CCME

Canadian Council of Ministers of the Environment | Le Conseil canadien des ministres de l'environnement

GUIDANCE MANUAL FOR ENVIRONMENTAL SITE CHARACTERIZATION IN SUPPORT OF ENVIRONMENTAL AND HUMAN HEALTH RISK ASSESSMENT

VOLUME 4 ANALYTICAL METHODS

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ABBREVIATIONS AND ACRONYMS

A	Area
AAS	Atomic absorption spectrophotometry
ABN	Acid base neutral extractable
AES	Atomic emission spectroscopy
AFFF	Aqueous film forming foam
AFS	Atomic fluorescence spectroscopy
aka	Also known as
AMPA	2-Amino-3-(5-methyl-3-oxo-1,2- oxazol-4-yl) propanoic acid
AOAC	Association of Analytical Chemists
APHA	American Public Health Association
ASTM	ASTM International (formerly the American Society for Testing and Materials)
AWWA	American Water Works Association
B[a]P	Benzo[a]pyrene
BTEX	Benzene/toluene/ethylbenzene/xylenes
C of A	Certificate of Analysis
CALA	Canadian Association for Laboratory Accreditation (formerly the Canadian Association for Environmental Analytical Laboratories, CAEAL)
CAN-P-1585	Standards Council of Canada *Requirements for the Accreditation of Environmental Testing Laboratories*
CAS RN	Chemical Abstract Service of the American Chemical Society Registration Number
CCME	Canadian Council of Ministers of the Environment
CCV	Continuing calibration verification
CEQG	Canadian Environmental Quality Guidelines
Ci	Concentration of compound *i* in µg/L
CITAC	Cooperation on International Traceability in Analytical Chemistry
CP	Chlorophenols
CRM	Certified Reference Material
CU	Colour units
CVAAS	Cold vapour atomic absorption spectrophotometry
CVAFS	Cold vapour atomic fluorescence spectrophotometry
CWS-PHC	Canada-Wide Standards for Petroleum Hydrocarbons
d	Distance
DC	Differential coliform
DF	Dilution factor
DL	Detection limit
DNP	2,4-Dinitrophenol
DO	Dissolved oxygen
DPC	1,5-Diphenylcarbazide

DPD	N,N-Diethyl-p-phenylenediamine
DQO	Data quality objectives
ECD	Electron capture detector
EDL	Estimated detection limit
EPA	Environmental Protection Act, R.S.O. 1990, c. E.19
F4Gsg	F4G, silica gel clean-up
FID	Flame ionization detector
FOC	Fraction organic carbon
GC	Gas chromatography (or GLC, gas liquid chromatography)
GCxGC	Two-dimensional gas chromatography
GC-ECD	Gas chromatography electron capture detector
GC-FID	Gas chromatography flame ionization detector
GC-HRMS	Gas chromatography high resolution mass spectrometry
GC-MS	Gas chromatography mass spectrometry
GC-MS/MS	Gas chromatography tandem mass spectrometry
HDPE	High density polyethylene
HPLC	High performance liquid chromatography
HPLC-UV	High performance liquid chromatography with ultraviolet detection
HPLC- FLU	High performance liquid chromatography with fluorescence detection
HRGC-HRMS	High resolution gas chromatography high resolution mass spectrometry
HRMS	High resolution mass spectrometry
HS GC-FID	Head space gas chromatography flame ionization detector
HWSB	Hot water soluble boron
IACR	Index of additive cancer risk
IC	Ion chromatography
ICP	Inductively coupled plasma spectroscopy
ICP-MS	Inductively coupled plasma mass spectrometry
ICP-OES	Inductively coupled plasma optical emission spectroscopy
IS	Internal standard
ISE	Ion selective electrode
ISO/IEC	International Organisation for Standardisation/International Electrotechnical Commission
IUPAC	International Union of Pure and Applied Chemistry
LC	Liquid chromatography
LC-MS	Liquid chromatography mass spectrometry
LC-MS/MS	Liquid chromatography tandem mass spectrometry
LCS	Laboratory control sample
LRL	Laboratory reporting limit, reporting limit, (aka reporting detection limit)
LRL_d	Laboratory reporting limit for diluted sample
LaSB	Laboratory Services Branch, Ontario Ministry of the Environment and Climate Change

MDDEP	Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs
MDL	Method detection limit
MEQ	Milliequivalents
MRM	Multiple reaction monitoring
MS	Mass spectrometry
N/A	Not applicable or not available
N/V	No value listed for standard
ND	Not detected
NCPs	Non-chlorinated phenolic compounds
NP	Nonylphenol
NPEC	Nonylphenol ethyl carboxylate
NPEO	Nonylphenol ethoxylate
NTU	Nephelometric turbidity units
O. Reg. 153/04	Ontario Regulation 153/04 Records of Site Condition: Part XV.1 of the Environmental Protection Act
OC	Organochlorine pesticides
OMOECC	Ontario Ministry of the Environment and Climate Change: when pertaining to Analytical Methods, OMOECC refers to the Laboratory Services Branch; when pertaining to the Standards or Regulation, OMOECC refers to the Standards Development Branch
OP	Octylphenol
OPEC	Octylphenol ethyl carboxylate
OPEO	Octylphenol ethoxylate
ORP	Other regulated parameters
P&H	Pesticides and herbicides
PAAM	Ontario Ministry of the Environment Protocol for the Acceptance of Alternate Methods
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCDD	Polychlorinated dibenzo-p-dioxin
PCDD/F	Polychlorinated dibenzo-p-dioxin/polychlorinated dibenzofuran
PCDF	Polychlorinated dibenzofuran
PEF	Potency equivalence factor
PET	Polyethylene terephthalate
PFOA	Perfluorooctanoate
PFOS	Perfluorooctanesulphonic acid
PHC	Petroleum hydrocarbon
PLE	Pressurised liquid extraction
PP	Polypropylene
PT	Proficiency testing (refers to performance testing sample)
QA	Quality assurance
QC	Quality control

QMS	Quality management system
QP	Qualified person
RHgCl	Organomercuric chloride
RPD	Relative percent difference
RSD	Relative standard deviation
SAR	Sodium adsorption ratio
SCC	Standards Council of Canada
SIM	Selected ion monitoring
SM	Standard Methods (American Public Health Association/American Water Works Association/Water Environmental Federation)
SPE	Solid phase extraction
SQRT	Square root
SVOC	Semi-volatile organic compound
TEF	Toxic equivalency factor
TEFi	Toxic equivalency factor for compound *i* (unitless)
TEQ	Toxic equivalent
TDS	Total dissolved solids
THM	Trihalomethanes
TISAB	Total ionic strength adjustment buffer
TKN	Total Kjeldahl nitrogen
TPE	Toxic potency equivalents
TSS	Total suspended solids, or suspended sediments
US EPA	United States Environmental Protection Agency
USGS-NWQL	United States Geological Survey-National Water Quality Laboratory
VOC	Volatile organic compound
Vt	Total solvent/water volume
v/v	Volume to volume
WEF	Water Environment Federation

GLOSSARY

Accreditation: Formal recognition that a testing laboratory is competent to carry out specific tests or specific types of tests.

Accuracy: The closeness in agreement between the test result and the accepted reference value.

Analyte: A substance or chemical constituent that is determined in an analytical procedure, such as a titration.

Analytical Run: A group of samples processed together through each step of an analytical procedure.

Analytical Standards: A series of chemical standards of the target analytes used to set the relationship between instrument response and concentration or qualitative verification of instrument output.

Blank: Reagent water or other type of blank (e.g., acid or solvent) used to monitor for contaminated reagents, glassware and method processes.

Composite Sample: A single sample that is made up of a number subsamples that have been thoroughly mixed together.

Contaminant: Any solid, liquid, gas, odour, heat, sound, vibration, radiation, or combination thereof resulting directly or indirectly from human activities that may cause an adverse effect.

Certified Reference Material (CRM): A reference material accompanied by documentation issued by an authoritative body and providing one or more specified property values with associated uncertainties and traceabilities using valid procedures. (ISO/IEC GUIDE 99.2007).

Data Quality Objectives (DQO): Qualitative and quantitative statements of the overall level of uncertainty that a decision-maker will accept in results or decisions based on environmental data. They provide the statistical framework for planning and managing environmental data operations consistent with user's needs.

Duplicate Sample: One of two samples taken from the same population and carried through all steps of sampling and analytical procedures in an identical manner.

Extractable Organic Compound: An organic compound that is separated from the sample matrix by solvent extraction prior to analysis. Such compounds have a boiling point higher than water and may vaporise when exposed to temperatures above room temperature. For the purposes of this compendium, extractable organic compound is equivalent to a semi-volatile organic compound (SVOC).

Field Blank: Blanks are defined as matrices that have negligible or non-detectable amounts of the substance of interest. A field blank is used to provide information about contaminants that may be introduced during sample collection, storage, and transport. The clean sample is carried to the sampling site, exposed to sampling conditions, returned to the laboratory, and treated as an environmental sample. (EPA530-D-02-002, Appendix A).

Field Duplicates: Independent samples that are collected as close as possible to the same point in space and time. They are two separate samples taken from the same source, stored in separate

containers, and analyzed independently.These duplicates are useful in documenting the precision of the sampling process. (US EPA SW-846, Chapter 1).

Field Filter: Where required, water samples must be filtered using a 0.45 µm membrane filter as soon as possible after sampling and immediately preserved (if preservation is required). Note: 0.45 µm pore size is the default filter pore size used to separate dissolved species, unless otherwise specified in the method for a given parameter.

Field Preservation: Where required, samples must be preserved with the specified preservative for that parameter group (within 24 hours of sampling) or immediately following filtration (if filtration is required).

Fit for Purpose: Degree to which data produced by a measurement process enables a user to make technically and administratively correct decisions for a stated purpose. (IUPAC).

Hermetic Sampler: A commercially available US EPA-accepted device for sampling soils for VOC analysis. The device is inserted into the soil where it collects and seals a soil core (with no headspace). The device is transported to the laboratory where the entire sample is extracted and analysed.

Holding Time: Elapsed time between sample collection and commencement of sample preparation or analysis, as appropriate.

Internal Standard: A standard that has chemical characteristics similar to those of the analyte(s) and provides an analytical response that is distinct from the analyte and not subject to interference. Internal standards usually are added to the sample or sample extract just prior to sample analysis in order to correct for variations in sample matrix, injection volume, *etc*.

ISO/IEC 17025 Standard: The requirements of the International Organization for Standardization, as amended from time to time, for testing laboratories to demonstrate that they are technically competent, maintain a quality system appropriate to the scope of their activities, and are able to generate technically valid calibration or test results.

Laboratory Control Sample: A sample of known concentration used as a basis for comparison with test samples, and which undergoes sample processing identical to that carried out for test samples, also referred to as a blank spike.

Laboratory Duplicate Sample: An additional or second aliquot (portion) of a randomly selected sample in the analytical run carried through the entire analytical process, also referred to as a split sample.

Laboratory Reporting Limit (LRL): The lowest concentration of an analyte reported within a reasonable degree of accuracy and precision, often synonymous with the LOQ or PQL. The LRL is typically 3-10 times the method detection limit (MDL); however, the LRL must be equal to or greater than the MDL.

Limit of Quantification (LOQ): The lowest concentration of an analyte that can be reliably measured within specified limits of precision and accuracy during routine operating conditions, as opposed to being detected. (US EPA, 2002; Gibbons and Coleman, 2001). Usually 10 times the standard deviation from replicate analysis of a low level sample.

Matrix: The environment from which a given sample is taken (analytical chemistry), typically air, soil/sediment, ground or surface water for the purposes of this compendium.

Method Detection Limit (MDL): The minimum concentration of an analyte that can be identified, measured and reported with 99% confidence that the analyte concentration is greater than zero. It is determined from data produced by replicate analysis of a sample in a given matrix containing the analyte. (CAN-P-1585-November 2006).

Method Blank: A blank sample that undergoes sample processing identical to that carried out for the test samples. Method blank results are used to assess contamination from the laboratory environment and reagents.

Method of Standard Additions: The determination of analyte concentration by adding known analyte amounts (spikes) to sample aliquots. Determination is based on the slope and intercept of the standard additions curve (recovery). The analytical response must be linear. This technique is used to correct for matrix effects.

Parameter: A parameter to be tested. Synonymous with other terminology such as "contaminant", "target analyte", or "analyte".

Practical Quantification Limit (PQL): May be similarly defined as the LOQ, the reporting limits in the method, or otherwise defined.

Precision: Relating to the variation between variates, i.e., the scatter between variates. (IUPAC).

Qualified Person (QP): Qualified Persons are professionals who are recognised as competent to assess analytical data as it pertains to provincial, territorial or federal legislation.

Quality Assurance (QA): Quality assurance is a system of planned activities intended to provide adequate confidence that quality requirements are being met. Quality assurance is one element of the quality system.

Quality Control (QC): Quality control is a set of operational techniques and activities intended to ensure that quality requirements are actually being met within known probability limits. Quality control is one part of the quality system.

Quality Control Sample: A sample (e.g., test sample or laboratory control sample/standard) used either singly or in replicate, as appropriate, to monitor performance characteristics [ISO 3534-1, 2.30].

Quality System: A set of interrelated elements (e.g., policies and objectives) that direct and control the way a facility operates with regard to quality.

Reference Material (RM): A material or substance one or more of whose property values are sufficiently homogeneous and well established to be used for calibration of an apparatus, the assessment of a measurement method, or for assigning values to the materials. The RM should be similar in matrix to the samples and carried through the entire analytical process.

Relative Percent Difference (RPD): The absolute difference between two results expressed as a percentage of the average result:

$$RPD = \left| \frac{(x_1 - x_2)}{(x_1 + x_2)/2} \right| \times 100$$

Relative Standard Deviation (RSD): A measure of precision in data analysis. Relative standard deviation is calculated by dividing the standard deviation of a series of values by the average of the values, usually expressed as a percentage.

$$RSD = (\text{Standard deviation}(1-x)/(\sum(1-x)/n)*100$$

Representative Sample: A subsample of material that has been taken so that it has essentially the same composition and characteristics of the sample in the container.

Semi-volatile Organic Compound (SVOC): A semivolatile organic compound is an organic compound which has a boiling point higher than water and which may vaporize when exposed to temperatures above room temperature. Semivolatile organic compounds include phenols and polynuclear aromatic hydrocarbons (PAH).

Site Condition Standards: For the purposes of this compendium the prescribed contaminants and the site condition standards for those contaminants are those set out in the Canadian Environmental Quality Guidelines and Tables 1 through 9 of the **Soil, Water and Sediment Standards. O. Reg. 153/04, s. 34 (1).**

Solids: Refers to soils and sediments for the purposes of this compendium.

Surrogate: Has chemical characteristics similar to that of the analyte and provides an analytical response which is distinct from the analyte. The surrogate(s) is added to the sample normally prior to sample preparation and used to assess the recovery of analyte(s) carried through the analytical process.

Spiked Samples: Analyte(s) of interest spiked into the sample matrix to monitor recovery from the sample matrix using the method or parts of the method.

Trip Blank (aka Travel Blank): A clean sample of a matrix that is taken to and from the sampling site unopened and transported to the laboratory for analysis without having been exposed to sampling procedures. A trip blank is used to document contamination attributable to preparation, shipping and field handling procedures. This type of blank is useful in documenting contamination of volatile organics samples. (EPA530-D-02-002, Appendix A).

Uncertainty: A non-negative parameter associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to the measurand. (International vocabulary of metrology – Basic and general concepts and associated terms; ISO/IEC Guide 99:2007 (VIM 2007)).

Volatile Organic Compound (VOC): Any organic compound having, at 20°C, a vapour pressure of 0.01 kPa, or more, or having a corresponding volatility under the particular conditions of use.

1 INTRODUCTION

The Canadian Council of Ministers of the Environment (CCME) publishes Canadian Environmental Quality Guidelines (CEQGs) for water, soil, sediment and biotic tissue, to protect aquatic and terrestrial flora and fauna. In 1993, CCME published a *Guidance Manual of Sampling, Analysis and Data Management for Contaminated Sites: Volume I (Sampling and Data Management)* and *Volume II (Analytical Method Summaries)* to provide a consistent approach to sampling, analysis and data management for contaminated sites across Canada. The following report updates Volume II and is entitled: *Guidance Manual for Environmental Site Characterisation in Support of Environmental and Human Health Risk Assessment. Volume IV: Analytical Methods*.

Since the CCME 1993 report was published, the Ontario Ministry of Environment published analytical methods guidance *Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act* (OMOE 2011). The OMOE (2011) document therefore served as the basis for updating Volume II. While OMOE (2011) addressed most of the analytes for which there are CEQGs, some CEQG analytes and media were not covered or methods have evolved and are therefore now addressed here.

This compendium provides guidance for a consistent approach to sample handling, analysis and data reporting for parameters contained in the Canadian Environmental Quality Guidelines. This document is provided by CCME as guidance, but individual jurisdictions may have differing specific requirements that also need to be taken into account.

This compendium sets out the sample handling and storage requirements, analytical methods and method-specific quality control and assurance procedures for laboratories established by recognised organizations: United States Environmental Protection Agency (US EPA), Ontario Ministry of the Environment and Climate Change (OMOECC; formerly Ontario Ministry of the Environment (OMOE) Laboratory Services Branch (LaSB), Association of Analytical Chemists (AOAC), ASTM International (formerly American Society for Testing and Materials), Standard Methods: American Public Health Association (APHA)/American Water Works Association (AWWA)/Water Environmental Federation (WEF), U.S. Geological Survey (USGS) of the U.S. Department of the Interior, the National Water Quality Laboratory (USGS-NWQL), Environment and Climate Change Canada (formerly Environment Canada) and Canadian Council of Ministers of the Environment (CCME).

