inhalation of vapours include:

Value Type	Value	Reference
inhalation SF	0.0146 $(mg/kg\text{-}bw/d)^{-1}$	Health Canada, 2004b
	0.0292 $(mg/kg\text{-}bw/d)^{-1}$	RAIS in 2003
unit risk	3.3×10^{-6}	Health Canada, 2004b
	8.3×10^{-6}	RAIS in 2003; used in MOE Guideline
	2.2 to 7.6×10^{-6}	U.S. EPS IRIS since 2000

For this SSRA, the unit risk of 3.3×10^{-6} is used. This value has been recommended by Health Canada, is slightly more stringent than the value used in the MOE Guideline, and is in the range currently cited by the U.S. EPA. This means that the incremental lifetime risk due to inhaling air that contains 1 $\mu g/m^3$ is 3.3×10^{-6}.

As a Threshold Toxicant

Benzene also can be assessed as a threshold toxicant. This often is not done because the toxicity reference values are considerably less stringent than those for non-threshold effects as illustrated by the following reference values.

Toxicity reference values for oral ingestion include:

Value Type	Value	Reference
oral RfD	0.004 mg/kg-bw/d	U.S. EPA IRIS since 2003
	0.005 mg/kg-bw/d	MOE Guideline

For this SSRA, the oral RfD of 0.004 mg/kg-bw/d is used. This value has been developed recently by the U.S. EPA and replaces the value used by the MOE in the Guideline. Health Canada has not established this type of toxicity reference value for benzene.

Toxicity reference values for inhalation include:

Value Type	Value	Reference
inhalation RfC	0.03 mg/m^3	U.S. EPA IRIS since 2000
	0.009 mg/m^3	MOE Guideline

For this SSRA, the inhalation RfC of 0.03 mg/m^3 is used. This value has been developed recently by the U.S. EPA and replaces the value used by the MOE in the Guideline. Health Canada has not established this type of toxicity reference value for benzene.

Dermal Contact Information

Health Canada recommends a relative dermal absorption factor of 0.08 for benzene (Health Canada, 2004a). This is the same value used in the MOE Guideline.

C.3 TOLUENE

As a Non-Threshold Toxicant

Toluene is not classified as a non-threshold toxicant. The U.S. EPA describes it as being not classifiable as to human carcinogenicity, largely because there is a lack of positive cancer data for humans and animals.

As a Threshold Toxicant

Toluene is classified as a threshold toxicant on the basis of occupational data and laboratory studies. Occupational exposures via inhalation have been associated with effects on the central nervous system. Relatively low exposures can cause drowsiness, ataxia, visual impairment, and headaches. Acute exposure can lead to narcosis. Studies in animals have demonstrated changes in liver and kidney. The toxicological assessment revised by the U.S. EPA in 2005 sets an RfD based on effects such as impaired colour vision, impaired hearing, and other effects on the central nervous system.

Toxicity reference values for oral ingestion include:

Value Type	Value	Reference
TDI	0.22 mg/kg-bw/d	Health Canada, 2004b
oral RfD	0.08 mg/kg-bw/d	U.S. EPA IRIS since 2005
	0.2 mg/kg-bw/d	MOE Guideline

For this SSRA, the oral RfD of 0.08 mg/kg-bw/d is used. This value is more stringent and more recent that the values used by Health Canada and in the MOE Guideline.

Toxicity reference values for inhalation include:

Value Type	Value	Reference
TC	3.8 mg/m^3	Health Canada, 2004b
inhalation RfC	5.0 mg/m^3	U.S. EPA IRIS since 2005
	0.4 mg/m^3	MOE Guideline

For this SSRA, the inhalation RfC of 5 mg/m³ is used. This value reflects the 2995 review by the U.S. EPA. (The value in the MOE Guideline is the former U.S. EPA RfC.) The origin is unclear for the more stringent TC value from Health Canada.

Dermal Contact Information

Health Canada recommends a relative dermal absorption factor of 0.12 for toluene (Health Canada, 2004a). This is the same value used in the MOE Guideline.

C.4 ETHYL BENZENE

As a Non-Threshold Toxicant

Ethyl benzene is not classified as a non-threshold toxicant. The U.S. EPA describes it as being not classifiable as to human carcinogenicity, largely because there is a lack of positive cancer data for humans. The International Agency for Research on Cancer (IARC) has classified ethyl benzene as a possible carcinogen based on results in animals exposed by inhalation; however, at this time it is standard practice in North America not to evaluate ethyl benzene as a non-threshold toxicant.

As a Threshold Toxicant

Ethyl benzene is classified as a threshold toxicant on the basis of occupational data and laboratory studies. Occupational exposures via inhalation have been associated with effects on the central nervous system. Relatively low exposures can cause visual impairment, dizziness, and headaches. Acute exposure can lead to narcosis. Studies in animals have demonstrated changes in liver and kidney function.

Toxicity reference values for oral ingestion include:

Value Type	Value	Reference
oral RfD	0.1 mg/kg-bw/d	U.S. EPA IRIS since 1991
	0.1 mg/kg-bw/d	MOE Guideline

For this SSRA, the oral RfD of 0.1 mg/kg-bw/d is used. This value is used by the U.S. EPA and in the MOE Guideline. Health Canada has not developed similar values for ethyl benzene

Toxicity reference values for inhalation include:

Value Type	Value	Reference
inhalation RfC	1 mg/m³	U.S. EPA IRIS since 1991
	1 mg/m³	MOE Guideline

For this SSRA, the inhalation RfC of 1 mg/m^3 is used. This value has been used for many years by the U.S. EPA and in the MOE Guideline. Health Canada has not developed similar values for ethyl benzene

Dermal Contact Information

Health Canada recommends a relative dermal absorption factor of 0.2 for ethyl benzene (Health Canada, 2004a). The same value is used in the MOE Guideline.

C.5 TOXICITY OF PETROLEUM HYDROCARBONS

Unlike individual chemicals, it is difficult to assess the potential risks posed by analytical results that reflect the presence of numerous constituents. In the case of total petroleum hydrocarbons (TPH), there are literally thousands of compounds that can be present. The relative abundance of these compounds can vary widely from site to site, and from one monitoring location to another on the same site.

The generic criteria used in Ontario were first established in 1993 and have been described by the MOE as "management numbers", not based on health risks but adequately protective against odours and staining. As a result, the generic criteria may not be well suited to evaluating the potential risks posed by the hydrocarbons present at the subject property.