This analytical methods compendium is Volume IV in the *Guidance Manual for Environmental Site Characteriszation in Support of Environmental and Human Health Risk Assessment*. While the scope of this document addresses testing methods for chemical and microbiological sample analysis, readers should also be aware that Environment and Climate Change Canada has published 22 standardised biological test methods that can be used for the assessment of contaminated water, soil, or sediment toxicity at contaminated sites. It is recognised that these biological test methods are important tools for the assessment of contaminant risk and useful in the remediation of sites. Environment and Climate Change Canada's Biological Test Method Series are available for viewing and/or download at:

http://www.ec.gc.ca/faunescience-wildlifescience/default.asp?lang=En&n=0BB80E7B-1

The information in this compendium is provided to ensure that appropriate samples are submitted to laboratories, the samples are analysed with methods that are fit for purpose and that the reported results are of sufficient quality to base decisions required for regulatory purposes.

Sample processing and analysis depends largely on the chemical and physical properties of the parameter to be measured. Parameters with similar chemical and physical properties can be grouped and processed together. Section 2 contains the parameters that can be grouped and processed together.

CCME recommends the use of laboratories that are accredited for the required tests by an internationally recognised accreditation body [e.g., Standards Council of Canada (SCC), or Canadian Association for Laboratory Accreditation (CALA)] in accordance with the International Standard ISO/IEC17025:2005 – *General Requirements for the Competence of Testing and Calibration Laboratories*. Consult with the appropriate jurisdiction for local regulatory requirements. Accreditation ensures that laboratories maintain a comprehensive documented quality system consistent with good analytical practice. Accreditation establishes a consistent basis for acceptable quality among analytical laboratories and ensures they adopt a satisfactory quality system to carry out sample analysis.

The compendium is organised as follows: Introduction (Section 1), Parameter Group Descriptions (Section 2), Sampling Handling and Storage Requirements (Section 3), Analytical Methods (Section 4), Reporting (Section 5), Required Quality Assurance/Quality Control (Section 6), and References (Section 7).

2 PARAMETER GROUP DESCRIPTIONS

This section identifies the substances associated within each parameter group. An alphabetical listing of contaminants and the parameter group to which each belongs is found in Appendix 1. Chemical Abstracts Service Registry Numbers (CAS RN) for individual chemical parameters (where applicable) are listed in Table 5.1. The analytical methods for each group are found in Section 4 and recommended laboratory reporting limits are found in Section 5.

All substances for which a CEQG exists are listed within the applicable parameter groups below. Some substances in a given parameter group may not currently have a CEQG, but have been included since they may be of future interest, or of interest to researchers interested in the parameter group, generally.

Identifying Suspected Contaminants: Phase 1 assessments identify the suspected contaminants associated with a site, which are investigated further in a Phase 2 assessment. If data requested are for one or a subset of many related substances, data may be reported from the specified subset alone, but be aware that in some situations a broader analytical report may be more appropriate. For example, at sites where there is a chance of a natural metal substance being mobilised by the suspected contaminants (e.g., via pH change for sulphur piles and other sources of acidification, redox changes for hydrocarbons and other readily bioavailable substances, ion exchange in the case of concentrated salt plumes) it is recommended that the full suite of metals associated in the parameter group be reported.

For non-naturally occurring substances that occur within a parameter group (e.g., chlorinated organics), it may be of interest to have the entire parameter group reported, since there are or may be daughter products which might be of interest or concern. Investigators are also encouraged to conduct gas chromatography-mass spectrometry (GC-MS) open scans which identify non target compounds by means of comparison of the mass spectrum of the unknown compound to the instrument library of mass spectra.

2.1 Organic Parameters Group

*2.1.1 Acid/Base/Neutral Extractable Organic Compounds (ABNs)**

Parameters

Aniline	Di(2-ethylhexyl) phthalate	Dinitrotoluene, 2,4-(2,6-)**
Biphenyl, 1,1'-	Dichlorobenzidine, 3,3'-	Di-n-octyl phthalate
Bis(2-chloroethyl)ether	Diethyl phthalate	Phthalic acid esters (each)†††
Bis(2-chloroisopropyl)ether	Dimethyl phthalate	
Chloroaniline, p-	Di-n-butyl phthalate	

* Selected ABN parameters contained within the CEQG and O. Reg. 153/04.

** The sum of 2,4- and 2,6-dinitrotoluene is compared to the standard.

††† CCME has not defined a list of phthalic acid esters. For the purposes of this document the list is the phthalate compounds listed above, which have Ontario guidelines.

*2.1.2 Chlorophenols (CPs) and Non-Chlorinated Phenols (NCPs)**

Parameters

Dichlorophenol, 2,4- 2,5- 2,6- 3,4- 3,5-	Phenol
Dimethylphenol, 2,4-**	Phenolic compounds, non-chlorinated**
Dinitrophenol, 2,4-**	Phenols (mono- & dihydric)††
Monochlorophenol, 2- 3- 4-	Tetrachlorophenol, 2,3,4,5- 2,3,4,6- 2,3,5,6-, 3,4,5,6-
Pentachlorophenol (PCP)	Trichlorophenol, 2,3,4- 2,3,5- 2,3,6- 2,4,5- 2,4,6-, 3,4,5-

* CPs and NCPs may also be determined with ABNs provided LRL requirements are met.

** Non-chlorinated phenolic (NCP) compounds include 2,4-dimethylphenol; 2,4-dinitrophenol; 2-methyl 4,6-dinitrophenol; 2-nitrophenol; 4-nitrophenol; *o*-, *m*-, *p*-cresol (methylphenol).

†† CCME has not selected a list of mono- and dihydric- phenols for monitoring. For this compendium, the list is the phenolic compounds: non-chlorinated plus phenol, 4-hydroxyphenol (hydroquinone) and 3-hydroxyphenol (resorcinol), which have British Columbia Guidelines.

*2.1.3 1,4-Dioxane**

Parameters

Dioxane, 1,4-

*May also be determined with ABNs or VOCs with isotope dilution.

2.1.4 Glycols

Diethylene glycol
Ethylene glycol
Propylene glycol 1,2-

2.1.5 Organochlorine Pesticides (OCs)

Parameters (Synonyms)

Aldrin	Hexachlorobenzene
Chlordane, *alpha*- (α-chlordane)*	Hexachlorobutadiene (HCBD)
Chlordane, *gamma*- (γ-chlordane)*	Hexachlorocyclohexane, *gamma*- (γ-HCH, Llindane, γ-BHC[†])
Dichloro diphenyl dichloroethane, (2,2-Bis (p-chlorophenyl)-1,1-dichloroethane, DDD)***	Hexachloroethane
Dichloro diphenyl ethylene, (1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene, DDE)***	Methoxychlor
Dichloro diphenyl trichloroethane; (2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane, DDT)***	Metolachlor[††]
Dieldrin	Pentachlorobenzene[††]
Endosulfan I (thiodan sulphate I)**	Tetrachlorobenzene, 1,2,3,4-[†††]
Endosulfan II (thiodan sulphate II)**	Tetrachlorobenzene, 1,2,3,5-[†††]
Endrin	Tetrachlorobenzene, 1,2,4,5-[†††]
Heptachlor	Toxaphene
Heptachlor epoxide	

* The sum of alpha- and gamma-chlordane is compared to the standard

** The sum of endosulfan I and II is compared to the standard

***DDT standard applies to the total DDT (i.e., sum of the DDT isomers), the DDE standard applies to total DDE (i.e., sum of the DDE isomers), and the DDD standard applies to the total DDD (i.e., sum of the DDD isomers).

† Erroneously known as benzene hexachloride (BHC).

†† May also be determined with ABNs.

††† Technically not OCs, but come out in the same analytical run. May also be determined with ABNs

2.1.6 Organotin Compounds

Parameters

Tributyltin
Tricyclohexyltin
Triphenyltin

2.1.7 Perfluorinated Sulphonic Acids, Perfluorinated Carboxylic Acids and their Salts*

Sulphonic Acid Salts	**Carboxylic Acid Salts**
Perfluorobutanesulphonate (PFBS)	Perfluorobutanoate (PFBA)
Perfluorohexanesulphonate (PFHxS)	Perfluoropentanoate (PFPeA)
Perfluorooctanesulphonate (PFOS)**	Perfluorohexanoate (PFHxA)
Perfluorooctane sulphonamide (PFOSA)	Perfluoroheptanoate (PFHpA)
	Perfluorooctanoate (PFOA)
	Perfluorononanoate (PFNA)

Sulphonic Acid Salts	Carboxylic Acid Salts
	Perfluorodecanoate (PFDA)
	Perfluoroundecanoate (PFUnA)
	Perfluorododecanoate (PFDoA)

* These compounds may be expressed as acids or salts. In the table they are listed as the anionic component of the salt because several different cations may pair with the anion.

** While there are currently no CCME guidelines for perfluorinated sulphonic acids and perfluorinated carboxylic acids, this group was included given recent interest in these parameters. This list represents the most commonly determined compounds. Other perfluorinated compounds may be determined using the same procedure.

*2.1.8 Pesticides and Herbicides (P&H)**

Parameters (Synonyms)

Atrazine	Deltamethrin	Metribuzin
Bromacil	Dicamba (3,6-dichloro-2-methoxybenzoic acid)	Permethrin
Bromoxynil	Diclofop-methyl	Picloram
Captan (ethanthiol)	Didecyl dimethyl ammonium chloride (DDAC)	Simazine
Carbaryl (1-naphthyl methylcarbamate)	Dimethoate	Tebuthiuron
Chlorothalonil (tetrachloroisophthalonitrile)	Dinoseb	Trifluralin
Chlorpyrifos	Linuron	
Cyanazine	Methoprene	

* Carbamate pesticides , glyphosate herbicides and phenoxy herbicides may be determined as separate groups.

*2.1.8.1 Carbamates**

Parameters (Synonyms)

Aldicarb
3-iodo-2-propynyl butyl Carbamate (IPBC)
Carbofuran
Imidacloprid
Triallate

* May also be determined with Pesticides and Herbicides.

*2.1.8.2 Glyphosate**

Parameters

Glyphosate

* May also be determined with Pesticides and Herbicides.

*2.1.8.3 Phenoxy Herbicides**

Parameters (Synonyms)

Dichlorophenoxyacetic Acid, 2,4- (2,4-D)
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid, MCPA)

* May also be determined with Pesticides and Herbicides or ABN.

2.1.9 Petroleum Hydrocarbons (PHCs)

Parameters

Petroleum hydrocarbons (PHCs) (C6–C10 Fraction) F1 (C6 to C10)
Petroleum hydrocarbons (PHCs) (C10–C50 Fraction) F2 (C10 to C16), F3 (C16 to C34), F4* (C34 to C50), F4G* (gravimetric)

* The larger result obtained for F4 and F4G is compared to the standard.

2.1.10 Polychlorinated Biphenyls (PCBs)

Parameters

Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260
Polychlorinated biphenyls (PCBs), total

2.1.11 Polychlorinated Dibenzo-p-Dioxins/Dibenzofurans (PCDDs/PCDFs)

Parameters (Synonyms)

Congener Groups	**2,3,7,8-Substituted Isomers**
Total Tetrachlorodibenzo-p-dioxins (T4CDDs)	2,3,7,8-TCDD
Total Pentachlorodibenzo-p-dioxins (P5CDDs)	1,2,3,7,8-PCDD
Total Hexachlorodibenzo-p-dioxins (H6CDDs)	1,2,3,4,7,8-HCDD
	1,2,3,6,7,8-HCDD
	1,2,3,7,8,9-HCDD
Total Heptachlorodibenzo-p-dioxins (H7CDDs)	1,2,3,4,6,7,8-HCDD
Octachlorodibenzo-p-dioxin (O8CDD)	OCDD
Total Tetrachlorodibenzofurans (T4CDFs)	2,3,7,8-TCDF
Total Pentachlorodibenzofurans (P5CDFs)	1,2,3,7,8-PCDF
	2,3,4,7,8-PCDF
Total Hexachlorodibenzofurans (H6CDFs)	1,2,3,4,7,8-HCDF

Congener Groups	2,3,7,8-Substituted Isomers
	1,2,3,6,7,8-HCDF
	1,2,3,7,8,9-HCDF
	2,3,4,6,7,8-HCDF
Total Heptachlorodibenzofurans (H7CDFs)	1,2,3,4,6,7,8-HCDF
	1,2,3,4,7,8,9-HCDF
Octachlorodibenzofuran (OCDF)	OCDF

2.1.12 Polycyclic Aromatic Hydrocarbons (PAHs)

Parameters (Synonyms)

Acenaphthene	Benzo[k]fluoranthene	Methylnaphthalenes*
Acenaphthylene	Benzo[g,h,i]perylene	Naphthalene
Acridine	Chrysene	Phenanthrene
Anthracene	Dibenz[a]anthracene	Pyrene
Benz[a]anthracene	Fluoranthene	Quinoline
Benzo[a]pyrene (B[a]P)	Fluorene	
Benzo[b+j+k]fluoranthene**	Indeno[1,2,3-c,d]pyrene	

* The sum of 1- and 2-methylnaphthalene is compared to the standard (O. Reg 153/04). Other jurisdictions vary.

** When b and k isomers cannot be reported separately, report them as the sum of the b, j and k isomers and compare to the CEQG. OMOE has individual standards for the b and k isomers.

*2.1.13 Trihalomethanes (THMs)**

Parameters (Synonyms)

Bromodichloromethane (Dichlorobromomethane)
Dibromochloromethane (Chlorodibromomethane)
Tribromomethane (Bromoform)
Trichloromethane (Chloroform)

*May also be determined with VOCs.

Note: The above THM compounds are commonly detected as a result of chlorination of drinking water and therefore are included as a separate group from the volatile organic compounds (Section 2.1.14). The sum of the trihalomethans is compared to the standard.

2.1.14 Volatile Organic Compounds I (VOCs)

Parameters (Synonyms)

Acetone	Monobromomethane** (Bromomethane, Methyl bromide)
Benzene***	Monochlorobenzene
Dichlorobenzene, 1,2-	Monochloromethane (Methyl chloride)

Dichlorobenzene, 1,3-	Styrene
Dichlorobenzene, 1,4-	Tetrachloroethane, 1,1,1,2-
Dichlorodifluoromethane	Tetrachloroethane, 1,1,2,2-
Dichloroethane, 1,1-	Tetrachloroethene, 1,1,2,2- (PCE, Tetrachloroethylene)
Dichloroethane, 1,2-	Tetrachloromethane (Carbon tetrachloride)
Dichloroethene, 1,1-	Thiophene
Dichloroethene, 1,2-*cis*-[†]	Toluene[***]
Dichloroethene, 1,2-*trans*-[†]	Trichlorobenzene, 1,2,3-[††]
Dichloromethane (Methylene chloride)	Trichlorobenzene, 1,2,4-[††]
Dichloropropane, 1,2-	Trichlorobenzene, 1,3,5-[††]
Dichloropropene, 1,3- (*cis*- and *trans*-)*	Trichloroethane, 1,1,1-
Ethylbenzene[***]	Trichloroethane, 1,1,2-
Ethylene dibromide (Dibromoethane, 1,2-)	Trichloroethene, 1,1,2- (TCE, Trichloroethylene)
Hexane, n-[†]	Trichlorofluoromethane
Methyl ethyl ketone (MEK)	Vinyl chloride
Methyl isobutyl ketone (MIBK)	Xylenes[***]
Methyl tertiary-butyl ether (MTBE)	

* The sum of *cis*- and *trans*- 1,3-dichloropropene is compared to the standard.

** Methanol-preserved samples may elevate the detection limit for bromomethane; a separate bisulphate-preserved sample or hermetically sealed sample may be required at the time of sampling if bromomethane is a chemical of concern.

***May also be determined with BTEX.

† OMOE regulates *cis* and *trans* 1,2-dichloroethene separately. The CEQG compares the sum of chlorinated aliphatics, which include 1,2-dichloroethene, to the standard.

†† May also be determined with ABNs.

2.1.15 Volatile Organic Compounds II: Benzene, Ethybenzene, Toluene, Xylenes (BTEX)

Parameters (Synonyms)

Benzene
Ethylbenzene
Toluene (Methylbenzene)
Xylenes, total (*o*-Xylene; *m*- & *p*-Xylene)

Note: The above BTEX compounds (benzene, toluene, ethylbenzene, xylenes) are a subset of volatile organic compounds (VOCs), are often analysed as a discrete analysis and are therefore included as a separate group from the VOCs (Section 2.1.14).

2.1.16 Organics Single Analysis Parameters (ORPs)

2.1.16.1 Diisopropanolamine

Parameter (Synonyms)

Diisopropanolamine (DIPA)

2.1.16.2 Fraction of Organic Carbon (FOC)

Parameter (Synonyms)

Fraction of Organic Carbon (FOC)

2.1.16.3 Methyl Mercury

Parameter

Methyl Mercury

2.1.16.4 Nonylphenol and its Ethoxylates

Parameters

Nonylphenol and its ethoxylates

2.1.16.5 Sulfolane

Parameters (Synonyms)

Sulfolane (Bondelane)

2.2 Inorganics Parameters Group

2.2.1 Metals

Parameters

Aluminium (Al)	Cobalt (Co)	Selenium (Se)
Antimony (Sb)	Copper (Cu)	Silver (Ag)
Arsenic (As)	Iron (Fe)	Sodium (Na)
Barium (Ba)	Lead (Pb)	Thallium (Tl)
Beryllium (Be)	Lithium (Li)	Tin (Sn)
Boron (B)*	Magnesium (Mg)	Uranium (U)
Cadmium (Cd)	Manganese (Mn)	Vanadium (V)
Calcium (Ca)	Molybdenum (Mo)	Zinc (Zn)

Chromium (Cr)	Nickel (Ni)

*Strong acid extractable boron

2.2.2 Inorganic Single Analysis Parameters (ORPs)

The other regulated parameters (ORPs) listed below are single parameter tests.

Parameters

Ammonia (total)	Dissolved Oxygen (DO)	Reactive Chlorine Species
Ammonia (un-ionised)	Fluoride	Salinity
Boron – Hot water soluble (HWSB)	Mercury	Sodium Adsorption Ratio
Chloride	Nitrate + Nitrite	Streambed Substrate
Chromium, trivalent (CR(III))	Nitrite	Sulphate
Chromium, hexavalent (Cr(VI))	Nitrogen (total)	Sulphur (elemental)
Colour (true)	Nutrients (TN & TP)	Suspended Sediments
Conductivity	Particle Size	Total Dissolved Solids*
Cyanide (free)	pH	Turbidity
Dissolved Gas Supersaturation	Phosphorus	

* Total Dissolved Solids can also be determined by calculation. See Section 4.2.2.26.

2.3 Microbiology

2.3.1 Coliforms

Parameters (Synonyms)

Coliforms, fecal (*Escherichia coli*)
Coliforms, total

2.3.2 Cyanobacteria

Parameters (Synonyms)

Cyanobacteria* (Blue-green algae)

* Often associated with analysis for chlorophyll *a* and nutrients.

3 SAMPLE HANDLING AND STORAGE REQUIREMENTS

This section provides details on the procedures for sample handling and storage, including the type of container, sample volume, preservation and storage requirements, and maximum holding time for all regulated analytes. The following is provided by CCME as guidance, but jurisdictions may have specific requirements that need to be taken into account.

For detailed information on sampling procedures refer to the *Guidance Manual for Environmental Site Characterization in Support of Environmental and Human Health Risk Assessment*, Volume I Guidance Manual, 2016.

It is especially important for samples requiring organic analysis that samples be placed in the appropriate containers and the cooling begun as soon as possible after sampling. Sufficient ice or other coolant should be added to produce a temperature less than or equal to (≤) 10°C in transit (but not frozen). Note that samples arriving at the laboratory on the day of sampling may not have had time to achieve a temperature of ≤ 10°C. This is acceptable as long as the cooling process has begun.

WATER SAMPLE CONTAINERS:

Extractable organics testing water samples is “whole bottle” analysis where the entire sample is extracted and the bottle rinsed with solvent to prevent analyte losses due to adsorption on the container walls. Thus, additional containers are required for laboratory QC (duplicates and matrix spikes). Similarly, for volatile organics testing additional vials are required for laboratory QC and possible repeats because once a vial has been sampled it is not suitable for further testing. Consult the laboratory for the correct number of sample vials.

Multiple samples may be needed for inorganic testing as different inorganic tests may have different container and preservative requirements.

WATER SAMPLES REQUIRING PAH ANALYSIS:

Polycyclic aromatic hydrocarbons adsorb strongly to particulate matter. Thus, analysis of a water sample containing particulate may be biased high relative to the PAH actually dissolved in the water. This will also be true for other hydrophobic organics such as PCBs. Filtration is not recommended for PAH and other organic tests due to adsorptive losses on filtration.

WATER SAMPLES REQUIRING HEXAVALENT CHROMIUM ANALYSIS:

For dissolved hexavalent chromium in water, the samples are field filtered through a 0.45 µm membrane filter and within 24 hours of sampling the pH is adjusted within a range of 9.3 to 9.7 with the addition of a buffer solution. Alternatively, samples may be preserved with sodium hydroxide. For total hexavalent chromium, samples are preserved without filtration. Unpreserved samples must be analysed within 24 hours of sampling.

SOIL AND SEDIMENT SAMPLE CONTAINERS:

For organic compound testing, each analysis requires about 10 g of sample, thus multiple tests can be conducted on subsamples taken from a full 60, 125 or 250 mL soil container. A single

container will normally suffice for inorganic tests. For physical parameters and stable inorganic analytes such as chloride and pH, samples may be collected in plastic bags designed for soil collection; however, use of glass jars is recommended due to potential exposure risk to lab personnel from highly contaminated samples.

Soil and sediments samples requiring analysis for VOCs, BTEX, PHCs (F1), and THMs are preserved in the field with methanol or collected using hermitically sealed sampling devices. For BTEX and PHC (F1), this is an accepted deviation from the CCME method. An additional sample collected in a glass jar is required for moisture content determination. Each batch of methanol-preserved soil samples requires an additional vial pre-charged with methanol for the field/travel blank.

Field preservation entails taking a sample of approximately 5 g using a coring device and extruding the core directly into a preweighed vial containing methanol and sealing the vial. The vial is reweighed at the laboratory and the sample weight obtained by difference.

Note: Tables 3A and 3B and the notations below them provide both the sampler and those receiving samples at a laboratory with the requirements for sample container, sample preservation, sample storage and sample holding times. The number of sampling containers and container sizes specified is a guide. Always consult the laboratory prior to sampling. The laboratory will provide sufficient appropriate containers for the required scope of testing. Collection of multiple sample containers is encouraged to avoid the need for re-sampling if the sample is consumed or compromised during shipping and/or analysis.

Table 3A: Soil and Sediment Sample Handling and Storage Requirements

SOIL and SEDIMENT Inorganic Parameters	**Container[1]**	**Field Preservation**	**Storage Temperature[2]**	**Preserved Holding Time[3]**	**Unpreserved Holding Time[3]**	**Reference**
Chloride, Conductivity, Particle Size	glass jar*, Teflon™ lined lid, HDPE, PET, PP	none	> 0 to 6°C or room temp.	N/A	30 days as received (without lab drying); indefinite when dried	Carter and Gregorich 2008 Table 4.1 OMOE
Cyanide (CN^-)	glass jar*, Teflon™ lined lid, HDPE	protect from light	> 0 to 6°C	N/A	14 days as received	SW-846 Ch 3 2007
Fraction Organic Carbon (FOC), Total Nitrogen	glass jar*, Teflon™ lined lid, HDPE, PET, PP	none	> 0 to 6°C	N/A	28 days as received (without lab drying); indefinite when dried	SW-846 Ch 3 2007 Carter and Gregorich 2008
Hexavalent Chromium, Elemental Sulphur	glass jar*, Teflon™ lined lid, HDPE	none	> 0 to 6°C	N/A	30 days as received 7 days to analyse extract	SW-846 Ch 3 2007
Metals, SAR, HWS Boron	glass jar*, Teflon™ lined lid, HDPE	none	> 0 to 6°C or room temp.	N/A	180 days as received (without lab drying); indefinite when dried	SW-846 Ch 3 2007 Carter and Gregorich 2008
Mercury, Methyl Mercury	glass jar*, Teflon™ lined lid, HDPE	none	> 0 to 6°C	N/A	28 days	SW-846 Ch 3 2007
pH	glass jar*, Teflon™ lined lid, HDPE, PET, PP	none	> 0 to 6°C or room temp.	N/A	30 days as received; indefinite when dried	Carter, OMOE
SOIL and SEDIMENT Organic Parameters	**Container[1, 4, 5, 6]**	**Field Preservation**	**Storage Temperature[2]**	**Preserved Holding Time[3]**	**Unpreserved Holding Time[3]**	**Reference**
BTEX , PHCs (F1)[7], THMs, VOCs[6]	40–60 mL glass vial (charged with methanol preservative, pre-weighed) [5] AND glass jar* (for moisture content) [hermetic samplers are an acceptable alternative[4, 14]]	methanol (aqueous $NaHSO_4$ is an acceptable alternative if required to meet LRLs)[5, 6, 14]	> 0 to 6°C	40 days methanol extract[7] 14 days aqueous $NaHSO_4$	hermetic samples: stabilise with methanol or aqueous $NaHSO_4$ preservative within 48 hours of sampling[17]	SW-846 Ch 4 2007
1,4-Dioxane[8]	May be sampled as a VOC or ABN		> 0 to 6°C	14 days	N/A	SW-846 Ch 4 2007
PHCs (F2–F4)	glass wide-mouth jar*, Teflon™ lined lid	none	> 0 to 6°C	N/A	14 days to extract 40 days to analyse extract	Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil - Tier 1 Method

ABNs, CPs, OCs, PAH, Pesticides & Herbicides	glass wide-mouth jar*, Teflon™ lined lid	none	> 0 to 6°C	N/A	14 days to extract 40 days to analyse extract	SW-846 Ch 4 2007
PFOS	glass wide-mouth jar*, PE- lined lid (Teflon™ lids cannot be used for PFOS)	none	> 0 to 6°C	N/A	14 days to extract 40 days to analyse extract	SW-846 Ch 4 2007
Dioxins and Furans, PCBs	glass wide-mouth jar*, Teflon™ lined lid	none	> 0 to 6°C	N/A	indefinite	SW-846 Ch 4 2007
Glycols	glass wide-mouth jar*, Teflon™ lined lid	none	> 0 to 6°C	N/A	14 days 40 days to analyse extract, if applicable	SW-846 Ch 4 2007

*Glass jars may be clear or amber glass. Samples for SVOC and other extractable organics should be submitted in amber glass jars.

HDPE = high density polyethylene; PET = polyethylene terephthalate; PP = polypropylene HWS = hot water soluble boron; THM = trihalomethanes; VOC = volatile organic compounds; BTEX = benzene, toluene, ethylbenzene, xylenes; PHCs = petroleum hydrocarbons; CPs = chlorophenols; PCBs = polychlorinated biphenyls; OCs = organochlorine pesticides, Pests & Herbs = Pesticides, Herbicides, Fungicides

N/A = Not applicable.

1–18 footnotes immediately follow Table B

Table 3B: Water Sample Handling and Storage Requirements

WATER **Inorganic Parameters**	**Container[9]**	**Field Preservation**	**Storage Temperature[2]**	**Preserved Holding Time[3]**	**Unpreserved Holding Time[3]**	**Reference**
Ammonia, Nitrate + Nitrite	HDPE[18] or glass*	H_2SO_4	> 0 to 6°C	28 days	3 days	SM 1060 (preserved.) BCMOE (unpreserved.)
Total N, Total P	HDPE[18] or glass*	H_2SO_4 or HCl	> 0 to 6°C	28 days	3 days	SM 1060 (preserved) BCMOE (unpreserved)
Chloride, Conductivity, Fluoride, Sulphate	HDPE[18] or glass*	none	> 0 to 6°C	N/A	28 days	SM 1060
Colour, Nitrite, Nitrate, *o*-Phosphate	HDPE[18] or glass*	none	> 0 to 6°C	N/A	3 days[16]	BCMOE
Cyanide (CN^-)	HDPE[18] or glass*	NaOH to a pH > 12 Protect from light	> 0 to 6°C	14 days	must be field preserved	SM 1060
Hexavalent Chromium	HDPE[18] or glass*	buffer solution to a target pH 9.3–9.7 or NaOH 1 mL 50% per 125 mL sample field filter for “dissolved” prior to preservation[10]	> 0 to 6°C	28 days	24 hours	SM 3500 (buffer) EPA 1669 (NaOH) SM 1060 (unpreserved)
Metals	HDPE[18] or Teflon™	HNO_3 to pH < 2 field filter for “dissolved” prior to preservation[10]	room temperature or > 0 to 6°C when preserved	180 days	must be field preserved[10]	SW-846 Ch 4 2007
Mercury	glass* or Teflon™	BrCl (recommended) or HCl to pH < 2 field filter for “dissolved”	room temperature or > 0 to 6°C when preserved	28 days	must be field preserved[10]	EPA 1631E

		prior to preservation[10]				
Methyl Mercury	glass* or Teflon™	HCl or H_2SO_4 to pH < 2 field filter for "dissolved" prior to preservation[10]	> 0 to 6°C	180 days	must be field preserved[10]	EPA 1630
pH, Reactive Chlorine Species, Dissolved Oxygen	HDPE[18] or glass*	none	> 0 to 6°C	15 min	Field tests	SM 1060
Solids, TSS, TDS	HDPE[18] or glass*	none	> 0 to 6°C	N/A	7 days	SM 1060
Turbidity	HDPE[18] or glass*	Protect from light	> 0 to 6°C	N/A	3 days[16]	BCMOE
WATER Organic Parameters[9, 11, 12]	**Container[9, 11, 12]**	**Field Preservation**	**Storage Temperature[2]**	**Preserved Holding Time[3]**	**Unpreserved Holding Time[3]**	**Reference**
BTEX, PHCs (F1),THMs, VOCs;	40–60 mL glass vials (minimum of 2)[13] (no headspace)	$NaHSO_4$ or HCl to a pH < 2[13] or $Na_2S_2O_3$ if chlorinated	> 0 to 6°C	14 days	7 days for aliphatics must preserve for aromatics	SW-846 Ch 4 2007
1,4-Dioxane[8]	May be sampled as a VOC or ABN		> 0 to 6°C	14 days	14 days	SW-846 Ch 4 2007
PHCs (F2–F4)[9]	amber glass bottle, Teflon™ lined lid	$NaHSO_4$ or HCl to a pH < 2[13]	> 0 to 6°C	14 days	7 days	SW-846 3511 (pres.) SW-846 Ch 4 2007 (unp.)
ABNs, CP, OCs, PAH, Pests & Herbs[9] PFOS	amber glass bottle, Teflon™ lined lid[10]	None or $NaHSO_4$ to pH < 2, $Na_2S_2O_3$ if chlorinated	> 0 to 6°C	14 days[17]	7 days	SW-846 Ch 4 2007 SW-846 3511
PFOS	amber glass bottle, PE-lined lid[10] (Teflon™ lids cannot be used for PFOS)	None or $NaHSO_4$ to pH < 2, $Na_2S_2O_3$ if chlorinated	> 0 to 6°C	14 days[17]	7 days	SW-846 Ch 4 2007 SW-846 3511
Dioxins and Furans, PCB[9]	amber glass bottle, Teflon™ lined lid	None $Na_2S_2O_3$ if chlorinated	> 0 to 6°C	N/A	indefinite	SW-846 Ch 4 2007
Glycols	40–60 mL glass vials (minimum of 2)	$NaHSO_4$ or HCl to a pH < 2	> 0 to 6°C	14 days	7 days	SW-846 3511 (preserved) SW-846 Ch 4 2007 (unpreserved)
WATER Microbiology Parameters	**Container[9]**	**Field Preservation**	**Storage Temperature[2]**	**Preserved Holding Time[3]**	**Unpreserved Holding Time[3]**	**Reference**
Coliforms	Sterile glass or plastic	$Na_2S_2O_3$	> 0 to 6°C	30 hr	N/A	SM 9060B
Cyanobacteria	N/A	Lugol solution	> 0 to 6°C	5 days	30 hr	See Note 15

*Glass bottles or jars may be clear or amber glass. Samples for SVOC and other extractable organics should be submitted in amber glass.

BTEX = benzene, toluene, ethylbenzene, xylenes; CPs = chlorophenols; HDPE = high density polyethylene; OCs = organochlorine pesticides; P&H = pesticides and herbicides; PCBs = polychlorinated biphenyls; PHCs = petroleum hydrocarbons; THM = trihalomethanes; VOC = volatile organic compounds

N/A = Not applicable

1. One soil container is generally sufficient for inorganic analysis and another for extractable organics. A separate container is required for BTEX, THM, VOC and PHC (F1) moisture analysis.
2. Storage temperature refers to storage at the laboratory. Samples should be cooled and transported as soon as possible after collection.

3. Holding time refers to the time delay between time of sample collection and time preparation/analysis is initiated. For samples stabilised with methanol, the hold time for the methanol extract is up to 40 days. Separation of the methanol from the soil is recommended.
4. As an alternative, the US EPA has investigated hermetic sample devices that take and seal a single core sample. The sample is submitted as is to the laboratory where it is extruded into an extracting solvent. Samples must be received at the laboratory within 48 hours of sampling. (Note that replicate samples are necessary for bisulphate and methanol extraction for all samples plus laboratory duplicates and spikes.) Consult the laboratory for the number of samples required.
5. The US EPA and OMOECC have approved field preservation procedures. Pre-weighed vials containing known weights of methanol preservative (or aqueous sodium bisulphate if lower LRLs are required) are sent to the field. Sample cores (approximately 5 g) are extruded directly into the vial. The vials are sealed, and submitted directly to the laboratory. In practice, this technique requires great care to prevent losses of methanol due to leaking vials or through splashing. Consult the laboratory for the number of containers required.
6. Methanol is a superior extraction solvent for VOCs as compared to sodium bisulphate. However, methanol-preserved samples have elevated DLs as compared to aqueous sodium bisulphate. A separate bisulphate-preserved sample or hermetically sealed sample may be submitted at the time of sampling if required LRLs can not be met with methanol extracts – contact the laboratory to determine if a separate sample should be collected.
7. For BTEX and PHC (F1) pre-charging the soil sampling container with methanol preservative is an accepted deviation from the CCME method.
8. 1,4-Dioxane may be analysed as an ABN or VOC. If analyzing a soil as a VOC, either a field preserved sample (Bisulphate will likely be required to achieve the LRL) may be used or an aliquot of a soil sample as received may be extracted and analysed.
9. Samples containing visual sediment at the time of analysis should be noted.
10. In general, for metals, mercury and hexavalent chromium, groundwaters are field filtered and preserved, surface and potable waters are unfiltered and preserved. If field filtration is not possible, lab filter and preserve asap. This must be noted on the C of A. Total metals samples and field filtered dissolved metals may be preserved at the laboratory in the original container. Samples must be allowed to sit for 16 hours prior to subsampling.
11. Aqueous extractable organic samples should be protected from light. If amber bottles are not available, glass should be wrapped in foil.
12. Separate containers are required for each organic water analysis. Consult the laboratory for required volumes and number of containers.
13. Preserved to reduce biodegradation, however severe effervescence/degassing may occur in some water samples. In this case, rinse preservative out three times with sample and submit to the laboratory as unpreserved.
14. Alternatively, to achieve a longer hold time, hermetic samples may be frozen within 48 hours of sampling as per ASTM method D6418 – 09; however, storage stability must be validated by the laboratory with no more than 10% losses.
15. Chorus, I and J. Bartram, Editors. *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management*, © 1999 WHO, E & FN Spon, an imprint of Routledge, New Fetter Lane, London EC4P 4EE.
16. Three day hold times may not be practically achievable, particularly for samples from remote locations. Laboratories should commence analysis as soon as possible but within 48 hours of receipt. Exceedance of hold time increases the uncertainty of test results, but does not necessarily imply that results are compromised.
17. Confirm stability of target analytes at acidic pH before using acid preservation.
18. HDPE is preferred. Other plastics such as PET or PP may be used provided they can be proven free of the analytes of interest.