In 1993, the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) was formed to develop scientifically defensible methods for establishing soil cleanup criteria for petroleum hydrocarbons. In 1997, the TPHCWG published a series of reports that describe its findings and an approach for assessing TPH. That approach requires that the TPH be resolved or divided into 13 fractions that are defined by molecular structure and Equivalent Carbon (EC) numbers. Aromatic hydrocarbons (those containing ring structures related to that of benzene) are differentiated from aliphatic hydrocarbons (those with straight or branched chain structures but no rings or closed loops). As a result, the Working Group has identified the following TPH fractions:

Aromatics:	Aliphatics:
EC_5 to EC_7 - benzene is the only member of this fraction	EC_5 to EC_6
$EC_{>7}$ to EC_8 - toluene is the only member of this fraction	$EC_{>6}$ to EC_8
$EC_{>8}$ to EC_{10}	$EC_{>8}$ to EC_{10}
$EC_{>10}$ to EC_{12}	$EC_{>10}$ to EC_{12}
$EC_{>12}$ to EC_{16}	$EC_{>12}$ to EC_{16}
$EC_{>16}$ to EC_{21}	$EC_{>16}$ to EC_{21}
$EC_{>21}$ to EC_{35}	

Each fraction has been assigned physical-chemical and toxicological properties based on the specific chemicals that are present in that fraction (TPHCWG, 1997; Gustafson *et al.*, 1997). The physical-chemical properties recommended by the TPHCWG are summarized in Table C1. Other physical-chemical properties needed for this risk assessment are provided in Table C2.

Two physical-chemical properties have been estimated specifically for this risk assessment from values for some of the individual chemicals in those fractions. As shown below, both parameters are directly proportional to carbon number:

C Number	Chemical	Critical Temperature (K)	Enthalpy of Vaporization (cal/mol)
6	n-hexane	507	value not found
	cyclohexane	554	value not found
	benzene	562	7,342
7	n-heptane	539	value not found
	toluene	593	7,930
8	ethyl benzene	617	8,501
	xylenes	615 to 650	8,500 to 8,600
	styrene	636	8,737
10	naphthalene	748	10,373
12	acenaphthene	803	12,155
13	fluorene	870	12,666
14	anthracene	873	13,121
16	fluoranthene	870	13,815
	pyrene	905	14,370

These values are taken from Perry *et al.*, 1984, and EQM, 2003.

Prior to selecting the values that appear in Table C2, the vapour transport model was run several times adjusting only the critical temperature or enthalpy of vaporization parameters to observe the sensitivity of the predicted vapour concentrations.

This showed that the predictions are relatively insensitive to both parameters, therefore the approximations are adequate for this risk assessment. One prerequisite is that the critical temperature must be greater than the normal boiling point temperature or else the model will produce error messages.
Also needed are toxicological values for the TPH fractions. These are shown in Table C3 along with the human health effect upon which the values are based.

Finally, the CCME estimates the percentages of TPHCWG fractions typically present in the CCME fractions (CCME, 2000). These are shown on Table C4.

TABLE C1 PHYSICAL-CHEMICAL CHARACTERISTICS OF TPH FRACTIONS

Fraction	Molecular Weight (g/mole)	Aqueous Solubility (mg/L)	Vapour Pressure (atm)	Henry's Law Constant (cm^3/cm^3)	Henry's Law Constant at Reference Temperature ($atm\text{-}m^3/mol$)
Aromatic C_5 to C_7	78	1800	1.3×10^{-1}	0.23	5.56×10^{-3}
Aromatic $C_{>7}$ to C_8	92	520	3.8×10^{-3}	0.27	6.63×10^{-3}
Aromatic $C_{>8}$ to C_{10}	120	65	6.3×10^{-3}	0.48	1.16×10^{-2}
Aromatic $C_{>10}$ to C_{12}	130	25	6.3×10^{-4}	0.14	3.37×10^{-3}
Aromatic $C_{>12}$ to C_{16}	150	5.8	4.8×10^{-5}	0.053	1.28×10^{-3}
Aromatic $C_{>16}$ to C_{21}	190	0.65	1.1×10^{-6}	0.013	3.14×10^{-4}
Aromatic $C_{>21}$ to C_{35}	240	0.0066	4.4×10^{-10}	0.00067	1.61×10^{-5}
Aliphatic C_5 to C_6	81	36	3.5×10^{-1}	33	0.793
Aliphatic $C_{>6}$ to C_8	100	5.4	6.3×10^{-2}	50	1.2
Aliphatic $C_{>8}$ to C_{10}	130	0.43	6.3×10^{-3}	80	1.93
Aliphatic $C_{>10}$ to C_{12}	160	0.034	6.3×10^{-4}	120	2.89
Aliphatic $C_{>12}$ to C_{16}	200	0.00076	4.8×10^{-5}	520	12.5
Aliphatic $C_{>16}$ to C_{21}	270	0.0000025	1.1×10^{-6}	4,900	118

Notes

All values taken from Gustafson *et al.* (1997).

Reference temperature typically is 20 or 25 °C (293 or 298 K).

TABLE C2 MORE PHYSICAL-CHEMICAL CHARACTERISTICS OF TPH FRACTIONS

Fraction	Organic Carbon Partition Coefficient (log)	Normal Boiling Point (K)	Critical Temperature (K)	Enthalpy of Vaporization at Normal Boiling Point (cal/mol)
Aromatic C_5 to C_7	1.9	350	562*	7,342*
Aromatic $C_{>7}$ to C_8	2.4	383	593*	7,930*
Aromatic $C_{>8}$ to C_{10}	3.2	423	~600	~8,500
Aromatic $C_{>10}$ to C_{12}	3.4	473	~700	~10,500
Aromatic $C_{>12}$ to C_{16}	3.7	533	~800	~13,500
Aromatic $C_{>16}$ to C_{21}	4.2	593	~900	~15,000
Aromatic $C_{>21}$ to C_{35}	5.1	613	~900	~15,000
Aliphatic C_5 to C_6	2.9	324	~500	~6,500
Aliphatic $C_{>6}$ to C_8	3.6	369	~550	~7,000
Aliphatic $C_{>8}$ to C_{10}	4.5	423	~600	~8,500
Aliphatic $C_{>10}$ to C_{12}	5.4	473	~700	~11,000
Aliphatic $C_{>12}$ to C_{16}	6.7	533	~800	~13,500
Aliphatic $C_{>16}$ to C_{21}	8.8	593	~900	~15,000

Notes

All values taken from Gustafson *et al.*, 1997 except those marked with an * which are taken from Perry *et al.*, 1984, and except for the approximations which are described further in Appendix C.

In addition, all fractions are assigned a value of 0.1 cm^2/s for diffusivity in air and a value of 1×10^{-5} cm^2/s for diffusivity in water (Gustafson *et al.*, 1997).