3.1 Subsampling

The procedures described below cover common situations when subsampling solid and liquid samples in the laboratory. Under such situations, these procedures shall be followed. All actions taken to obtain representative samples other than those described below must be included in the Certificate of Analysis or written report so that the Qualified Person (QP) will be able to assess the data properly and be able to determine if the data are of sufficient quality upon which to base decisions.

3.1.1 Procedure: Soils and Sediment – Inorganic/Other Regulated Parameters

1. Prior to homogenization or drying, samples are to be inspected in the laboratory for multiphase conditions (free water, petroleum product, *etc*.) or other anomalies. Small amounts of free water or petroleum product may be mixed with the sample but large amounts of free water or petroleum product should be separated. The QP should be contacted and agreement reached on how to proceed. Anomalies and the actions taken must be noted in the Certificate of Analysis or analytical report.

   Because of potential volatilization losses for cyanide and possible redox reactions for hexavalent chromium, subsamples for these tests are taken from the sample as received. Subsamples for pH may be taken from the sample as received or from an aliquot dried and ground as described below.

   The sample is mixed as well as possible and several aliquots taken to obtain the desired weight. Hard clay samples that cannot be mixed are “cored”, using a spatula, in different spots or sections of the jar. Stones, twigs and other foreign materials are excluded from the subsamples. To ensure a representative subsample is obtained, a minimum 10 g aliquot is taken.

2. For other inorganic soils and sediment tests, samples are air-dried or oven dried at ≤ 60°C (to prevent the potential loss of volatile analytes). Drying times vary with sample size, moisture content, and oven type. Laboratories should determine minimum drying times for the conditions / sample types within their facilities. To determine moisture content, a separate aliquot is taken and dried to a constant weight at 105°C, usually 2 – 4 hours is sufficient.

   Stones, twigs and other foreign materials are excluded from the subsamples.

   Physical reduction of large clay aggregates is required.

   Dried samples are then passed through a 2 mm sieve. Any portion that does not pass through this sieve is discarded. Minimum 5 g aliquots of the < 2 mm portion of the sample are used in the analysis of chloride, conductivity and hot water soluble boron. Minimum 1.0 g aliquots are recommended for metals and sodium adsorption ratio. Smaller aliquots may be used provided precision is not degraded.

3.1.2 Procedure: Soils and Sediment – Organic Parameters

1. Prior to subsampling, samples are inspected for multiphase conditions (free water, petroleum product, *etc*.) or other anomalies. Small amounts of free water or petroleum product may be mixed with the sample but large amounts of free water or petroleum product should be

separated and retained for possible analysis. The QP should be contacted and asked how to proceed. Anomalies and the actions taken must be noted in the Certificate of Analysis.

2. Normal practice is to prepare samples requiring semivolatile organic analysis as received (without drying). Samples requiring organic analysis for relatively non-volatile compounds such as ABN, dioxins, CP, OC pesticides, PCB, may be air dried until no visible moisture remains, disaggregated, and homogenised. Samples can also be chemically dried by mixing with an equal amount of anhydrous sodium sulphate, or until the sample resembles a free flowing powder. Caution must be used due to heat generation, which may cause losses of more volatile organics such as light PAH. Alternatively, samples may be dried during extraction via toluene azeotrope technique (e.g., Dean-Stark extractions with toluene as the extracting solvent, a technique commonly employed for PCDD/F via US EPA Method 1613B and PCB via US EPA Method 1668C), or samples may be extracted as received using a water-miscible solvent. Stones, twigs and other foreign materials are excluded from the subsamples. For PAH and other relatively volatile analytes, samples are extracted as received.
3. Field-preserved samples requiring analysis for volatile analytes (VOC, BTEX, PHC (F1), THM) are processed as received. Samples collected in hermetic sampling devices are extruded directly into the extraction solvent.
4. For samples requiring analysis for PHC (F2, F3, F4 and F4G), the use of sodium sulphate as a drying agent could lead to an exothermic reaction and therefore should not be used. A minimum of the equivalent (estimated) of 5 g dry weight of the soil as received is taken for analysis. The extraction fluid is added immediately after weighing to minimise volatilization losses.
5. For all other organic analyses, the sample is mixed as well as possible and several aliquots taken to obtain the desired weight. Hard clay samples that cannot be mixed are “cored”, using a spatula, in different spots or sections of the jar. Stones, twigs and other foreign materials are excluded from the subsamples. The extraction fluid should be added as soon as possible after weighing to minimise sample degradation.

3.1.3 Procedure: Water Samples – Inorganic/Other Regulated Parameters

Prior to subsampling, samples are inspected for particulate and the approximate amount of visible particulate (v/v) noted. If particulate is > 5% v/v the QP is contacted and asked how to proceed. It may be necessary to separate the solids and treat them as separate samples. If multiphase samples are encountered (usually petroleum product on the surface), the non-aqueous phase is excluded from any subsamples. The non-aqueous phase should be retained for possible analysis. Such anomalies and the actions taken must be noted on the Certificate of Analysis or analytical report.

Conductivity and pH

Do not shake, dilute or alter the samples in any way as this can alter the result. Pour the sample into the sample cup or measurement vessel.

Ammonia, Chloride, Colour, Cyanide, Nitrates, Nitrites, Phosphorus, Sulphate

Shake and pour the sample. An aliquot may be filtered or decanted to prevent instrument problems. Note that for phosphorus parameters, only samples to be analysed for "dissolved" phosphorus tests may be filtered.

Dissolved Metals, Including Mercury, Methylmercury and Hexavalent Chromium

In general, groundwaters requiring these tests are field filtered and preserved. Surface waters and potable waters are usually preserved unfiltered and analyzed for total metals. Samples requiring analysis for dissolved metals, mercury, methylmercury, or hexavalent chromium in groundwater are field filtered through a 0.45 µm filter immediately followed by field preservation as described in Table 3B. In the event field filtration/preservation is not possible, samples may be filtered and preserved as soon as possible at the laboratory. However, this deviation must be indicated on the Certificate of Analysis with a cautionary note that values may not reflect concentrations at the time of sampling. Note that in some jurisdictions, lab filtration for dissolved metals is not permitted. Unfiltered, preserved samples are not suitable for laboratory filtration. The filter media must be proven to yield < LRL levels of the analytes of interest.

Total Metals

Aqueous samples requiring total metals analysis may be preserved in the field or at the laboratory. If laboratory-preserved, samples must be allowed to sit in their original containers for a minimum of 16 hours prior to digestion and analysis.

Note: The CEQG are based on on "total" metals. The OMOECC standards for groundwater are based on "dissolved" metals. Other jurisdictions may vary.

Total Suspended Solids, Total Dissolved Solids, Turbidity

Shake and pour the sample. Samples must not be filtered or diluted prior to analysis.

3.1.4 Water Samples – Organic Parameters

Volatile Organic Compounds

Volatile organic compound samples (VOC, BTEX, PHC (F1), THM) are treated differently from extractable organic samples. Samples should be received in replicate VOC vials.

1. When sampling, the vials or bottles should be filled slowly to the rim of the container so that a dome or convex meniscus is present. A slight loss of sample may occur when the cap is applied. When capped, the cap or septum should be in contact with the sample so that no air is trapped in the sample container and when the vial or bottle is inverted any air bubble present should not cover the bottom of the vial. The Teflon™ liner, not the silicone or rubber backing of the septum, must be in contact with the sample.
2. Prior to analysis, samples are inspected for particulate and the approximate amount of visible particulate (v/v) noted. Samples are also examined for headspace and if, on inversion, there is an air bubble present that covers the bottom of the vial (> approximately 2 mL air volume), the samples may be compromised and should not be analysed. If the client requires analysis,

the data reported must be qualified accordingly. Note that an air bubble of up to 5% of the total volume of the sample container has been shown to cause almost no significant loss of most VOCs if samples are stored appropriately.

3. Modern purge and trap autosampler systems permit direct aliquoting and surrogate/internal standard addition without opening the vial.
4. For older purge and trap apparatus and headspace systems, the vial is opened and the appropriate aliquot is removed, immediately placed in the analysis vessel and the vessel sealed. Once subsampled, the sample vial is compromised and not suitable for reanalysis.
5. If the sample contains a non-aqueous layer, it is generally unsuitable for analysis. If the client requires analysis of the aqueous fraction of the sample, an aliquot may be drawn with a syringe from below the non-aqueous layer and analysed. Anomalies and the actions taken must be noted in the Certificate of Analysis.

Extractable Organic Compounds

Extractable organic analytes tend to be hydrophobic and will adsorb to both the sample bottle and any particulate in the sample. As such, the default method of analysis is "whole sample" analysis in which the entire contents of the sample bottle are extracted, the sample bottle rinsed with solvent and the combined extract used for analysis. Because organics tend to adsorb on particulate, if "dissolved" organics are required, care should be taken to exclude particulates at the time of sampling. Similarly, organics tend to adsorb to filter materials so filtration is not an acceptable option.

1. Prior to extraction the sample is inspected for particulate and a non-aqueous phase. If there is no non-aqueous phase, the amount of particulate (if any) is noted. The entire sample is extracted, the sample bottle rinsed with solvent and the combined extract used for analysis.
2. If a surface "sheen" is observed it is noted but the sample is treated as in 1, above.
3. If a substantial (separable) non-aqueous layer is observed, the QP is contacted for instructions as to how to proceed. If instructions are not received, the non-aqueous layer is separated from the aqueous layer, its volume estimated and it is retained for possible analysis. The aqueous layer is extracted as in 1, above. The preferred approach is to analyse both phases. If only one phase of the sample is analysed, this must be clearly indicated on the Certificate of Analysis.

3.1.5 Biotic Samples

Concentrations of substances in biotic samples can vary depending on several factors, notably, the type of tissue consumed, the metabolism of compounds by the plant or animal species, and cooking and food preparation methods. Depending on data use objectives, these issues should be considered and identified at the design stage of the sampling campaign to ensure that the samples submitted to the testing laboratory are prepared for consumption in the same manner as practiced by the affected community and analysed for the appropriate chemical species. Additional guidance for sampling and analysing biotic food samples can be found in Meridian (2011) and Health Canada (2011).

4 ANALYTICAL METHODS

The analytical methods described in this section derive from the following sources:

1. AOAC International (Association of Analytical Chemists), http://www.aoac.org.
2. ASTM International (formerly American Society for Testing and Materials), www.astm.org.
3. British Columbia Environmental Laboratory Manual, www.env.gov.bc.ca/epd/wamr/labsys/lab-man-09/.
4. British Columbia Ministry of the Environment, http://www.env.gov.bc.ca/wat/wq/BCguidelines/samp_strat/sampstrat.html#analytical.
5. Canadian Council of Ministers of the Environment (CCME), www.ccme.ca.
6. Carter, M.R. and E.G. Gregorich, Editors. 2008. Soil Sampling and Methods of Analysis. Canadian Society of Soil Science. 2nd Edition.
7. Centre d'expertise en analyse environnementale du Québec, http://www.ceaeq.gouv.qc.ca/methodes/methode_index.htm.
8. Chorus, I. and J. Bartram, Editors. 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management, © 1999 WHO, E & FN Spon, an imprint of Routledge.
9. Dionex Corporation, 1997-2003, Document No. 034217, Revision 09, 21 May 2003.
10. Emerson, K., R.E. Lund, R.V. Thurston and R.C. Russo. 1975. Aqueous ammonia equilibrium calculations: effect of pH and temperature. J. Fish. Res. Board Can. 32: 2379-2383.
11. Environment Canada. 2012. Canadian Aquatic Biomonitoring Network, Field Manual, Wadeable streams. Cat. No. En84-87/2012E-PDF, ISBN 978-1-100-20816-9, http://www.ec.gc.ca/Publications/C183563B-CF3E-42E3-9A9E-F7CC856219E1/CABINFieldManual_EN_2012.pdf .
12. Environment Canada. 1997. Environmental Technology Advancement Directorate, Environment Reference Series, Report EPS 1/RM/31E, Reference Method for the Analysis of Polychlorinated Biphenyls, March 1997, http://www.ec.gc.ca/Publications/35F34D26-5DC5-49B3-9D8D-098C6392DD9B%5CReferenceMethodfortheAnalysisofPolychlorinatedBiphenylsPCBs.pdf
13. Environment Canada. 2010. Reference Method for the Determination of Polychlorinated Dibenzoparadioxins and Polychlorinated Dibenzofurans in Pulp and Paper Mill Effluents, December 07, 2010, http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=89496F4E-1&offset=4&toc=show.
14. Gupta, UC. 1967. A simplified method for determining hot water soluble boron in podzol soils. *Soil Science* 103: 424-428.
15. Hach Company. 2012. Method 8025, Color, True and Apparent, Low Range. DOC316.53.01252.

16. Hach Company. 2002. Method 7019, Harp, J.D. Current Technology of Chlorine Analysis for Water and Wastewater. *Technical Information Series*, Booklet No. 17.

17. Ikonomou MG, Fernandez MP, He T, Cullon D. 2002. Gas chromatography–high-resolution mass spectrometry based method for the simultaneous determination of nine organotin compounds in water, sediment and tissue. Journal of Chromatography A 975(2):319-333.

18. Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup, http://www.mass.gov/dep/cleanup.

19. Maynard, DG, and P.A. Addison. 1985. Extraction and Colorimetric Determination of Elemental Sulfur in Organic Horizons of Forest Soils. Canadian Journal of Soil Science 65(4): 811-813.

20. McKeague, J.A., Editor. 1976. Manual of Soil Sampling and Methods of Analysis. Soil Research Institute.

21. Ontario Ministry of the Environment and Climate Change (OMOECC) Laboratory Services Branch (LaSB). Email requests for these methods can be sent to LaboratoryServicesBranch@ontario.ca.

22. Standard Methods for the Examination of Water and Wastewater: American Public Health Association (APHA)/American Water Works Association (AWWA)/Water Environmental Federation (WEF). www.standardmethods.org.

23. United States Environmental Protection Agency (US EPA). www.epa.gov , http://www.epa.gov/epawaste/hazard/testmethods/sw846/online/index.htm#table, http://www.epa.gov/region1/info/testmethods/pdfs/testmeth.pdf.

24. United States Geological Survey (USGS) of the United States Department of the Interior. (www.usgs.gov) and the National Water Quality Laboratory (USGS-NWQL), http://nwql.usgs.gov.

ANALYTICAL METHOD SUMMARIES

In most cases, more than one preparation or analytical technique may be employed for the determination of most analytes. The relative merits of alternative techniques are discussed in the Analytical Method Summaries below, but, in general, as long as a specific procedure meets the data quality objectives (DQOs) (precision, accuracy, sensitivity) outlined in Section 6 of this compendium, it is considered fit for purpose and may be employed.

The methods discussed below represent current mainstream analytical technology. This is not intended to exclude new and emerging technology such as time-of-flight mass spectrometry, high resolution inductively coupled plasma-mass spectrometry (ICP-MS), two dimensional gas chromatography (GC x GC), *etc*., which, in fact, may provide improved sensitivity or specificity as compared to the current technologies and may be used provided the DQOs in Section 6 are met.

Laboratories are required to verify that all procedures in the analytical method are documented and based on the current valid edition of the reference method. All modifications to the analytical method must be documented; the method must be validated and must contain a statement that the

method is fit for the intended use with respect to sensitivity, selectivity, analytical range, and method precision and bias.

All method validation, quality assurance, and quality control requirements in Section 6 must be met.

There are several cases outlined below where stated test groups can be analysed together. Combining test groups may compromise analytical conditions. Such combinations are permitted only when all of the required performance standards in Tables 6-1 to 6-16 are met.

4.1 Organic Parameters Group

4.1.1 Acid/Base/Neutral Extractable Organic Compounds (ABNs)

Selected ABN parameters contained within the **CEQG** and **O. Reg. 153/04**.

Parameters

Aniline	Di(2-ethylhexyl) phthalate	Dinitrotoluene, 2,4-(2,6-)*
Biphenyl, 1,1'-	Dichlorobenzidine, 3,3'-	Di-n-octyl phthalate
Bis(2-chloroethyl)ether	Diethyl phthalate	Phthalic acid esters (each)†††
Bis(2-chloroisopropyl)ether	Dimethyl phthalate	
Chloroaniline, p-	Di-n-butyl phthalate	

* The sum of 2,4- and 2,6-dinitrotoluene is compared to the standard.

††† CCME has not defined a list of phthalic acid esters. For this compendium the list is the phthalate compounds listed above, which have Ontario guidelines.

Table 4.1.1

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3546 SW-846, Method 3550C SW-846, Method 3570 **Sample Clean-up** SW-846, Method 3610B SW-846, Method 3630C **Analysis** SW-846, Method 8270D EPA Method 1625C	**Sample Preparation** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535A **Analysis** SW-846, Method 8270D EPA Method 1625C
Standard Methods		Method 6410B
OMOECC		E3265
Centre d'expertise en analyse environnementale		MA. 400 - Phe 1.0 MA. 400 - COSVc 1.0 MA. 403 - COSV 1.0

Method Principle

Aqueous or soil samples, as received, are fortified with surrogates and extracted with a solvent or solvent mix.

Soil and sediment samples are normally dried by mixing with a desiccant prior to extraction, or are extracted with a water-miscible solvent. Water sample extraction must be carried out at pH < 2 (acid extractable) and > 11 (base neutral extractable). Extracts are dried, concentrated and exchanged into a solvent compatible with the clean-up (if necessary) or determinative technique being employed. Clean-up with silica gel or alumina may be required for difficult samples and laboratories may elect to perform clean-up routinely to extend column life. See reference methods for additional details.

Internal standards are added after all preparation and clean-up steps are completed. Extracts are stable for up to 40 days. Analysis is by GC-MS operated in either the full scan or selected ion monitoring (SIM) mode. The SIM mode provides lower detection limits, while the full scan mode provides diagnostic capability and permits investigation of non-target analytes.

Quantitation is by the internal standard method.

GC-MS in the full scan mode may also be used to identify non-target compounds by comparing the mass spectrum of each unknown to the GC-MS library of mass spectra. Concentrations can be approximated using the response factor of a similar target compound. This technique can be applied equally well to VOC scans.

4.1.2 Chlorophenols (CPs) and Non-Chlorinated Phenols (NCPs)

Chlorophenols and non-chlorinated phenols may also be determined with ABNs (Section 4.1.1), provided LRL requirements are met.

Parameters

Dichlorophenol, 2,4- 2,5- 2,6- 3,4- 3,5-	Phenol
Dimethylphenol, 2,4-*	Phenolic compounds, non-chlorinated*
Dinitrophenol, 2,4-*	Phenols (mono- & dihydric)**
Monochlorophenol, 2- 3- 4-	Tetrachlorophenol, 2,3,4,5- 2,3,4,6- 3,4,5,6-
Pentachlorophenol (PCP)	Trichlorophenol, 2,3,4- 2,3,5- 2,3,6- 2,4,5- 2,4,6-

* Non-chlorinated phenolic compounds include 2,4-dimethylphenol; 2,4-dinitrophenol; 2-methyl 4,6-dinitrophenol; 2-nitrophenol; 4-nitrophenol; *o*-, *m*-, *p*-cresol (methylphenol).

** CCME has not selected a list of mono- and dihydric- phenols for monitoring. For this compendium, the list is the phenolic compounds: non-chlorinated plus phenol, 4-hydroxyphenol (hydroquinone), 3-hydroxyphenol (resorcinol), which have British Columbia guidelines.

Table 4.1.2

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3546 SW-846, Method 3550C SW-846, Method 3570 **Analysis** SW-846, Method 8270D	**Sample Preparation** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535A EPA Method 1653 **Analysis** SW-846, Method 8270D EPA Method 1653
Standard Methods		Method 6410B Method 6420C
OMOECC		E3119 E3265
Centre d'expertise en analyse environnementale		MA. 400 - Phe 1.0 MA. 403 - COSV 1.0

Method Principle

Reference methods in Table 4.1.2 shall be followed with the following addition: water samples must be acidified to pH < 2 prior to liquid/liquid extraction in order to achieve adequate recoveries. Solid phase extraction (SPE) procedures (SW-846, Method 3535A) may not require acidification. Samples are extracted, derivatised, if required, and analysed by GC-MS as described in Section 4.1.1.

Derivatisation, when required, involves a chemical reaction that converts the phenol and chlorophenol analytes of interest to their corresponding esters, resulting in improved chromatography and detection limits. Clean-up techniques remove interferences that may impact quantitation and degrade column performance. In general, derivatisation will not be required to achieve the required reporting limits (LRLs) for phenols and chlorophenols.

4.1.3 1,4-Dioxane

1,4-Dioxane may be determined with ABNs (Section 4.1.1) or VOCs (Section 4.1.14).

Parameters

Dioxane, 1,4-

Table 4.1.3

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Introduction for 8260** SW-846, Method 5021A SW-846, Method 5035 **Sample Preparation for 8270** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3546 SW-846, Method 3550C SW-846, Method 3570 **Analysis** EPA Method 1624C EPA Method 1625C SW-846, Method 8260C SW-846, Method 8270D	**Sample Introduction for 8260** SW-846, Method 5000 SW-846, Method 5030C **Sample Preparation for 8270** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535A **Analysis** EPA Method 1624C EPA Method 1625C SW-846, Method 8260C SW-846, Method 8270D
Centre d'expertise en analyse environnementale		MA. 403 - COSV 1.0

Method Principle

1,4-Dioxane is a water soluble organic compound which can be analysed either as an extractable organic or volatile organic compound

Because 1,4-dioxane recovers poorly using either extraction or purging techniques, isotope dilution, where the native analyte is quantitated using the deuterated analogue (US EPA Method 1624C, US EPA Method 1625C), is required. Other than quantitation by isotope dilution, all other facets of the preparation and analysis are similar to the analysis of VOCs (Table 4.1.14) or ABNs (Table 4.1.1).

4.1.4 Glycols

Diethylene glycol
Ethylene glycol
Propylene glycol 1,2-

Table 4.1.4

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3570 **Analysis** SW-846, Method 8015D SW-846, Method 8270D	**Sample Preparation** SW-846, Method 3510C SW-846, Method 8015D **Analysis** SW-846, Method 8015D SW-846, Method 8270D
Centre d'expertise en analyse		MA. 400 - Eth-Gly 1.0

Method Reference Source	Soil & Sediment	Water
environnementale		

Method Principle

Water samples are analysed by direct aqueous injection by gas chromatography-flame ionization detector (GC-FID). Soil samples are subjected to aqueous extraction prior to direct injection of the aqueous extract. This method yields detection limits of approximately 5 mg/L, which is well below regulatory guidelines. If lower reporting limits are required, samples may be extracted, derivatised, and analysed by GC-MS.

Note: The CEQG is based on 1,2-propylene glycol.

4.1.5 Organochlorine Pesticides (OCs)

Parameters (Synonyms)

Aldrin	Hexachlorobenzene
Chlordane, *alpha*- (α-chlordane)*	Hexachlorobutadiene (HCBD)
Chlordane, *gamma*- (γ-chlordane)*	Hexachlorocyclohexane, *gamma*- (γ-HCH, Lindane, γ-BHC†)
Dichloro diphenyl dichloroethane, 2,2-Bis (p-chlorophenyl)-1,1-dichloroethane, DDD***	Hexachloroethane
Dichloro diphenyl ethylene, 1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene, DDE***	Methoxychlor
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane, DDT***	Metolachlor††
Dieldrin	Pentachlorobenzene††
Endosulfan I (thiodan sulphate I)**	Tetrachlorobenzene, 1,2,3,4-††
Endosulfan II (thiodan sulphate II)**	Tetrachlorobenzene, 1,2,3,5-††
Endrin	Tetrachlorobenzene, 1,2,4,5-††
Heptachlor	Toxaphene
Heptachlor epoxide	

* The sum of alpha- and gamma-chlordane is compared to the standard.

** The sum of endosulfan I and II is compared to the standard.

***DDT standard applies to the total DDT (i.e., sum of the DDT isomers), the DDE standard applies to total DDE (i.e., sum of the DDE isomers), and the DDD standard applies to the total DDD (i.e., sum of the DDD isomers).

† Erroneously known as benzene hexachloride (BHC).

†† May also be determined with ABNs.

Table 4.1.5

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3545A SW-846, Method 3546 SW-846, Method 3550C SW-846, Method 3570 **Sample Clean-up** SW-846, Method 3610B SW-846, Method 3620C SW-846, Method 3630C SW-846, Method 3660B **Analysis** SW-846, Method 8081B SW-846, Method 8270D SW-846, Method 8276 SW-846, Method 8290A EPA Method 1613B EPA Method 1699	**Sample Preparation** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535A **Sample Clean-up** SW-846, Method 3610B SW-846, Method 3620C SW-846, Method 3630C SW-846, Method 3660B **Analysis** SW-846, Method 8081B SW-846, Method 8270D SW-846, Method 8276 SW-846, Method 8290A EPA Method 1613B EPA Method 1699
Standard Methods		Method 6410B Method 6630B Method 6630C
OMOECC	E3487	E3400
Centre d'expertise en analyse environnementale		MA. 400-SPE - BPC/Clbz/HAP 1.0 MA. 403 - P. Ocl 4.0 MA. 416 - P. Ocl 1.0

Method Principle

Each soil sample is extracted in a solvent or solvent mix. Extraction methods include using Soxhlet extraction or ultrasonic bath followed by vortex shaker. Alternatively, pressurised fluid extraction may be used for soil or sediment samples.

Each aqueous sample is extracted with a solvent or solvent mix. After extraction, a number of clean-up techniques may be applied, depending on the sample matrix and the determinative analytical method. The cleaned extract is concentrated to a small final volume.

Soil and water extracts can be kept for 40 days.

To reliably achieve the CEQG for some of the OCs, analysis by high resolution mass spectrometry (HRMS) is required. Negative chemical ionization mass spectrometry has also been employed for toxaphene.

However, dual-column gas chromatography with electron capture detector (GC-ECD) is almost as sensitive and is routinely used for many applications. GC-MS may also be used. The GC-ECD is very sensitive for highly chlorinated compounds but the ECD is nonspecific and subject to

interferences. Thus, sample clean-up is required and second column confirmation of target analytes is required.

Calculations:

When dual column ECD analysis is conducted, OCP results are computed for each column independently. For each parameter, if acceptable and comparable results (within 30% RPD) are generated by both columns, both results should be averaged. Otherwise, results should be taken from the column that gives the best qualitative match with reference standards in terms of peak shape and retention time.

4.1.6 Organotin Compounds

Parameters

Tributyltin
Tricyclohexyltin
Triphenyltin

Table 4.1.6

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** SW-846, Method 3511 **Analysis** SW-846, Method 8323
Journal of Chromatography A, 2002, Volume 975, Issue 2, 319-333	**Analysis** Michael G. Ikonomou, Marc P. Fernandez, Tim He, Donna Cullon, "Gas chromatography-high resolution mass spectrometry based method for the simultaneous determination of nine organotin compounds in water, sediment and tissue"	**Analysis** Michael G. Ikonomou, Marc P. Fernandez, Tim He, Donna Cullon, "Gas chromatography-high resolution mass spectrometry based method for the simultaneous determination of nine organotin compounds in water, sediment and tissue"
Standard Methods		Method 6710A Method 6710B

Method Principle

Samples are extracted, derivatised, cleaned up, concentrated, and analysed by GC-MS in the SIM mode. Alternatively, samples may be analysed by GC using other detectors such as inductively coupled plasma spectroscopy (ICP) or inductively coupled plasma-mass spectrometry (ICP-MS). However, to meet the lowest CEQG, HRMS may be required. EPA has also published a solid phase extraction, liquid chromatography (LC), electrospray MS method.

4.1.7 Perfluorinated Sulphonic Acids, Perfluorinated Carboxylic Acids and their Salts

These compounds may be expressed as acids or salts. In the table they are listed as the anionic component of the salt because several different cations may pair with the anion.

Sulphonic Acid Salts	Carboxylic Acid Salts
Perfluorobutanesulphonate (PFBS)	Perfluorobutanoate (PFBA)
Perfluorohexanesulphonate (PFHxS)	Perfluoropentanoate (PFPeA)
Perfluorooctanesulphonate (PFOS)*	Perfluorohexanoate (PFHxA)
Perfluorooctane sulphonamide (PFOSA)	Perfluoroheptanoate (PFHpA)
	Perfluorooctanoate (PFOA)
	Perfluorononanoate (PFNA)
	Perfluorodecanoate (PFDA)
	Perfluoroundecanoate (PFUnA)
	Perfluorododecanoate (PFDoA)

* While there are currently no CCME guidelines for perfluorinated sulphonic acids and perfluorinated carboxylic acids, this group was included given recent interest in these parameters. This list represents the most commonly determined compounds. Other perfluorinated compounds may be determined using the same procedure.

Table 4.1.7

Method Reference Source	Soil & Sediment	Water
US EPA		**Preparation and Analysis** EPA 537
OMOECC	**Preparation and Analysis** E3506	**Preparation and Analysis** E3457

Method Principle

Perfluorooctanesulphonate (PFOS) is an exceptionally stable compound in industrial applications and in the environment because of the effect of aggregate carbon–fluorine bonds. PFOS is a fluorosurfactant that lowers the surface tension of water more than do hydrocarbon surfactants. Although attention typically is focused on the straight-chain isomer (n-PFOS), which is dominant in commercial mixtures and environmental samples, there are 89 linear and branched congeners that are expected to have different physical, chemical, and toxicological properties. PFOS together with perfluorooctanoate (PFOA) has also been used to make aqueous film forming foam (AFFF), a component of fire-fighting foams and alcohol-type concentrate foams.

The analysis may be used to determine only PFOS and PFOA or an extended list of similar perfluorinated sulphonates and carboxylates.

Water samples are analysed by direct aqueous injection liquid chromatography tandem mass spectrometry (LC-MS/MS). If additional sensitivity is required, SPE may be employed to concentrate the sample prior to analysis.

Solid samples are mixed with an ion-pairing agent prior to extraction. Extracts are evaporated to dryness and reconstituted in methanol prior to analysis by LC-MS/MS.

4.1.8 Pesticides and Herbicides (P&H)

Most of the current pesticides in use are water-soluble, often do not extract well from aqueous solution, and are difficult to determine with adequate sensitivity by GC-MS. In recent years,

improvements to LC-MS/MS technology have made it an excellent technique for broad spectrum analysis of these compounds. The technique is much more specific than conventional high performance liquid chromatography (HPLC) and provides equal or better sensitivity. Since the technique and the instrumentation are evolving, there are few published methods and lab methods might best be described as “in-house”. Some compounds are amenable to analysis by GC-MS, however, and this technique can be very effective when specific subsets of the full list, for example, soil sterilants (atrazine, bromacil, linuron, simazine, tebuthiuron), are requested. Similarly, there are several liquid chromatography-mass spectrometry (LC-MS) methods employing fluorescence detection that can be used for subsets of the list.

The no-longer-in-use organochlorine pesticides listed in Section 4.1.5 are not amenable to analysis by LC-MS/MS and require analysis by GC-ECD or HRMS to achieve sufficient sensitivity.

Carbamate pesticides are often determined as a separate group and glyphosate is usually determined as a single analysis or in combination with 2-amino-3-(5-methyl-3-oxo-1,2- oxazol-4-yl) propanoic acid (AMPA) (no CEQG).

Except as indicated, the methodologies described below achieve the CEQG. Analytical techniques are continually improving and additional analytes may be added to scans provided they meet the DQOs in Section 6.

All parameters have water CEQGs. Note that only Dinoseb has a soil CEQG.

Parameters

Atrazine	Deltamethrin	Metribuzin
Bromacil	Dicamba	Permethrin
Bromoxynil	Diclofop-methyl	Picloram
Captan	Didecyl dimethyl ammonium chloride (DDAC)	Simazine
Carbaryl	Dimethoate	Tebuthiuron
Chlorothalonil	Dinoseb	Trifluralin
Chlorpyrifos	Linuron	
Cyanazine	Methoprene	

Table 4.1.8

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3550C **Analysis** EPA 538 Ver 1.0 (LC-MS/MS) EPA Method 1699	**Sample Preparation** SW-846, Method 3035A SW-846, Method 3510C SW-846, Method 3520C EPA Method 1699 **Sample Clean-up** EPA Method 1699 **Analysis** EPA 538 Ver 1.0 (LC-MS/MS) SW-846, Method 8270D SW 848, Method 8151B EPA Method 1699
OMOECC		E3119 E3121 E3389 E3415 E3437
Centre d'expertise en analyse environnementale		MA. 403 - PEST 4.1 MA. 416 - PEST 1.0

Method Principle

Water samples may be subjected to direct aqueous injection into an LC-MS/MS operating in the multiple reaction monitoring (MRM) mode. Alternatively, samples may be concentrated by solid phase extraction prior to analysis by LC-MS/MS.

LC-MS/MS is either not sufficiently sensitive to achieve the lowest CEQG (dicamba, deltamethrin, permethrin, triallate) or not determinable (chlorothalonil, trifluralin) for several compounds.

Clorothalonil, triallate and trifluralin are determined by extraction GC-MS using procedures for ABNs described in Section 4.1.1. Dicamba is also analysed by GC-MS but requires derivatisation prior to analysis. Permethrin requires preparation and analysis by HRMS in order to achieve the CEQG. The CEQG for deltamethrin is not achievable even by HRMS, but HRMS provides the lowest achievable LRL.

Soil samples are subjected to an aqueous leach prior to LC-MS/MS analysis of the leachate, or solvent extraction prior to derivatisation and analysis by GC-MS.

4.1.8.1 Carbamates

Carbamates may also be determined with P&H (Section 4.1.8) by LC-MS/MS.