TABLE C3 TOXICOLOGICAL CHARACTERISTICS OF TPH FRACTIONS

Fraction	Oral RfD (mg/kg-bw/d)	Inhalation RfC ($\mu g/m^3$)	Critical Effect
Aromatic $C_{>7}$ to C_8	0.2	400	liver and kidney weight changes
Aromatic $C_{>8}$ to C_{10}	0.04	200	decreased body weight
Aromatic $C_{>10}$ to C_{12}	0.04	200	decreased body weight
Aromatic $C_{>12}$ to C_{16}	0.04	200	decreased body weight
Aromatic $C_{>16}$ to C_{21}	0.03	No value	nephrotoxicity
Aromatic $C_{>21}$ to C_{34}	0.03	No value	nephrotoxicity
Aromatic $C_{>34}$	0.03	No value	nephrotoxicity
Aliphatic C_5 to C_6	5	18,400	neurotoxicity
Aliphatic $C_{>6}$ to C_8	5	18,400	neurotoxicity
Aliphatic $C_{>8}$ to C_{10}	0.1	1,000	hepatic and hematological changes
Aliphatic $C_{>10}$ to C_{12}	0.1	1,000	hepatic and hematological changes
Aliphatic $C_{>12}$ to C_{16}	0.1	1,000	hepatic and hematological changes
Aliphatic $C_{>16}$ to C_{21}	2	No value	hepatic (foreign body reaction) granuloma
Aliphatic $C_{>21}$ to C_{32}	2	No value	hepatic (foreign body reaction) granuloma
Aliphatic $C_{>34}$	20	No value	hepatic (foreign body reaction) granuloma

Notes

For Aromatic $C_{>6}$ to C_7 (benzene), the U.S. EPA has established a slope factor of 0.029 $(\mu g/kg\text{-}bw/d)^{-1}$.

All entries taken from TPHCWG (1997).

TABLE C4 TYPICAL COMPOSITION OF TPHCWG FRACTIONS IN CCME FRACTIONS

TPHCWG Fraction	CCME Fraction 1 (F1)	CCME Fraction 2 (F2)	CCME Fraction 3 (F3)	CCME Fraction 4 (F4)
Aliphatic C_5 to C_6				
Aliphatic $C_{>6}$ to C_8	0.55			
Aliphatic $C_{>8}$ to C_{10}	0.36			
Aliphatic $C_{>10}$ to C_{12}		0.36		
Aliphatic $C_{>12}$ to C_{16}		0.44		
Aliphatic $C_{>16}$ to C_{21}			0.56	
Aliphatic $C_{>21}$ to C_{34}			0.24	
Aliphatic $C_{>34}$				0.8
Aromatic $C_{>7}$ to C_8				
Aromatic C_8 to C_{10}	0.09			
Aromatic $C_{>10}$ to C_{12}		0.09		
Aromatic $C_{>12}$ to C_{16}		0.11		
Aromatic $C_{>16}$ to C_{21}			0.14	
Aromatic $C_{>21}$ to C_{34}			0.06	
Aromatic $C_{>34}$				0.2

Notes

While the TPHCWG describes fractions that include all compounds between C_5 to C_{34}, the CCME defines fractions between C_6 to $C_{>34}$. These are small differences and unlikely to be important in most risk assessments.

C.6 TOXICITY OF SODIUM

As a Non-Threshold Toxicant

Sodium is an essential mineral and therefore is not a non-threshold toxicant. There is some evidence to suggest that sodium chloride may be a gastric tumour promoter in experimental animals, and high intakes of sodium chloride have been associated with incidences of stomach cancers in human population (EGVM, 2003a), but this aspect of the toxicity of sodium is not well understood.

As a Threshold Toxicant

Sodium is classified as an essential mineral and as a threshold toxicant on the basis of laboratory studies and studies of human populations and individuals.

Too little intake of sodium (around 500 mg/d) can lead to low blood pressure, dehydration and muscle cramps (EGVM, 2003a).

To avoid deficiencies, various regulatory agencies have established recommended intake rates. Health Canada recommends adequate intake (AI) rates in the range of 1,000 to 1,500 mg/d for children over 1 year through to adults. It also recommends Upper Limits (UL) in the range of 1,500 to 2,300 mg/d (Health Canada, 2006).

In the United Kingdom, the recommended normal intake (RNI) is 1,600 mg/d for adults (EGVM, 2003a).

Intake of more than 6,000 mg/d can result in hypertension and increased blood pressure. Excessive intake (around 500 to 1,000 mg/kg/d) can cause vomiting, ulcers in the gastrointestinal tract, muscle weakness, kidney damage, and severe effects on the central nervous system (EGVM, 2003a).

An extensive review of the literature found no officially recommended threshold for sodium in either Canada or the United States. In the absence of formal guidance, an upper limit of 2,400 mg/d of sodium often is recommended by medical professionals to people on salt restricted diets (Bright and Addison, 2002).

While the usual types of TRVs have not been set for sodium, the following nutritional values have been recommended. They apply to total daily intakes.

Value Type	Value	Reference
AI	1000 to 1,500 mg/d	Health Canada, 2006
UL	1,500 to 2,300 mg/d	Health Canada, 2006
RNI	1,600 mg/d	EGVM, 2003a

For this SSRA, the UL of 2,300 mg/d is used. It is the UL recommended by Health Canada for people over the age of 1 year. The receptor of interest is the Outdoor Worker, an adult.

TRVs for inhalation have not been established for sodium. That pathway is not complete for the Outdoor Worker.

TRVs for dermal contact have not been established for sodium; however, that pathway is complete for the Outdoor Worker. The U.S. EPA often estimates dermal RfD values from an oral RfD and the gastrointestinal absorption factor. For this RA, the gastrointestinal absorption factor is assumed to be the maximum value of 1 (that value appears in RAIS, 2007), therefore, the TRV for dermal contact is equal to that used for oral ingestion.

Dermal Contact Information

Health Canada recommends a relative absorption factor (RAF) for dermal contact of 0.001 for inorganics if a chemical-specific value has not been established (Health Canada, 2004). That same value appears in RAIS, 2007.

For dermal contact with ground water, the U.S. EPA recommends a permeability coefficient (sometimes called the permeability constant) of 0.001 cm/h (U.S. EPA, 2004; RAIS, 2007).

C.7 TOXICITY OF CHLORIDES

As a Non-Threshold Toxicant

Chlorides is an essential mineral and therefore is not a non-threshold toxicant. There is some evidence to suggest that sodium chloride may be a gastric tumour promoter in experimental animals. High intakes of sodium chloride have been associated with incidences of stomach cancers in human population (EGVM, 2003a), but this aspect of the toxicity of chlorides is not well understood.

As a Threshold Toxicant

Chlorides is classified as an essential mineral and as a threshold toxicant on the basis of laboratory studies and studies of human populations and individuals.

Too little intake of chlorides (around 9 mg/kg-bw/d) can lead to alkosis, in which blood becomes overly alkaline, loss of appetite, lethargy, and muscle weakness (MRI, 2003).