Parameters

Aldicarb
Carbamate, 3-Iodo-2-propynyl butyl
Carbofuran
Imidacloprid
Triallate

Table 4.1.8.1

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** EPA 531.2 Rev 1.0 **Analysis** EPA 531.2 Rev 1.0 EPA 538 Ver 1.0
Standard Methods		6610B
AOAC		AOAC Method 991.06
OMOECC		E3501
Centre d'expertise en analyse environnementale		MA. 403 - PesCar 1.1

Method Principle

Samples are subjected to direct aqueous injection into an HPLC followed by post column derivatisation and fluorescence detection. Alternatively, samples may be analysed by LC-MS/MS as described in Section 4.1.8.

4.1.8.2 Glyphosate

Glyphosate

Table 4.1.8.2

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** EPA 547 **Analysis** EPA 547
Standard Methods		Method 6651B
AOAC		AOAC 991.08
OMOECC	E3505	E3500
Centre d'expertise en analyse environnementale		MA. 403 - GlyAmp 1.0

Method Principle

Samples are subjected to direct aqueous injection into an HPLC followed by post column oxidation, derivatisation of the oxidised product and fluorescence detection. Alternatively, samples may be analysed by LC-MS/MS as described in Section 4.1.8. AMPA is chemically similar to and normally determined in conjunction with glyphosate.

4.1.8.3 Phenoxy Herbicides

Phenoxy herbicides may also be determined with P&H (Section 4.1.8) or ABNs (Section 4.1.1).

Parameters

Dichlorophenoxyacetic Acid, 2,4- (2,4-D)
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid, MCPA)

Table 4.1.8.3

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535A **Analysis** EPA 538 Ver 1.0 EPA Method 1625C SW-846, EPA 8151B SW-846, Method 8270D
Standard Methods		Method 6640B
AOAC		AOAC 992.32
OMOECC	E3504	E3119
Centre d'expertise en analyse environnementale		MA. 403 - P Chlp 2.1 MA. 416 - P Chlp 1.1

Method Principle

Samples may be analysed by LC-MS/MS as described in Section 4.1.8 or by acidification and solvent extraction followed by GC-MS as described in Section 4.1.1. Derivatisation prior to GC-MS is optional and may be required to achieve the required LRLs.

Traditional methods involve acidification, extraction, derivatisation, optional clean-up, and analysis by GC-ECD. These methods, although very sensitive, are more interference-prone than GC-MS or LC-MS/MS techniques.

4.1.9 Petroleum Hydrocarbons (PHCs)

Parameters

Petroleum Hydrocarbons (PHCs) (C6–C10 Fraction) F1 (C6 to C10)
Petroleum Hydrocarbons (PHCs) (C10–C50 Fraction) F2 (C10 to C16), F3 (C16 to C34), F4* (C34 to C50), F4G* (gravimetric)

*The larger result obtained for F4 and F4G is compared to the standard.

Table 4.1.9

Method Reference Source	Soil & Sediment	Water
CCME	**Sample Preparation and Analysis** Reference Method for the Canada-Wide Standards for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method, 2001 Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method – Addendum 1, 2002	**Analysis** Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method, 2001 Reference Method for the Canada-Wide Standards for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method – Addendum 1, 2002
OMOECC		E3421

Method Principle

PHCs in Soils and Sediment

Note: The analysis of petroleum hydrocarbons (PHCs) must be in accordance with the CCME method (Table 4.1.9), which is composed of both "prescriptive" and "performance based" elements. The method also contains mandatory chromatography performance elements. For BTEX and F1, pre-charging the soil sampling container with methanol preservative is an accepted deviation from the CCME method.

Fraction F1 is determined by processing a field-preserved soil or sediment sample as received (approximately 5 g) (refer to Table 3A) then analysing by purge & trap or headspace GC-FID. Hermetic samplers and freezing are additional sample handling options that require modified preparation techniques. See Section 4.1.1.14 (VOCs) for details.

Fractions F2, F3, F4 are determined by extracting a minimum of 5 g dry weight soil sample with 50:50 hexane/acetone in a Soxhlet apparatus or equivalent (e.g., mechanical extractor). The solvent recovered from the extracted soil sample is partitioned with water to remove and/or minimise the acetone content in the organic extract. The organic extract is dried using sodium sulphate and treated with silica gel (100% activated) either *in situ* or by column chromatography to remove polar material (50:50 dichloromethane/hexane). Recovered solvent extracts are analysed within 40 days from extraction. The extract is analysed by GC-FID.

Moisture content is determined as described in Section 3.1.1 (2).

For F1 the sample is analysed by gas chromatography with a 100% polydimethylsiloxane column (DB-1 or equivalent) and a flame ionization detector. All area counts are integrated from the beginning of the nC_6 peak to the apex of the nC_{10} peak to give F1. Standards containing nC_6, nC_{10}, and toluene are run. Toluene is used as a calibration standard. The nC_6 and nC_{10} response factors must be within 30% of the response factor for toluene.

For F2, F3, F4, the sample is analysed by gas chromatography with a 100% polydimethylsiloxane column (DB-1 or equivalent) and a flame ionization detector. It must be demonstrated daily that the response factors for nC_{10}, nC_{16} and nC_{34} have a relative standard deviation (RSD) $\leq$ 10% and the response factor for nC_{50} is within 30% of the average response factor for nC_{10} nC_{16} and nC_{34}. The hydrocarbon concentrations are calculated in the following three ranges.

1. F2 (nC10 to nC16 hydrocarbons) is determined by integration of all area counts from the apex of the nC10 peak to the apex of the nC16 peak. The average response factor for nC10, nC16 and nC34 hydrocarbons is used for primary calibration.
2. F3 (nC16 to nC34 hydrocarbons) is determined by integration of all area counts from the apex of the nC16 peak to the apex of the nC34 peak. The average response factor for nC10, nC16 and nC34 hydrocarbons is used for primary calibration.
3. F4 (nC34 to nC50 hydrocarbons) is determined by integration of all area counts from the apex of the nC34 peak to the apex of the nC50 peak. The average response factor for nC10, nC16 and nC34 hydrocarbons is used for primary calibration. The GC response factor of the nC50 must be within 30% of the average response factor of the nC10, nC16 and nC34 hydrocarbons. This result gives fraction F4 provided the chromatogram descends to baseline by the retention time of nC50.

   F4G hydrocarbons (gravimetric analysis) is determined if the chromatogram does not return to baseline at or before nC50 and the total hydrocarbon envelope is > 500 mg/kg. A $\geq$ 5 g soil sample is extracted with 50:50 hexane:acetone, treated with silica gel (F4Gsg), the solvent evaporated, and the weight of residue determined. Both the F4 (GC) result and the F4Gsg (gravimetric) result are reported, but the greater result is used for comparison to the applicable PHC standard for F4. Note that F4G is a gravimetric measurement that includes > C50 hydrocarbons as well as F4, F3 and the majority of F2 hydrocarbons.

F2–F4 analysis of high organic carbon soils

Soils and sediment with high organic content such as peat may exceed the capacity of the silica gel to remove non-petroleum hydrocarbons. Another aliquot of the extract may be treated with a larger weight of silica gel if required. GC-MS analysis may also be used to identify non-petroleum hydrocarbons. The reference method also suggests comparison to background samples. See the Reference Method for the Canada-Wide Standards for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method, 2001 for additional detail.

PHCs in Water

Note: A national method has not been approved for water samples. However, analysis of PHCs in water must be in accordance with the prescribed instrumental analysis and instrumental performance requirements of Canada-Wide Standards for Petroleum Hydrocarbons

(CWS-PHC) in Soil – Tier 1 Method, 2001, and must meet all prescribed performance requirements of the CCME method.

Fraction F1 is determined by purging a volume of a water sample, or sampling its headspace, then analysing by GC-FID.

Fractions F2, F3 and F4 are determined by extraction with hexane. Recovered extracts may be kept for up to 40 days from extraction. The solvent recovered from the extracted sample is dried using sodium sulphate and can be treated with silica gel either *in situ* or by column chromatography to remove polar material (50:50 dichloromethane/hexane). The extract is then analysed by GC-FID.

For F1, the sample is analysed by gas chromatography with a 100% polydimethylsiloxane column (DB-1 or equivalent) and a flame ionization detector. All area counts are integrated from the beginning of the nC_6 peak to the apex of the nC_{10} peak to give F1. Standards containing nC_6, nC_{10}, and toluene are run. Toluene is used as the calibration standard. The nC_6 and nC_{10} response factors must be within 30% of the response factor for toluene.

For F2, F3, F4, the sample is analysed by gas chromatography with a 100% polydimethylsiloxane column (DB-1 or equivalent) and a flame ionization detector as shown in Method Principle for PHCs in Soils and Sediment.

In some cases, analysis without silica gel treatment may be requested or required by the regulatory body. This provides concentrations equal to or greater than values obtained after silica gel treatment and will include any partially degraded (polar) petroleum hydrocarbons as well as naturally occurring organics. Information on individual compounds can by obtained by open scan GC-MS.

Calculations

For F1 in soils and sediment, the result is corrected for the soil moisture extracted into the methanol. The total solvent/water volume (V_t) is calculated using the following equation:

Final Volume (methanol + water) mL = methanol volume mL + (% moisture / 100 × wet sample wt g)

The results of PHC analysis need not include benzene, toluene, ethylbenzene, xylenes (BTEX), or polycyclic aromatic hydrocarbons (PAHs). If concentrations of BTEX and/or PAHs are determined, both corrected and uncorrected results must be reported as follows:

F1, $F1_{-BTEX}$

F2, $F2_{-naphthalene}$

F3, $F3_{-PAH}$*

F4, F4G

*PAH = phenanthrene; benz[a]anthracene; benzo[b]fluoranthene; benzo[k]fluoranthene; benzo[a]pyrene; fluoranthene; dibenz[a]anthracene; indeno[1,2,3-c,d]pyrene; pyrene

4.1.10 Polychlorinated Biphenyls (PCBs)

Parameters*

Aroclor 1242
Aroclor 1248
Aroclor 1254
Aroclor 1260
Polychlorinated biphenyls (PCBs), total

*Other Aroclors (1016, 1221, 1232, 1262, 1268) may also be determined.

Table 4.1.10

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3545A SW-846, Method 3546 SW-846, Method 3550 SW-846, Method 3570 **Sample Clean-up** SW-846, Method 3610B SW-846, Method 3620C SW-846, Method 3630C SW-846, Method 3640A SW-846, Method 3660B SW-846, Method 3665A **Analysis** SW-846, Method 8082A SW-846, Method 8270D EPA Method 1668C	**Sample Preparation** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535A **Sample Clean-up** SW-846, Method 3610B SW-846, Method 3620C SW-846, Method 3630C SW-846, Method 3640A SW-846, Method 3660B SW-846, Method 3665A **Analysis** SW-846, Method 8082A SW-846, Method 8270D EPA Method 1668C
Standard Methods		Method 6630B
ASTM		Method D5175-91 (2003)
USGS	O-5129-95	
Environment and Climate Change Canada		EPS 1/RM/31E
OMOECC	E3487	E3400
Centre d'expertise en analyse environnementale		MA.400-SPE- BPC/Clbz/HAP 1.0

Historically, PCBs (also OCs and heaver chlorinated aliphatics) have been determined by GC-ECD. The ECD is very sensitive to electronegative elements such as Cl^-; however, because it is non-specific, it is prone to interferences and thus sample extracts usually require extensive clean-up prior to analysis. Quantitation is achieved by comparing the chromatographic pattern of standard PCB mixtures called Aroclors to that of the sample. Interpretation of complex mixtures

requires experience and skill, and the technique is not applicable to incinerated samples since incineration destroys the Aroclor pattern.

Low resolution mass spectrometer (GC-MS) methods have been developed that can determine congener groups (e.g., tetrachloro PCB, heptachloro PCB). High resolution mass spectrometer methods (HRMS) that can determine all the 209 individual congeners ($C_{12}H_{(10-n)}Cl_n$, where n = 1 to 10), or the subset of the most toxic congeners, are also available. The HRMS methods provide ultimate specificity and sensitivity for individual congeners.

There are interim CEQG for "total PCBs" and Aroclor 1254 in sediment. The criteria are based on toxicity information where concentrations were determined using the ECD technique. "Total PCBs" is the sum of the concentrations of the identified Aroclors. If GC-MS or HRMS techniques are employed, "total PCBs" is the sum of all the individual congeners or the congener groups. The values obtained from the MS and ECD techniques may not be equivalent.

It is recommended that congener-specific analyses of total PCBs, as opposed to analyses of Aroclor mixtures, be used for sediment samples that are environmentally weathered or have been historically contaminated. Diagenesis of sediments and dechlorination of PCBs may alter the original Aroclor profile, making it difficult or impossible to match Aroclor patterns, and may lead to a high degree of error in estimating the concentration of PCBs as Aroclor mixtures in sediment samples (Duinker *et al*. 1991). Thus, measurements of mixtures of Aroclor (including 1254) may be more appropriate for sediments in which recent contamination is suspected.

In summary, for most routine applications, GC-ECD is satisfactory and can be used to determine OCs and heavier chlorinated aliphatics on the same extract and is the method of choice for determining specific Aroclors. HRMS (US EPA Method 1668A) provides greater sensitivity and specificity for individual congeners and accurate toxicity information. Note that the cost of an HRMS test is approximately ten times that of an ECD test.

Method Principle

ECD Procedure: An aliquot of a solid sample is extracted with a solvent or solvent mix. Extracts may be kept for up to 40 days. The extract is cleaned up using an approved reference method technique. After clean-up, the extract is analysed by injecting an aliquot into a GC-ECD. Analysis is normally performed using single column.

Aqueous samples are extracted then concentrated, reconstituted, and analysed by GC-ECD. Typical extraction solvents are methylene chloride or methylene chloride/hexane.

Alternatively, GC-MS may be used provided the reporting limits (LRLs) in Table 5 can be achieved and the quantitation protocol described below is used.

PCB Identification and Quantitation for the ECD Procedure

The recommended quantitation protocol is as follows: Four Aroclors are quantitated, 1242, 1248, 1254 and 1260. Each Aroclor contains a mixture of individual PCB congeners that form a distinctive recognizable pattern in the chromatogram. Identification is accomplished by comparing the sample chromatogram to reference chromatograms of the individual Aroclors. Retention times and relative intensities of at least three and preferably five major peaks must match the reference spectrum within specified limits, for positive identification. An Aroclor concentration is computed based on each of the identified peaks, and the average Aroclor

concentration determined from all of the identified peaks is calculated. Acceptance limits for retention times are ± 6 seconds relative to the standard of the corresponding Aroclor. Any individual peak(s) with concentration > ± 30% from the average, or falling outside the retention time window, is discarded and the average concentration recalculated. A minimum of three peaks must remain for positive identification.

If the sample contains a single Aroclor, compare the response of the major peaks in the identified Aroclor to the reference Aroclor chromatogram and calculate the concentration of each. The average of the major peak concentrations is the concentration of the Aroclor (after including appropriate dilution factors).

If more than one Aroclor is identified and quantified, "total PCBs" is the sum of the identified and quantitated Aroclors. If an Aroclor other than 1242, 1248, 1254 or 1260 (e.g., 1016) is identified in the sample, a reference spectrum must be obtained and the Aroclor included in the quantification of "total PCBs". In cases where chromatographic patterns indicate the presence of PCBs, but it is difficult to assign to specific Aroclor(s), analyst judgement is used to select the best fit. If a mixture or extreme weathering precludes individual Aroclor identification, results should be reported with an elevated LRL.

HRMS Procedure: Aqueous samples (usually 1 litre) and solids (usually 10 grams) are spiked with stable isotopically-labelled analogues of the toxic congeners, extracted, subjected to a multi-step clean-up, and the cleaned extract concentrated to 20 µL. The samples are analysed by HRMS and quantitation performed by isotope dilution for all analytes corresponding to the isotopically-labelled analogues, or otherwise by the internal standard method.

4.1.11 Polychlorinated Dibenzo-p-Dioxins/Dibenzofurans (PCDDs/PCDFs)

Parameters

Congener Groups	2,3,7,8-Substituted Isomers
total tetrachlorodibenzo-p-dioxins (T4CDDs)	2,3,7,8-TCDD
total pentachlorodibenzo-p-dioxins (P5CDDs)	1,2,3,7,8-PCDD
total hexachlorodibenzo-p-dioxins (H6CDDs)	1,2,3,4,7,8-HCDD
	1,2,3,6,7,8-HCDD
	1,2,3,7,8,9-HCDD
total heptachlorodibenzo-p-dioxins (H7CDDs)	1,2,3,4,6,7,8-HCDD
octachlorodibenzo-p-dioxin (O8CDD)	OCDD
total tetrachlorodibenzofurans (T4CDFs)	2,3,7,8-TCDF
total pentachlorodibenzofurans (P5CDFs)	1,2,3,7,8-PCDF
	2,3,4,7,8-PCDF
total hexachlorodibenzofurans (H6CDFs)	1,2,3,4,7,8-HCDF
	1,2,3,6,7,8-HCDF
	1,2,3,7,8,9-HCDF
	2,3,4,6,7,8-HCDF
total heptachlorodibenzofurans (H7CDFs)	1,2,3,4,6,7,8-HCDF

Congener Groups	2,3,7,8-Substituted Isomers
	1,2,3,4,7,8,9-HCDF
octachlorodibenzofuran (OCDF)	OCDF

Table 4.1.11.1

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3545A SW-846, Method 3546 SW-846, Method 8290A Method 1613B **Analysis** SW-846, Method 8290A Method 1613B	**Sample Preparation** Method 1613B **Analysis** SW-846, Method 8290A Method 1613B
Environment and Climate Change Canada	EPSI/RM/19	EPSI/RM/19
OMOECC	E3418	E3418
Centre d'expertise en analyse environnementale		MA. 400 - D.F. 1.0

Method Principle

This analytical method is used to determine the concentrations of PCDDs and PCDFs in a variety of matrices using isotope dilution with HRMS.

Solid samples are normally analyzed as received. All samples are fortified with known amounts of [$^{13}C_{12}$−] isotopically-labelled PCDDs and PCDFs prior to sample extraction, digestion, or elution. All analytes are quantified using isotope dilution against labelled standards. Solid samples are solvent-extracted using Soxhlet, Dean-Stark, microwave, or pressurised liquid extraction (PLE), followed by a multi-stage chromatographic clean-up procedure to remove any potential chemical interference.

Aqueous samples are spiked with known amounts of [$^{13}C_{12}$−] isotopically-labelled PCDDs and PCDFs prior to extraction with solvent followed by chromatographic clean-up procedures (typically two stage) to remove potential chemical interferences. Extracts are stable indefinitely. The final extracts are analysed using high resolution gas chromatography-high resolution mass spectrometry (HRGC-HRMS).

Calculation of Toxic Equivalents (TEQ)

There are a total of 210 dioxins and furans. Only seventeen are considered to be highly toxic (2,3,7,8-substituted congeners, Environment and Climate Change Canada, World Health Organization) and their toxicity is normalised to 2,3,7,8-TCDD (the most toxic). The TEQ is determined as shown in Table 4.1.11.2 by multiplying the concentration of each detected 2,3,7,8-substituted congener by its respective toxic equivalent factor (TEF) to determine its TEQ. The TEFs in Table 4.1.11.2 are those provided by the World Health Organization (WHO), 2005, as amended from time to time. For any 2,3,7,8-substituted congeners that are not detected, half of

the estimated detection limit (EDL) is multiplied by the TEF to determine the middle-bound TEQ for that congener[1]. This converts each of the congeners to 2,3,7,8-TCDD toxic equivalents. The sum of the seventeen toxic equivalents gives the TEQ for the sample normalised to 2,3,7,8-TCDD. The result in this example is 1.64 pg/L.

Table 4.1.11.2. TEQ Example

Compound	CAS Number	Conc. pg/L	EDL pg/L	TEF*	TEQ /Congener pg/L
2,3,7,8-TCDD	1746-01-6	ND	1.1	1	0.55
1,2,3,7,8-PeCDD	40321-76-4	ND	1	1	0.5
1,2,3,4,7,8-HxCDD	39227-28-6	ND	1.2	0.1	0.06
1,2,3,6,7,8-HxCDD	57653-85-7	ND	0.89	0.1	0.045
1,2,3,7,8,9-HxCDD	19408-74-3	ND	1	0.1	0.05
1,2,3,4,6,7,8-HpCDD	35822-46-9	ND	1.1	0.01	0.0055
OCDD	3268-87-9	3.4		0.0003	0.00102
2,3,7,8-TCDF	51207-31-9	ND	1	0.1	0.05
1,2,3,7,8-PeCDF	57117-41-6	ND	1	0.03	0.015
2,3,4,7,8-PeCDF	57117-31-4	ND	1	0.3	0.15
1,2,3,4,7,8-HxCDF	70648-26-9	ND	0.82	0.1	0.041
1,2,3,6,7,8-HxCDF	57117-44-9	ND	1.1	0.1	0.055
2,3,4,6,7,8-HxCDF	60851-34-5	ND	1.1	0.1	0.055
1,2,3,7,8,9-HxCDF	72918-21-9	ND	1.2	0.1	0.06
1,2,3,4,6,7,8-HpCDF	67562-39-4	ND	0.95	0.01	0.0048
1,2,3,4,7,8,9-HpCDF	5567-89-7	ND	1	0.01	0.005
OCDF	39001-02-0	1.8		0.0003	0.00054
				Total TEQ 2,3,7,8-TCDD (0.5 DL) (Sum of the TEQ/congener for each compound listed above)	**1.64 pg/L**

TEQ = toxic equivalents = sum of individual TEQ/congener

EDL = estimated detection limit

TEF = toxic equivalency factor

* The CEQG are based on older, differing TEFs. Fish and birds also have different TEFs.

[1] Environment and Climate Change Canada and OMOECC specify the use of middle-bound values in the TEQ calculation. Other agencies may require a different method. For components that are not detected above the EDL, middle-bound TEQs use ½ the value of the EDL, upper-bound TEQs use the value of the EDL, and lower-bound TEQs use a value of zero.

Reporting

The source and year of the TEF values used to calculate the TEQ must be identified (e.g., World Health Organization 2005).

4.1.12 Polycyclic Aromatic Hydrocarbons (PAHs)

Polycyclic aromatic hydrocarbons may also be determined with ABNs (Section 4.1.1).

Parameters (Synonyms)

Acenaphthene	Benzo[k]fluoranthene	Methylnaphthalenes*
Acenaphthylene	Benzo[g,h,i]perylene	Naphthalene
Acridine	Chrysene	Phenanthrene
Anthracene	Dibenz[a]anthracene	Pyrene
Benz[a]anthracene	Fluoranthene	Quinoline
Benzo[a]pyrene	Fluorene	
Benzo[b+j+k]fluoranthene**	Indeno[1,2,3-c,d]pyrene	

* The sum of 1- and 2-methylnaphthalene is compared to the standard (O. Reg 153/04). Other jurisdictions vary.

**When b and k isomers cannot be reported separately, report them as the sum of the b, j and k isomers and compare to the CEQG. OMOECC has individual standards for the b and k isomers.

Table 4.1.12

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846, Method 3541 SW-846, Method 3546 SW-846, Method 3550C SW-846, Method 3570 **Sample Clean-up** SW-846, Method 3610B SW-846, Method 3630C **Analysis** SW-846, Method 8270D	**Sample Preparation** SW-846, Method 3510C SW-846, Method 3520C SW-846, Method 3535 SW-846, Method 3611B **Analysis** SW-846, Method 8270D SW-846, Method 8272
Standard Methods		Method 6440C
OMOECC	E3425	E3480
Centre d'expertise en analyse environnementale		MA. 403 - HPA 4.1

Method Principle

Soil samples fortified with deuterium-labelled surrogates are extracted using a solvent or solvent mix. Clean-up of the extract is optional.

Aqueous samples, fortified with surrogates, are extracted with solvent. If only PAHs are being determined, extraction may be at neutral or basic pH. If quinoline and/or acridine, the nitrogen-

containing PAHs, are to be determined, extraction at basic pH is recommended to optimise extraction efficiency. Since these analytes may be the most difficult of the PAH suite to extract, use of deuterated analogues such as d_9-acridine is recommended, and required if extraction is done at neutral pH. Analysis by the isotope dilution method for quinoline and acridine may also be used to improve recovery.

Extracts may be kept for up to 40 days. The sample extract is concentrated then analysed by GC-MS, with or without using SIM mode.

GC-MS provides adequate sensitivity and specificity to achieve the CEQGs. If lower LRLs are required, or interferences are suspected, HRMS may be used.

See Section 4.1.1 (ABNs) for additional details.

Calculations

CCME protocols require the calculation of benzo[a]pyrene (B[a]P), Toxic Potential Equivalents (TPE), and Index of Additive Cancer Risk (IACR) for soil samples using the concentrations of the potentially carcinogenic PAH.

Benzo[a]pyrene Toxic Potential Equivalents

The B[a]P TPE for a soil sample is calculated by multiplying the concentration of each PAH in the sample by its B[a]P Potency Equivalence Factor (PEF), given below, and summing the products. B[a]P PEFs are order of magnitude estimates of carcinogenic potential and are based on the World Health Organization (WHO/IPCS 1998) scheme, as follows:

PAH	Potency Equivalency Factor
Benz[a]anthracene	0.1
Benzo[g,h,i]perylene	0.01
Indeno[1,2,3-c,d]pyrene	0.1
Benzo[a]pyrene	1
Chrysene	0.01
Benzo[b+j+k]fluoranthene	0.1
Dibenz[a,h]anthracene	1

IACR:

$$\text{IACR} = \frac{\text{Benz[a]anthracene}}{0.33\ \text{mg/kg}} + \frac{\text{Benzo[b,j,k]fluoranthene}}{0.16\ \text{mg/kg}} + \frac{\text{Benzo[g,h,i]perylene}}{6.8\ \text{mg/kg}} + \frac{\text{Benzo[a]pyrene}}{0.37\ \text{mg/kg}} + \frac{\text{Chrysene}}{2.1\ \text{mg/kg}} + \frac{\text{Dibenz[a,h]anthracene}}{0.23\ \text{mg/kg}} + \frac{\text{Indeno[1,2,3-c,d]pyrene}}{2.7\ \text{mg/kg}}$$

For this calculation, for non-detects, use ½ the non-detect value. For further details and calculation examples, see the Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health Polycyclic Aromatic Hydrocarbons factsheet, CCME 2010.

4.1.13 Trihalomethanes (THMs)

Trihalomethanes may also be determined with VOCs (Section 4.1.14).

Parameters (Synonyms)

Bromodichloromethane (Dichlorobromomethane)
Dibromochloromethane (Chlorodibromomethane)
Tribromomethane (Bromoform)
Trichloromethane (Chloroform)

Note: The above compounds are commonly detected because of chlorination of drinking water and therefore are included as a separate group from the volatile organic compounds (VOCs). The method principle for THMs is identical to the VOCs as outlined in Section 4.1.14 and Table 4.1.14.

Calculations

Total THM = sum of the individual compounds in mg/L.

4.1.14 Volatile Organic Compounds I (VOCs)

Parameters (Synonyms)

Acetone	Monobromomethane** (Bromomethane, Methyl bromide)
Benzene***	Monochlorobenzene
Dichlorobenzene, 1,2-	Monochloromethane (Methyl chloride)
Dichlorobenzene, 1,3-	Styrene
Dichlorobenzene, 1,4-	Tetrachloroethane, 1,1,1,2-
Dichlorodifluoromethane	Tetrachloroethane, 1,1,2,2-
Dichloroethane, 1,1-	Tetrachloroethene, 1,1,2,2- (PCE, Tetrachloroethylene)
Dichloroethane, 1,2-	Tetrachloromethane (Carbon tetrachloride)
Dichloroethene, 1,1-	Thiophene
Dichloroethene, 1,2-*cis*-†	Toluene***
Dichloroethene, 1,2-*trans*-†	Trichlorobenzene, 1,2,3-††
Dichloromethane (Methylene chloride)	Trichlorobenzene, 1,2,4-††
Dichloropropane, 1,2-	Trichlorobenzene, 1,3,5-††
Dichloropropene, 1,3- (*cis*- and *trans*-)*	Trichloroethane, 1,1,1-
Ethylbenzene***	Trichloroethane, 1,1,2-
Ethylene dibromide (Dibromomethane, 1,2-)	Trichloroethene, 1,1,2- (TCE, Trichloroethylene)
Hexane, n-	Trichlorofluoromethane
Methyl ethyl ketone (MEK)	Vinyl chloride
Methyl isobutyl ketone (MIBK)	Xylenes***
Methyl tertiary-butyl ether (MTBE)	

* The sum of *cis*- and *trans*-dichloropropene is compared to the standard.

** Methanol-preserved samples may elevate the detection limit for bromomethane; a separate bisulphate-preserved sample or hermetically sealed sample may be submitted at the time of sampling if bromomethane is a chemical of concern.

***May also be determined with BTEX (Section 4.1.15).

† OMOE regulates *cis* and *trans* 1,2 dichloroethene separately. The CEQG compares the sum of chlorinated aliphatics, which include 1,2-dichloroethene, to the standard.

†† May also be determined with ABNs (Section 4.1.1).

Table 4.1.14

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3570 SW-846, Method 5035A SW-847, Method 8261A **Sample Introduction** SW-846, Method 5021A SW-846, Method 5035A **Analysis** SW-846, Method 8260C SW-847, Method 8261A	**Sample Preparation** **Sample Introduction** SW-846, Method 5000 SW-846, Method 5030C **Analysis** SW-846, Method 8260C SW-846, Method 8261A SW-846, Method 8265 EPA Method 624
CCME	Reference Method for the Canada-Wide Standards for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method	
Standard Methods		Method 6200B
OMOECC	E3490	E3132 E3144
Centre d'expertise en analyse environnementale		MA. 400 - COV 1.1 MA. 403 - COV 1.1

VOCs in Soils and Sediment

Method Principle

As-received field-preserved soil and sediment samples (approximately 5 g) are processed in the laboratory for VOCs within 14 days of sampling. If required for LRLs below what can be achieved from a methanol extract, duplicate samples preserved with aqueous sodium bisulphate can be analysed as received.

Unpreserved samples collected in hermetic sampling devices are extracted in the laboratory with methanol within 48 hours of sampling. To achieve a 14 day hold time, hermetically collected samples may be frozen within 48 hours of sampling as per ASTM method D6418 – 09.

Methanol extracts are stable for 40 days. Bisulphate extracts are stable for 14 days. If methanol extracts are retained after analysis, separation of the extract from the soil matrix is recommended to ensure consistent results over time.

Moisture content is determined as described in Section 3.1.1 (2).

Extracts containing compounds exceeding the calibration range of the instrument are diluted with volatile-free water and analysed. Samples may be pre-screened by headspace GC-MS or other appropriate instrumentation to determine appropriate dilutions.

The volatile compounds present in the methanol or bisulphate solution are introduced by purge & trap or headspace into the gas chromatograph where they are separated by a capillary column then detected by a mass spectrometer operating in either full scan or SIM mode. Note that matrix-matching samples and standards (preservatives, amount of methanol, etc.) is critical to prevent biases for VOC analyses employing headspace technology. Addition of salt to headspace samples improves sensitivity.

Target analytes are identifed by comparing sample mass spectra with the mass spectra of analytical standards. Quantitation is accomplished by comparing the response of a major (quantitation) ion relative to an internal standard and a response factor generated from a calibration curve.

Calculations and Reporting

When reporting data based on a methanol extraction, concentrations must be corrected for the moisture extracted into the methanol.

VOCs in Water

Method Principle

Aqueous samples are analysed as received by purge & trap or headspace GC-MS.

4.1.15 Volatile Organic Compounds II: Benzene, Ethylbenzene, Toluene, Xylenes (BTEX)

Compounds may also be determined with VOCs (Section 4.1.14).

Parameters (Synonyms)

Benzene
Ethylbenzene
Toluene (methylbenzene)
Xylenes, total (*o*-xylene; *m*- & *p*-xylene)

Note that the above BTEX compounds (benzene, toluene, ethylbenzene, xylenes) are a subset of volatile organic compounds (VOCs), but are often analysed as a discrete analysis and, therefore, are included as a separate group. The method principle for BTEX is identical to VOC as outlined in Section 4.1.14 and Table 4.1.14.

4.1.16 Organics Single Analysis Parameters

4.1.16.1 Diisopropanolamine

Parameters (Synonyms)

Diisopropanolamine (DIPA)

Table 4.1.16.1

Method Reference Source	Soil & Sediment	Water
SIELC Technologies, "HPLC Application: Separation of Ethanolamines"; http://www.sielc.com/application_041.htmL		**Analysis** Dionex Manual, Document No. 034217, Revision 09.

Method Principle

Waters may be analysed as received by HPLC or direct aqueous injection into an ion chromatograph using reversed phase chromatography with amperometric detection. Soils are subjected to an aqueous acid leach prior to analysis of the leachate. Alternatively, if lower LRLs are required, samples can be derivatised and analysed by HPLC with fluorescence detection.

4.1.16.2 Fraction of Organic Carbon (FOC)

Parameters

Fraction of Organic Carbon in soils or sediment

Table 4.1.16.2

Method Reference Source	Soil & Sediment	Water
ASTM	Method D2974-00 Method E1915-07	
OMOECC	E3142, E3012	

Method Principle

Fraction of organic carbon (FOC) in soil is a measure of the ratio of the organic carbon in the soil relative to the mass of sample ($g_{(carbon)}/g_{(soil)}$). Total organic carbon (TOC) is calculated as the difference between measurements of total carbon (TC) and total inorganic carbon (TIC). The measurement of total carbon in soils and sediments requires the destruction of carbonate minerals (primarily calcite and dolomite) as well as organic carbon.

Oxygen is purged through the system as the samples are combusted, oxidizing carbon to carbon dioxide (CO_2). The CO_2 is collected, passed through two traps to remove moisture and dust, and then measured by an infrared detector (TC in mg/g carbon). Inorganic carbon (carbonate carbon) is determined by the measurement of CO_2 evolved by the reaction of carbonate with strong acid solution swept by purified nitrogen through a potassium iodide scrubber into the cathode compartment of a coulometer. The evolved CO_2 is quantitatively absorbed by the cathode

solution and converted to a strong acid causing the indicator colour to fade. Base is electrically generated to titrate the solution back to the starting point (TIC in mg/g carbon).

Alternatively, approved wet chemical reference methods can be used. In these procedures, soil, after carbonate removal using acid, is treated with excess acidic dichromate, which reacts with the organic carbon, oxidizing it to CO_2. The residual dichromate is titrated with ferrous ammonium sulphate and TOC calculated by difference.