To avoid deficiencies, various regulatory agencies have established recommended intake rates. Health Canada recommends adequate intake (AI) rates in the range of 1,500 to 2,300 mg/d for children over 1 year through to adults. It also recommends Upper Limits (UL) in the range of 2,300 to 3,600 mg/d (Health Canada, 2006).

Chlorides toxicity rarely is observed in people except individuals with impaired sodium chloride metabolism (i.e. congestive heart failure). Healthy individuals can tolerate a large intake of chlorides provided there is a corresponding intake of water (WHO, 1996).

Excessive sodium chloride intake (at concentrations above 2.5 g/L) can cause dehydration, although this may be due to the sodium (WHO, 1996). Excess chlorides intake may elevate blood pressure in individuals sensitive to salt.

An extensive review of the literature found no officially recommended threshold for chlorides in either Canada or the United States ((Bright and Addison, 2002).

Oral LD_{50} values (does lethal to 50% of subjects) in the range of 1 to 3 g/kg-bw have been observed in rats (WHO, 1996).

While the usual types of TRVs have not been set for chlorides, the following nutritional values have been recommended. They apply to total daily intakes.

Value Type	Value	Reference
AI	1,500 to 2,300 mg/d	Health Canada, 2006
UL	2,300 to 3,600 mg/d	Health Canada, 2006

For this RA, the UL of 3,600 mg/d is used. It is recommended by Health Canada for people over the age of 1 year. The receptor of interest is the Outdoor Worker, an adult.

TRVs for inhalation have not been established for chlorides. That pathway is not complete for the Outdoor Worker.

TRVs for dermal contact have not been established for chlorides; however, that pathway is complete for the Outdoor Worker. The U.S. EPA often estimates dermal RfD values from an oral RfD and the gastrointestinal absorption factor. For this RA, the gastrointestinal absorption factor

is assumed to be the maximum value of 1 (that value appears in RAIS, 2007), therefore, the TRV for dermal contact is equal to that used for oral ingestion.

Dermal Contact Information

Health Canada recommends a relative dermal absorption factor of 0.001 for inorganics if a chemical-specific value has not been established (Health Canada, 2004). That same value appears in RAIS, 2007.

For dermal contact with ground water, the U.S. EPA recommends a permeability coefficient (sometimes called the permeability constant) of 0.001 cm/h (U.S. EPA, 2004; RAIS, 2007).

C.8 TOXICITY OF ARSENIC

As a non-threshold toxicant

Arsenic is classified by the U.S. EPA as A, a human carcinogen based on occupational epidemiological studies in addition to mortality in human populations due to inhalation (IRIS, 1998). Also observed is mortality due to multiple organ cancers (liver, lung, kidney and bladder) and skin cancer due to consumption of arsenic in water supplies.

The toxicity information is available for arsenic as a non-threshold toxicant.

There is no Oral Slope Factor for oral ingestions or dermal Slope Factor for dermal contact (IRIS, 1992)

Toxicity reference values for inhalation include:

Value Type	Value	Reference
IUR	6.4 $(mg/m^3)^{-1}$	Health Canada, 2004b

For this SSRA, the Health Canada IUR of 6.4 $(mg/m^3)^{-1}$ is used.

Toxicity reference values for ingestion include:

Value Type	Value	Reference
Oral Slope factor	2.8 $(mg/kg\text{-}bw/d)^{-1}$	Health Canada, 2004b based on $TD_{0.5}$
RfD	1.5 $(mg/kg\text{-}bw/d)^{-1}$	IRIS, 1993

For this SSRA, the Health Canada Oral Slope Factor of 2.8 $(mg/kw\text{-}bw/d)^{-1}$ is used.

Toxicity reference values for dermal contact include:

Value Type	Value	Reference
dermal RfD	2.8 $(mg/kg\text{-}bw/d)^{-1}$	see discussion

This SSRA uses the dermal RfD of 2.8 $(mg/kg\text{-}bw/d)^{-1}$. It is based on the oral slope factor selected above multiplied by the gastrointestinal absorption factor of 1.

As a threshold toxicant

Arsenic is also classified as a threshold toxicant on the basis that thresholds exist that result in certain toxic effects such as hyperpigmentation, keratosis and possible vascular complications (IRIS, 1993). Exposures can lead to various types of health effects on the kidneys and the blooding forming system.

Toxicity reference values for oral ingestion include:

Value Type	Value	Reference
TDI	0.0003 mg/kg-bw/d	U.S. EPA IRIS, 1993

This SSRA uses the oral RfD of 0.0003 mg/kg-bw/d from U.S. EPA IRIS.

Toxicity reference values for inhalation include:

Value Type	Value	Reference
RfC	3×10^{-5} mg/m^3	CalEPA, 2000
	1.5×10^{-5} mg/m^3	CalEPA, 2009

This SSRA uses the RfC of 0.000015 mg/m^3 from CalEPA, 2009.

Toxicity reference values for dermal contact include:

Value Type	Value	Reference
dermal RfD	3×10^{-4} mg/kg-bw/d	see discussion

This SSRA uses the dermal RfD of 3×10^{-4} mg/kg-bw/d. It is based on the ingestion RfD selected above multiplied by the gastrointestinal absorption factor of 1.

Dermal Contact Information

Health Canada recommends a relative dermal absorption factor of 0.03 (Health Canada, 2004a).

Inhalation absorption factors

CalEPA recommends a relative inhalation absorption factor of 0.5 (CalEPA, 2008).

Uncertainty Factors

Type of TRV	UF	MF	Confidence Level	Key Studies Conducted
Oral RfD	3 (due to lack of reproductive toxicity data)	1	Medium	Based on studies of blackfoot disease and incidence of skin cancer (Tseng 1968 and 1977).

C.9 REFERENCES FOR THIS APPENDIX

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APPENDIX D SUMMARY OF RISK CALCULATIONS

OUTDOOR WORKER

Parameter	Units	Commercial Worker Receptor Characteristics Adult	Remediation Worker Receptor Cha Adult
Age		20+ years	20+ years
Age range duration	y	55	55
Body weight (BW)	kg	70.7	70.7
Breathing height	cm	150	150
Inhalation rate (IRair)	m3/h	1.5	1.5
Inhalation rate (IRair)	m3/d	15.8	15.8
Time spent outdoors	h/d	8	8
	d/week	5	5
	w/y	48	19
non-winter weeks/year	w/y	35	NA
Exposure Duration (ED)	y	25	7
Averaging Time (NTT)	y	75	75
Averaging Time (NTT)	d	27,375	27,375
Averaging Time (TT)	d	9,125	2,555
AFinh	unitless	1	1
SA (hands and arms)	cm2	3,390	3,390
SL (hands)	kg/cm2	1.0E-07	1.0E-06
SL (arms)	kg/cm2	1.0E-08	1.0E-07
IRsoil	kg/d	2.0E-05	1.0E-04
IRground water	L/d	0.0	1.5
TEV	h/event	0.0	4.0

INHALATION OF SOIL PARTICLES (fugitive dust)

$$\text{Dose} = \frac{Cs \times Pair \times IRair \times AFinh \times D1 \times D2 \times D3 \times D4}{BW \times AT}$$

Cs = concentration of COC in soil (µg/g = mg/kg)
Pair = concentration of soil particles in air (kg/m3)
IRair = receptor's inhalation rate (m^3/h)
AF inh = inhalation absorption factor (unitless)
D1 = hours per day of exposure (h/d)
D2 = days per week of exposure (d/w)
D3 = weeks per year of exposure (w/y)
D4 = duration of exposure (y)
BW = receptor's body weight (kg)
AT = averaging time (days)
Pair = 2.50E-07 (remediation)
kg/m^3'= 250 µg/m^3; Health Canada, 2004
Pair = 7.60E-10 (commercial)
The commercial worker is assumed to inhale respirable particles, those with diameter of 0.76 µg/m3.

The remediation worker is assumed to inhale airborne particles, those with diameter of 0.250 µg/m3.

For a threshold toxicant (tt), HQ = (avg. daily dose x bw ÷ inh. rate m3/d) ÷ TRV
For a non-threshold toxicant (ntt), ILCR = (avg. daily dose x bw ÷ inh. rate m3

Note: HQ = (Dose x BW / InhR)/TRV
ILCR = (Dose x BW / InhR) x TRV

COC	Cs	TRV	AF inh
Arsenic (TT)	110	1.5E-05	0.5
Arsenic (NTT)	110	6.4	0.5
Benzene (NTT)	2	0.0033	
Aliphatic C>10 to C12 (F2)	2,678	1.00	
Aliphatic C>12 to C16 (F2)	3,274	1.00	
Aromatic C>10 to C12 (F2)	670	0.20	
Aromatic C>12 to C16 (F2)	818	0.20	
Aliphatic C>16 to C21 (F3)	2,380	NSV	
Aliphatic C>21 to C34 (F3)	1,020	NSV	
Aromatic C>16 to C21 (F3)	595	NSV	
Aromatic C>21 to C34 (F3)	255	NSV	

	Commercial Worker	Remediation Worker
Dose	2.3E-09	5.7E-08
HQ	0.001	0.017
Dose	2.3E-09	6.1E-07
ILCR	3.3E-11	1.7E-05
Dose	9.3E-11	1.7E-08
ILCR	1.4E-12	2.4E-10
Dose	1.7E-07	2.8E-06
HQ	7.4E-07	1.2E-05
Dose	2.0E-07	3.4E-06
HQ	9.1E-07	1.5E-05
Dose	4.1E-08	6.9E-07
HQ	9.3E-07	1.5E-05
Dose	5.1E-08	8.4E-07
HQ	1.1E-06	1.9E-05
Dose	1.5E-07	2.5E-06
HQ	#VALUE!	#VALUE!
Dose	6.3E-08	1.1E-06
HQ	#VALUE!	#VALUE!
Dose	3.7E-08	6.1E-07
HQ	#VALUE!	#VALUE!
Dose	1.6E-08	2.6E-07
HQ	#VALUE!	#VALUE!

F2 SUM: 3.7E-06 6.2E-05
F3 SUM: There are no TRV for inhalation for PHC F3

OUTDOOR WORKER

Parameter	Units	Commercial Worker Receptor Characteristics Adult	Remediation Worker Receptor Cha Adult
Age		20+ years	20+ years
Age range duration	y	55	55
Body weight (BW)	kg	70.7	70.7
Breathing height	cm	150	150
Inhalation rate (IRair)	m3/h	1.5	1.5
Inhalation rate (IRair)	m3/d	15.8	15.8
Time spent outdoors	h/d	8	8
	d/week	5	5
	w/y	48	19
non-winter weeks/year	w/y	35	NA
Exposure Duration (ED)	y	25	7
Averaging Time (NTT)	y	75	75
Averaging Time (NTT)	d	27,375	27,375
Averaging Time (TT)	d	9,125	2,555
AFinh	unitless	1	1
SA (hands and arms)	cm2	3,390	3,390
SL (hands)	kg/cm2	1.0E-07	1.0E-06
SL (arms)	kg/cm2	1.0E-08	1.0E-07
IRsoil	kg/d	2.0E-05	1.0E-04
IRground water	L/d	0.0	1.5
TEV	h/event	0.0	4.0

DERMAL CONTACT WITH SOIL

$$\text{Dose} = \frac{Cs \times SA \times SL \times AFderm \times EF \times D1 \times D2 \times D3}{BW \times AT}$$

where,

Cs	=	concentration of COC in soil (µg/g = mg/kg)
SA	=	receptor's skin area exposed to soil (cm2/event)
SL	=	soil loading on exposed skin (kg/cm2)
AFderm	=	dermal absorption factor (unitless and COC-specific)
EF	=	events per day = 1
D1	=	days per week of exposure (d/w)
D2	=	weeks per year of exposure (w/y)
D3	=	duration of exposure (y)
BW	=	receptor's body weight (kg)
AT	=	averaging time (days over which exposure is averaged)

Note: HQ = Total Dose/TRV
ILCR = Total Dose * TRV

COC	Cs	AFderm	TRV		Commercial Worker	Remediation Worker
Arsenic (TT)	110	0.03	3.0E-04	Dose (hands)	7.6E-06	4.1E-05
				Dose (arms)	7.6E-07	4.1E-06
				HQ	0.028	0.151
Arsenic (NTT)	110	0.03	2.8	Dose (hands)	7.6E-06	4.1E-05
				Dose (arms)	7.6E-07	4.1E-06
				ILCR	**2.3E-05**	**1.3E-04**
Benzene (NTT)	2	0.08	0.0292	Dose (hands)	9.2E-08	1.4E-07
				Dose (arms)	9.2E-09	1.4E-08
				ILCR	3.0E-09	4.5E-09
Aliphatic C>10 to C12 (F2)	2,678	0.20	0.10	Dose (hands)	1.2E-03	6.7E-03
				Dose (arms)	1.2E-04	6.7E-04
				HQ	0.01	0.07
Aliphatic C>12 to C16 (F2)	3,274	0.20	0.10	Dose (hands)	1.5E-03	8.2E-03
				Dose (arms)	1.5E-04	8.2E-04
				HQ	0.02	0.09
Aromatic C>10 to C12 (F2)	670	0.20	0.04	Dose (hands)	3.1E-04	1.7E-03
				Dose (arms)	3.1E-05	1.7E-04
				HQ	0.01	0.05
Aromatic C>12 to C16 (F2)	818	0.20	0.04	Dose (hands)	3.8E-04	2.0E-03
				Dose (arms)	3.8E-05	2.0E-04
				HQ	0.01	0.06
Aliphatic C>16 to C21 (F3)	2,380	0.20	2.00	Dose (hands)	1.1E-03	5.9E-03
				Dose (arms)	1.1E-04	5.9E-04
				HQ	0.001	0.003
Aliphatic C>21 to C34 (F3)	1,020	0.20	2.00	Dose (hands)	4.7E-04	2.5E-03
				Dose (arms)	4.7E-05	2.5E-04
				HQ	0.000	0.001
Aromatic C>16 to C21 (F3)	595	0.20	0.03	Dose (hands)	2.7E-04	1.5E-03
				Dose (arms)	2.7E-05	1.5E-04
				HQ	0.010	0.054
Aromatic C>21 to C34 (F3)	255	0.20	0.03	Dose (hands)	1.2E-04	6.4E-04
				Dose (arms)	1.2E-05	6.4E-05
				HQ	0.004	0.023
				F2 SUM:	0.05	**0.27**
				F3 SUM:	0.02	0.08

OUTDOOR WORKER

Parameter	Units	Commercial Worker Receptor Characteristics Adult	Remediation Worker Receptor Cha Adult
Age		20+ years	20+ years
Age range duration	y	55	55
Body weight (BW)	kg	70.7	70.7
Breathing height	cm	150	150
Inhalation rate (IRair)	m3/h	1.5	1.5
Inhalation rate (IRair)	m3/d	15.8	15.8
Time spent outdoors	h/d	8	8
	d/week	5	5
	w/y	48	19
non-winter weeks/year	w/y	35	NA
Exposure Duration (ED)	y	25	7
Averaging Time (NTT)	y	75	75
Averaging Time (NTT)	d	27,375	27,375
Averaging Time (TT)	d	9,125	2,555
AFinh	unitless	1	1
SA (hands and arms)	cm2	3,390	3,390
SL (hands)	kg/cm2	1.0E-07	1.0E-06
SL (arms)	kg/cm2	1.0E-08	1.0E-07
IRsoil	kg/d	2.0E-05	1.0E-04
IRground water	L/d	0.0	1.5
TEV	h/event	0.0	4.0

INGESTION OF SOIL

$$\text{Dose} = \frac{Cs \times IRsoil \times AFgit \times D1 \times D2 \times D3}{BW \times AT}$$

where,

Cs = concentration of COC in soil (µg/g = mg/kg)
IRsoil = receptor's soil ingestion rate (kg/d)
AFgit = ingested soil absorption faction in the G-I tract (unitless)
D1 = days per week of exposure (d/w)
D2 = weeks per year of exposure (w/y)
D3 = duration of exposure (y)
BW = receptor's body weight (kg)
AT = averaging time (days over which exposure is averaged)

Note: HQ = Dose/TRV
ILCR = Dose * TRV

COC	Cs	AFgit	TRV		Commercial Worker	Remediation Worker
Arsenic	110	0.41	0.0003	Dose (ingest)	6.1E-06	1.7E-05
TT				HQ	0.020	0.055
Arsenic	110	0.41	2.8	Dose (ingest)	6.1E-06	1.7E-05
NTT				ILCR	**1.7E-05**	**4.6E-05**
Benzene	2	1.0	0.0292	Dose (ingest)	2.0E-07	5.5E-07
NTT				ILCR	5.9E-09	1.6E-08
Aliphatic C>10 to C12 (F2)	2,678	1.0	0.10	Dose (ingest)	3.6E-04	9.9E-04
				HQ	0.004	0.010
Aliphatic C>12 to C16 (F2)	3,274	1.0	0.10	Dose (ingest)	4.4E-04	1.2E-03
				HQ	0.004	0.012
Aromatic C>10 to C12 (F2)	670	1.0	0.04	Dose (ingest)	9.1E-05	2.5E-04
				HQ	0.002	0.006
Aromatic C>12 to C16 (F2)	818	1.0	0.04	Dose (ingest)	1.1E-04	3.0E-04
				HQ	0.003	0.008
Aliphatic C>16 to C21 (F3)	2,380	1.0	2.00	Dose (ingest)	3.2E-04	8.8E-04
				HQ	0.0002	0.0004
Aliphatic C>21 to C34 (F3)	1,020	1.0	2.00	Dose (ingest)	1.4E-04	3.8E-04
				HQ	0.0001	0.0002
Aromatic C>16 to C21 (F3)	595	1.0	0.03	Dose (ingest)	8.1E-05	2.2E-04
				HQ	0.0027	0.0073
Aromatic C>21 to C34 (F3)	255	1.0	0.03	Dose (ingest)	3.5E-05	9.4E-05
				HQ	0.0012	0.0031
				F2 SUM:	0.01	0.04
				F3 SUM:	0.004	0.011

OUTDOOR WORKER

Parameter	Units	Commercial Worker Receptor Characteristics Adult	Remediation Worker Receptor Characteristics Adult
Age		20+ years	20+ years
Age range duration	y	55	55
Body weight (BW)	kg	70.7	70.7
Breathing height	cm	150	150
Inhalation rate (IRair)	m3/h	1.5	1.5
Inhalation rate (IRair)	m3/d	15.8	15.8
Time spent outdoors	h/d	8	8
	d/week	5	5
	w/y	48	19
non-winter weeks/year	w/y	35	NA
Exposure Duration (ED)	y	25	7
Averaging Time (NTT)	y	75	75
Averaging Time (NTT)	d	27,375	27,375
Averaging Time (TT)	d	9,125	2,555
AFinh	unitless	1	1
SA (hands and arms)	cm2	3,390	3,390
SL (hands)	kg/cm2	1.0E-07	1.0E-06
SL (arms)	kg/cm2	1.0E-08	1.0E-07
IRsoil	kg/d	2.0E-05	1.0E-04
IRground water	L/d	0.0	1.5
TEV	h/event	0.0	4.0

DERMAL CONTACT WITH GROUND WATER

Dose = $\frac{DA_{event} \times EV \times ED \times EF \times SA}{BW \times AT}$

where,

DA_{event} = absorbed dose per event (mg/cm^2)
EV = event frequency (events/ day) = 1
ED = exposure duration (years)
EF = exposure frequency (days/ year)
SA = skin area for contact (cm^2) (hands and forearms)
BW = receptors body weight (kg)
AT = averaging time (days over which exposure is averaged)
= ED x 365 d/y for threshold toxicants
= 365 d/y x 70 y for non-threshold toxicants

DA_{event} = $K_p \times C_w \times T_{ev}$
K_p = dermal permeability coefficient of the compound in water (cm/ h)
(from Health Canada, 2008)
C_w = concentration in water (mg/ cm^3)
(1 µg/L = 1/1000 µg/mg/1000 cm^3/L)
T_{ev} = event duration (h/event)
see above (varies with receptor)

Note: HQ = Dose/TRV

COC	Cw (µg/L)	Kp	TRV		Commercial Worker	Remediation Worker
Sodium	17,800,000			DAevent		
				Dose	the	
				HQ	adult	
Chlorides	33,300,000			DAevent	commercial	
				Dose	worker	
				HQ	does	
Aliphatic C>10 to C12 (F2)	62.4	2.90	0.10	DAevent	not	7.2E-04
				Dose	come	9.0E-03
				HQ	into	0.090
Aliphatic C>12 to C16 (F2)	2.6	18.66	0.10	DAevent	direct	1.9E-04
				Dose	contact	2.4E-03
				HQ	with	0.024
Aromatic C>10 to C12 (F2)	1567.8	0.10	0.04	DAevent	ground	6.4E-04
				Dose	water	8.0E-03
				HQ		0.200
Aromatic C>12 to C16 (F2)	964.6	0.16	0.04	DAevent		6.0E-04
				Dose		7.5E-03
				HQ		0.187
Aliphatic C>16 to C21 (F3)	0	432.51	2.00	DAevent		0.0E+00
				Dose		0.0E+00
				HQ		0.000
Aliphatic C>21 to C34 (F3)	0	1.5E+05	2.00	DAevent		0.0E+00
				Dose		0.0E+00
				HQ		0.000
Aromatic C>16 to C21 (F3)	1140	0.24	0.03	DAevent		1.1E-03
				Dose		1.3E-02
				HQ		0.448
Aromatic C>21 to C34 (F3)	60	0.48	0.03	DAevent		1.2E-04
				Dose		1.4E-03
				HQ		0.048
Aliphatic C>34 (F4)	0	1.9E+09	20.00	DAevent		0.0E+00
				Dose		0.0E+00
				HQ		0.000
Aromatic C>34 (F4)	620	0.64	0.03	DAevent		1.6E-03
				Dose		2.0E-02
				HQ		0.663

F2 SUM: **0.50**
F3 SUM: **0.50**
F4 SUM: **0.66**

Appendix F

Remedial Cost Summary Tables

TABLE F.1
ESTIMATED COSTS
EXCAVATION WITH OFFSITE DISPOSAL
WEST WHARF - OSHAWA HARBOUR
OSHAWA, ONTARIO

Item	Quantity	Unit	Unit Rate	Cost
Excavate and Load Soil	10575	m^3	$4.00	$42,300.00
Transport and Landfill Disposal of Soil	21150	tonne	$55.00	$1,163,250.00
Supply, place and compact imported fill	21150	tonne	$20.00	$423,000.00
Excavation Dewatering/Treatment System	1	LS	$85,000.00	$85,000.00
Operate and maintain dewatering/pumping equipment [during excavation and backfilling operations, includes sanitary sewer disposal fee]	25	day	$1,500.00	$37,500.00
Trenching and Liner Installation	240	L.m	$400.00	$96,000.00
Consulting (management and field supervision)	30	day	$2,400.00	$72,000.00
Consulting (permits, approvals, specifications, reporting)	1	LS	$100,000.00	$100,000.00
			sub-total	$2,019,050.00
		15%	contingency	$302,857.50
			Total	**$2,321,907.50**

TABLE F.2
ESTIMATED COSTS
EXCAVATION WITH SOIL TRANSFER AND OFFSITE DISPOSAL
WEST WHARF - OSHAWA HARBOUR
OSHAWA, ONTARIO

Item	Quantity	Unit	Unit Rate	Cost
Excavate and Load Soil	10575	m^3	$4.00	$42,300.00
Transport and Landfill Disposal of PHC contaminated soil	12600	tonne	$55.00	$693,000.00
Transfer metals contaminated soil to South Rail Spur	4275	m^3	$5.00	$21,375.00
Supply, place and compact imported fill	21150	tonne	$20.00	$423,000.00
Excavation Dewatering/Treatment System	1	LS	$85,000.00	$85,000.00
Operate and maintain dewatering/pumping equipment [during excavation and backfilling operations, includes sanitary sewer disposal fee]	25	day	$1,500.00	$37,500.00
Trenching and Liner Installation	240	L.m	$400.00	$96,000.00
Consulting (management and field supervision)	30	day	$2,400.00	$72,000.00
Consulting (permits, approvals, specifications, reporting)	1	LS	$100,000.00	$100,000.00
			sub-total	$1,570,175.00
		15%	contingency	$235,526.25
			Total	**$1,805,701.25**

TABLE F.3
ESTIMATED COSTS
ASPHALT CAP
WEST WHARF - OSHAWA HARBOUR
OSHAWA, ONTARIO

Item	Quantity	Unit	Unit Rate	Cost
Supply, place and compact granular base and asphalt	6000	m^2	$50.00	$300,000.00
Cap Monitoring and Maintainence Program (30 years) [1]	1	PW	$170,000.00	$170,000.00
Consulting (field supervision/cap inspection)	5	day	$1,500.00	$7,500.00
Consulting (design, specifications, cap monitoring and maintenance plan, reporting)	1	LS	$75,000.00	$75,000.00
			sub-total	$552,500.00
		15%	contingency	$82,875.00
			Total	**$635,375.00**

PW = present worth
1 - cost is present worth, assuming:
- annual inspection of cap (site visit and inspection letter)
- resurfacing/paving of cap in year 10, 20 and 30
- rate of return assumed at 7% per annum
- CPI assumed at 2% per annum
- current cost of annual inspection, assumed at $1300
- current cost of resurfacing/paving, asumed at $200,000

Cap Monitoring and Maintenance - Present Worth Cos

	N=	inspection $(1.02/1.07)^N$	paving $(1.02/1.07)^N$
	1	1.000	
	2	0.909	
	3	0.866	
	4	0.826	
	5	0.787	
	6	0.750	
	7	0.715	
	8	0.682	
	9	0.650	
	10	0.620	0.620
	11	0.591	
	12	0.563	
	13	0.537	
	14	0.512	
	15	0.488	
	16	0.465	
	17	0.443	
	18	0.423	
	19	0.403	
	20	0.384	0.384
	21	0.366	
	22	0.349	
	23	0.333	
	24	0.317	
	25	0.302	
	26	0.288	
	27	0.275	
	28	0.262	
	29	0.250	
	30	0.238	0.238
	sum $(1.02/1.07)^N$	15.592	1.242
inspection program	$1,300.00	$20,270.22	
resurfacing/paving	$120,000.00		$148,995.04
	Total	**$169,265.266**	

TABLE F.4
ESTIMATED COSTS
ASPHALT CAP WITH SOIL TRANSFER
WEST WHARF - OSHAWA HARBOUR
OSHAWA, ONTARIO

Item	Quantity	Unit	Unit Rate	Cost
Supply, place and compact granular base and asphalt	3150	m^2	$50.00	$157,500.00
Excavate and transfer metals contaminated soil to South Rail Spur	4275	m^3	$5.00	$21,375.00
Supply, place and compact imported fill	8550	tonne	$20.00	$171,000.00
Vacuum Truck (extract and dispose of excavation water)	5000	Litre	$2.50	$12,500.00
Cap Monitoring and Maintenance Program (30 years) [1]	1	PW	$90,000.00	$90,000.00
Consulting (field supervision/cap inspection and excavation monitoring)	10	day	$1,800.00	$18,000.00
Consulting (design, specifications, soil mnmt plan, cap monitoring and maintenance plan, reporting)	1	LS	$100,000.00	$100,000.00
			sub-total	$570,375.00
		15%	contingency	$85,556.25
			Total	**$655,931.25**

PW = present worth
1 - cost is present worth, assuming:
- annual inspection of cap (site visit and inspection letter)
- resurfacing/paving of cap in year 10, 20 and 30
- rate of return assumed at 7% per annum
- CPI assumed at 2% per annum
- current cost of annual inspection at $1000
- current cost of resurfacing/paving at $100,000

Cap Monitoring and Maintenance - Present Worth Cost

		inspection	paving
	N=	$(1.02/1.07)^N$	$(1.02/1.07)^N$
	1	1.000	
	2	0.909	
	3	0.866	
	4	0.826	
	5	0.787	
	6	0.750	
	7	0.715	
	8	0.682	
	9	0.650	
	10	0.620	0.620
	11	0.591	
	12	0.563	
	13	0.537	
	14	0.512	
	15	0.488	
	16	0.465	
	17	0.443	
	18	0.423	
	19	0.403	
	20	0.384	0.384
	21	0.366	
	22	0.349	
	23	0.333	
	24	0.317	
	25	0.302	
	26	0.288	
	27	0.275	
	28	0.262	
	29	0.250	
	30	0.238	0.238
	sum $(1.02/1.07)^N$	15.592	1.242
inspection program	$700.00	$10,914.74	
resurfacing/paving	$63,000.00		$78,222.40
	Total	**$89,137.133**	

TABLE F.5
ESTIMATED COSTS
GROUNDWATER MITIGATION
WEST WHARF - OSHAWA HARBOUR
OSHAWA, ONTARIO

Item	Quantity	Unit	Unit Rate	Cost
Groundwater Flow and Contaminant Transport Model	1	LS	$125,000.00	$125,000.00
Wharf Wall Integrity Assessment	1	LS	$25,000.00	$25,000.00
10 year groundwater monitoring program (1)	1	PW	$96,000.00	$96,000.00
			sub-total	$246,000.00
		15%	contingency	$36,900.00
			Total	**$282,900.00**

PW = present worth
1 - cost is present worth, assuming:
- quarterly program with mNA assessment for Year 1
- semi-annual program for Year 2
- annual program for Years 3 to 10
- program includes monitoring and groundwater sampling from 9 wells - 2 nests (4 wells) and 5 area wells
- analytical program includes F1 to F4 (7), chloride and free cyanide (5) and mNA parameters (9) in Year 1
- one duplicate sample analysed for F1 to F4, one duplicate analysed for cyanide and chloride
- rate of return assumed at 7% per annum
- CPI assumed at 2% per annum
- current cost withouth mNA parameters and interpretation estimated at $7500 per event
- current cost with mNA parameters and interpretation estimated at $9500 per event

Groundwater Monitoring Program - Present Worth Costing

	Year 2	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
N=	2	2.5	3	4	5	6	7	8	9	10
$(1.02/1.07)^N$	0.908725653	0.887239739	0.8662618	0.825782	0.787194	0.75041	0.715344	0.681916	0.650051	0.619675
sum $(1.02/1.07)^N$	7.69259972									
current cost	$7,500.00									
present worth cost (Year 2 to 10)	$57,694.50									
Year 1 (4 @ $9500)	$38,000.00									
Total	**$95,694.50**									

TABLE F.6

EVALUATION OF REMEDIAL/RISK MANAGEMENT OPTIONS

WEST WHARF - OSHAWA HARBOUR

Evaluation Factor	Excavation with Offsite Disposal	Excavation with Offsite Transfer and Disposal	Capping with Offsite Transfer and Groundwater Mitigation
Effectiveness			
1. Remediation	effective, results in site remediation and closure	effective, results in site remediation and closure	contamination remains indefinitely
2. Risk Management	not applicable	not applicable	effective, exposure pathways cut-off
Ease of Implementation	Moderate	Moderate	Moderate
Community Acceptance	Moderate	Moderate	Moderate
Permitting and Regulatory Approvals	Permit to Take Water?	Permit to Take Water?	Permit to Take Water?
	Certificates of Approvals - Dewatering/Treatment/Reinjection	Certificates of Approvals - Dewatering/Treatment/Reinjection	Certificates of Approvals - Dewatering/Treatment/Reinjection
	Permit to Discharge to Sanitary Sewer	Permit to Discharge to Sanitary Sewer	Permit to Discharge to Sanitary Sewer
Timeline			
1. Design, Permitting and Approvals	3 to 6 months	3 to 6 months	3 to 6 months
2. Construction	1.5 to 2 months	1.5 to 2 months	1 to 2 months
Total	4.5 to 8 months	4.5 to 8 months	4 to 8 months
Estimated Cost (excluding taxes)	$2.3 Million	$1.8 Million	$939,000
Advantages	- complete remediation of site will be achieved	- complete remediation of site will be achieved	- eliminates active pathways; thereby preventing receptor exposure to contaminants
Disadvantages	- may be difficult to acquire affordable fill material of sufficient environmental and geotechnical quality	- may be difficult to acquire affordable fill material of sufficient environmental and geotechnical quality	- may be difficult to acquire affordable fill material of sufficient environmental and geotechnical quality
	- excavation dewatering and treatment will be required	- excavation dewatering and treatment will be required	- excavation dewatering and treatment will be required
	- processing of regulatory approvals and permitting items may require additional time, affecting the project schedule	- processing of regulatory approvals and permitting items may require additional time, affecting the project schedule	- processing of regulatory approvals and permitting items may require additional time, affecting the project schedule
	- longest timeframe	- longest timeframe	- long term cap monitoring and repair plan will need to be implemented
	- barrier wall required to prevent recontamination of site from upgradient organic contamination	- barrier wall required to prevent recontamination of site from upgradient organic contamination	- contaminnation remains indefinitely