4.1.16.3 Methyl Mercury

Parameters (Synonyms)

Methyl Mercury (Monomethyl Mercury, CH_3Hg^+, $MeHg^+$)

Table 4.1.16.3

Method Reference Source	Soil & Sediment, Tissue	Water
US EPA	**Sample Preparation** SW-846, Method 3200 Brooks Rand Application Notes **Analysis** Method 1630	**Sample Preparation** **Method 1630Analysis** Method 1630

Method Principle

Soils

Extractable organomercury and inorganic mercury compounds are extracted from the soil matrix with acid followed by solvent extraction. The organomercury compounds in the extract are separated using solid phase extraction or distillation and determined using a method for total mercury analysis or using the analytical techniques of EPA 1630 (as per water samples). Extracts/distillates must be analysed within 48 hours of preparation. Other techniques such as LC ICP-MS may also be employed providing they can meet the required LRLs.

Waters

Aqueous samples are acidified with hydrochloric acid forming organomercuric chloride (RHgCl) which is separated by distillation (US EPA Method 1630). The distillate is ethylated forming RHgEt. The volatile RHgEt complexes are purged onto a carbon trap and subsequently thermally desorbed onto a gas chromatograph with detection by pyrolysis/cold vapour atomic fluorescence spectrophotometry (CVAFS) as per US EPA Method 1630.

Tissue

Samples are extracted with potassium hydroxide/methanol and the extract distilled and analysed as per the soil extracts. Alternatively, samples may be nitric-acid-digested at 60°C prior to analysis as per the soil extracts.

Reporting

The CEQG for methylmercury in tissue is specified as wet weight. There are no criteria for soil or sediment but if requested they are normally reported in units of µg/g dry weight.

4.1.16.4 Nonylphenol and its Ethoxylates

Parameters (Synonyms)

Nonylphenol and its Ethoxylates

Table 4.1.16.4

Method Reference Source	Soil & Sediment	Water
ASTM		ASTM D7485-09 ASTM D7065

Method Principle

Water samples are acidified in the field then extracted by SPE. The SPE cartridge is eluted with acetonitrile. The acetonitrile is concentrated then analysed by LC-MS/MS in the MRM mode. Alternatively, water samples may be solvent extracted, the extract concentrated and analysed by GC-MS in the SIM mode. Isotope dilution may be used to improve the sensitivity of the method.

Soils are subjected to an aqueous base extraction. The extract is analysed as a water sample. Derivatisation and clean-up may be used to improve the sensitivity of the method.

To analyze for all the compounds and compound groups that are included in the toxic equivalency factor (TEF) table below is a difficult if not impossible task. At a minimum nonylphenol (NP), nonylphenol 1 ethoxylate (NP1EO) and nonylphenol 2 ethoxylate (NP2EO) should be analyzed. Analysis of NP, nonylphenol ethoxylates (NPnEO) ($1 \leq n \leq 8$) and octylphenol (OP) are preferred. The CEQG is based on Total NP and NPEO so the analysis should include the linear and branched isomers. These compounds contribute the most toxicity in a mixture of NP and NPEO and, due to their higher recalcitrance to biodegradation, are likely to be present in the highest concentrations.

If not all ethoxylates are measured in a sample, then some caution should also be exercised when comparing the results to the guideline value. For example, if only three chemicals have been measured and the total toxic equivalency (TEQ) concentration comes out very close to the guideline value then there's a good chance that the guideline is actually being exceeded if all ethoxylates had been considered (Environment Canada, Kelly Potter, 2004, personal correspondence).

Calculations

The CEQG of 1 µg/L is based on toxic equivalents

Total TEQ = Σ (Ci × TEFi)

Where: Ci = the concentration of compound *i* in µg/L

TEFi = the Toxic Equivalency Factor for compound *i* (unitless)

Toxic equivalency factors (TEFs) for NP, NPEs, NPECs, OP, OPEs, and OPECs (Servos *et al*. 2000; Environment Canada 2002).	
Chemical	**TEFs (relative to NP)**
NP	1
NPnEO (1 ≤ n ≤ 8)	0.5
NPnEO (n ≥ 9)	0.005
NP1EC	0.005
NP2EC	0.005
OP	1
OPnEO (1 ≤ n ≤ 8)	0.5
OPnEO (n ≥ 9)	0.005
OP1EC	0.005
OP2EC	0.005

NP = Nonylphenol

NPEC = Nonylphenol ethyl carboxylate

NPEO = Nonylphenol ethoxylate

OP = Octylphenol

OPEC = Octylphenol ethyl carboxylate

OPEO = Octylphenol ethoxylate

See Canadian Water Quality Guidelines for the Protection of Aquatic Life for Nonylphenol and its Ethoxylates for more details: <http://st-ts.ccme.ca/?lang=en&factsheet=146>.

4.1.16.5 Sulfolane

Parameters (Synonyms)

Sulfolane (Bondelane)

Table 4.1.16.5

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C **Analysis** SW-846, Method 8015D EPA Method 1625C	**Sample Preparation** SW-846, Method 3510C **Analysis** SW-846, Method 8015D EPA Method 1625C

Method Principle

Water samples are analysed by direct aqueous injection GC-FID. Soils are subjected to an aqueous leach. The leachate is analysed as a water sample. Alternatively, if greater sensitivity and specificity is required, samples can be extracted, the extract concentrated and analysed by GC-MS. Isotope dilution may be used to improve further the sensitivity of the method.

4.2 Inorganic Parameters Group

4.2.1 Metals

Parameters

Aluminium (Al)	Cobalt (Co)	Selenium (Se)
Antimony (Sb)	Copper (Cu)	Silver (Ag)
Arsenic (As)	Iron (Fe)	Sodium (Na)
Barium (Ba)	Lead (Pb)	Thallium (Tl)
Beryllium (Be)	Lithium (Li)	Tin (Sn)
Boron (B)*	Magnesium (Mg)	Uranium (U)
Cadmium (Cd)	Manganese (Mn)	Vanadium (V)
Calcium (Ca)	Molybdenum (Mo)	Zinc (Zn)
Chromium (Cr)	Nickel (Ni)	

* Strong acid extractable boron.

Table 4.2.1

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3050B (with HCl) SW-846, Method 3051A Method 200.2, Rev 2.8 **Sample Analysis** SW-846, Method 6010C SW-846, Method 6020A SW-846, Method 7000B SW-846, Method 7010	**Sample Preparation** SW-846, Method 3005A SW-846, Method 3010A SW-846, Method 3015A SW-846, Method 3020A Method 200.2 Rev 2.8 Method 200.8 Rev 5.4 **Sample Analysis** SW-846, Method 6010C SW-846, Method 6020A SW-846, Method 7000B SW-846, Method 7010 Method 200.5, Rev 4.2 Method 200.7, Rev 4.4 Method 200.8, Rev 5.4 Method 200.9, Rev 2.2 Method 200.15, Rev 1.2
Standard Methods		Method 3111 B Method 3111 D Method 3113 B Method 3120 B Method 3125 B
OMOECC	E3075 E3470	E3094 E3474 E3497

Method Reference Source	Soil & Sediment	Water
British Columbia Ministry of the Environment, Environmental Laboratory Manual	**Sample Preparation** Strong Acid Leachable Metals (SALM) in Soil	
Centre d'expertise en analyse environnementale		MA. 200 - Mét. 1.2

Method Principle

Sample Preparation

The preparation techniques described here are not designed to provide true total metal content in the soil or sediment, but rather the environmentally available (strong acid leachable) portion. Elements bound in silicate structures are not normally dissolved by these procedures, as they are not usually mobile in the environment. If true totals are required, more aggressive preparation techniques such as hydrofluoric acid digestion or fusion are required. X-ray fluorescence techniques also provide total metals data.

There are many different strong acid leachable techniques involving various acid mixtures and usually a hot block or microwave digestion apparatus. Note that microwave digestion techniques may give higher values than hot block digestions for some elements.

For soils, a previously dried, disaggregated, sieved (< 2 mm) sample is subjected to digestion with a heated, hydrochloric:nitric acid solution. The digestate is separated from the soil residue and brought to volume with deionised water. Note that OMOECC requires further grinding and sieving to 355 µm since the additional grinding reduces the variability of the results when small samples are used for analysis.

Water samples requiring analysis for "dissolved" metals must be previously field-filtered (0.45 µm) and field preserved to pH < 2. In the event that field filtration is not possible, unpreserved and unfiltered samples can be filtered and preserved at the laboratory; however, this deviation must be indicated on the Certificate of Analysis with a cautionary note that values may not reflect concentrations at the time of sampling. Note that lab filtration for dissolved metals is not permitted in some jurisdictions. For additional details, see Section 3.1.3. Filtered, preserved samples requiring dissolved metals analysis may be analyzed as received without further pre-treatment.

Samples requiring analysis for total (aka strong acid leachable or total recoverable) metals must be subjected to acid digestion before analysis unless turbidity is < 1 Nephelometric Turbidity Units (NTU).

Note: Unless otherwise specified, the CEQG are based on "total metals". The OMOE Reg. 153/04 Groundwater Guidelines are based on "dissolved" metals. Other jurisdictions may vary.

Analysis is performed with inductively coupled plasma-optical emission spectroscopy (ICP-OES), ICP-MS, atomic absorption spectrophotometry (AAS), atomic emission spectroscopy (AES), or atomic fluorescence spectroscopy (AFS).

The analytical standards must be matrix-matched to the samples.

Calculations

Although there is no CEQG for hardness, several CEQGs, for example, cadmium and nickel, are based on hardness. Hardness is determined by calculation according to the following formula

Hardness, mg equivalent $CaCO_3$/L = 2.497 [Ca, mg/L] + 4.118 [Mg, mg/L] (APHA 2340B)

where the concentrations of calcium and magnesium are determined as "dissolved" metals, i.e., on an aliquot filtered through a 0.45 µm filter.

4.2.2 Inorganic Single Analysis Parameters

4.2.2.1 Ammonia (total)

Parameters

Ammonia

Table 4.2.2.1

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** AQ2 EPA-103A **Sample Analysis** AQ2 EPA-103A
Standard Methods		Method 4500 N Method 4500 NH3
OMOECC		E3364
Centre d'expertise en analyse environnementale		MA. 300 - N 2.0

Method Principles

Ammonia is determined colourimetrically using the Berthelot (indophenol blue) reaction. In the first stage of the reaction, the acid-preserved sample is adjusted to a target pH of 6.5 to 7.0; the ammonia then undergoes a chlorination reaction with hypochlorite to form a monochloramine. In the second stage, the monochloramine is reacted with phenate under alkaline conditions (approximately pH 10) and in the presence of nitroprusside to form benzoquinone chlorimine. In the third stage, benzoquinone chlorimine further reacts with phenate to form the blue indophenol complex. The intensity of the colour is proportional to the amount of ammonia present and is measured colourimetrically at 660 nm. The analysis is usually automated using continuous flow, flow-injection or discrete analysis autoanalysers.

Although the phenate chemistry is the most widely used, other techniques are available such as the orthophthaldialdehyde fluorescence method and the salicylate method where ammonia reacts with salicylate and hypochlorite ions in the presence of ferricyanide ions to form the salicylic acid analogue of indophenol blue. Ion selective electrode (ISE) and ion chromatography (IC) methods may also be used, provided they can meet the LRL requirements.

4.2.2.2 Ammonia (un-ionised)

Parameters

Ammonia (un-ionised)

Table 4.2.2.2

Method Reference Source	Soil & Sediment	Water
Standard Methods		See Ammonia (Total) Section 3.2.2.1 Method 4500 NH4
CCME		CCME Ammonia 2010

Method Principle

Un-ionised ammonia is calculated from sample temperature and pH (field measurements) and the concentration of total ammonia, using the table below.

Fraction of un-ionised ammonia in aqueous solution at different pH values and temperatures is calculated from data in Emerson, *et al* (1975).

To calculate the amount of un-ionised ammonia present, the Total Ammonia Nitrogen must be multiplied by the appropriate factor selected from this chart using the pH and temperature from the water sample.

Temperature														
pH	(°F) 42	46.4	50	53.6	57.2	60.8	64.4	68	71.6	75.2	78.8	82.4	86	89.6
	(°C) 6	8	10	12	14	16	18	20	22	24	26	28	30	32
7	0.0013	0.0016	0.0018	0.0022	0.0025	0.0029	0.0034	0.0039	0.0046	0.0052	0.0060	0.0069	0.0080	0.0093
7.2	0.0021	0.0025	0.0029	0.0034	0.0040	0.0046	0.0054	0.0062	0.0072	0.0083	0.0096	0.0110	0.0126	0.0150
7.4	0.0034	0.0040	0.0046	0.0054	0.0063	0.0073	0.0085	0.0098	0.0114	0.0131	0.0150	0.0173	0.0198	0.0236
7.6	0.0053	0.0063	0.0073	0.0086	0.0100	0.0116	0.0134	0.0155	0.0179	0.0206	0.0236	0.0271	0.0310	0.0369
7.8	0.0084	0.0099	0.0116	0.0135	0.0157	0.0182	0.0211	0.0244	0.0281	0.0322	0.0370	0.0423	0.0482	0.0572
8	0.0133	0.0156	0.0182	0.0212	0.0247	0.0286	0.0330	0.0381	0.0438	0.0502	0.0574	0.0654	0.0743	0.0877
8.2	0.0210	0.0245	0.0286	0.0332	0.0385	0.0445	0.0514	0.0590	0.0676	0.0772	0.0880	0.0998	0.1129	0.1322
8.4	0.0328	0.0383	0.0445	0.0517	0.0597	0.0688	0.0790	0.0904	0.1031	0.1171	0.1326	0.1495	0.1678	0.1948
8.6	0.0510	0.0593	0.0688	0.0795	0.0914	0.1048	0.1197	0.1361	0.1541	0.1737	0.1950	0.2178	0.2422	0.2768
8.8	0.0785	0.0909	0.1048	0.1204	0.1376	0.1566	0.1773	0.1998	0.2241	0.2500	0.2774	0.3062	0.3362	0.3776
9	0.1190	0.1368	0.1565	0.1782	0.2018	0.2273	0.2546	0.2836	0.3140	0.3456	0.3783	0.4116	0.4453	0.4902
9.2	0.1763	0.2008	0.2273	0.2558	0.2861	0.3180	0.3512	0.3855	0.4204	0.4557	0.4909	0.5258	0.5599	0.6038
9.4	0.2533	0.2847	0.3180	0.3526	0.3884	0.4249	0.4618	0.4985	0.5348	0.5702	0.6045	0.6373	0.6685	0.7072
9.6	0.3496	0.3868	0.4249	0.4633	0.5016	0.5394	0.5762	0.6117	0.6456	0.6777	0.7078	0.7358	0.7617	0.7929
9.8	0.4600	0.5000	0.5394	0.5778	0.6147	0.6499	0.6831	0.7140	0.7428	0.7692	0.7933	0.8153	0.8351	0.8585
10	0.5745	0.6131	0.6498	0.6844	0.7166	0.7463	0.7735	0.7983	0.8207	0.8408	0.8588	0.8749	0.8892	0.9058
10.2	0.6815	0.7152	0.7463	0.7746	0.8003	0.8234	0.8441	0.8625	0.8788	0.8933	0.9060	0.9173	0.9271	0.9389

Calculation

F = 1/(10^(pKa + pH) +1)

Where

pKa = pH + log $[NH_4^+]/[NH_3 \cdot HOH]$

F = mole fraction un-ionised ammonia

4.2.2.3 Boron – Hot Water Soluble

Parameters

Boron, hot water soluble (HWSB)

Table 4.2.2.3

Method Reference Source	Soil & Sediment	Water
OMOECC	**Analysis** E3470	

Method Reference Source	Soil & Sediment	Water
Gupta, 1967, *Soil Science* 103	**Sample Preparation** Pages 424-428	
Soil Sampling and Methods of Analysis, 2nd Edition. Carter and Gregorich, Editors	Chapter 9, Boron, Molybdenum, and Selenium	
Methods of Soil Analysis Part 3. Chemical Methods. 1996. Sparks, Editor	Chapter 21, Boron	

Boron in Soil or Sediment

Method Principle

A minimum 5 g portion of a dried, disaggregated, sieved (< 2 mm) solid sample is extracted with 10 mL of 0.01 M calcium chloride (used to ensure a clear filtrate) through a Whatman® 42 filter, or equivalent. Note that OMOECC requires filtration through a 0.45 µm filter. The sample is heated and must boil for five minutes followed by cooling and filtration. The sample is then analysed using one of the spectrometric techniques listed in Table 4.2.1 (Metals) or Table 4.2.2.3.

Note 1: 5 g is the minimum size for a representative sample. Larger weights may be used but the 2:1 ratio (v/w) of aqueous calcium chloride to soil must be maintained.

Note 2: For certain soil types such as peats and swelling clays, a larger water:soil ratio may be required. In such cases, use the smallest practical ratio. This comment also applies to other aqueous extracted parameters.

Reporting

All results are reported as µg/g dry weight.

4.2.2.4 Chloride (Water Extractable)

Parameters

Chloride (Cl^-)

Table 4.2.2.4

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** **Analysis** SW-846, Method 6500 SW-846, Method 9056A SW-846, Method 9250 SW-846, Method 9251

Method Reference Source	Soil & Sediment	Water
		SW-846, Method 9253 Method 300.0, Rev 2.1 Method 300.1, Rev 1.0
Standard Methods		Method 4110 B Method 4110 C Method 4500-Cl^-C Method 4500-Cl^-D Method 4500-Cl^-E
OMOECC	E3013	E3016
Soil Sampling and Methods of Analysis, 2nd Edition, Carter and Gregorich, Editors	Chapter 15, Section 15.2.1, Saturation Extract	
Centre d'expertise en analyse environnementale		MA. 300 - Ions 1.3

Method Principle

Soils and Sediment

A minimum 5 g portion of the previously dried, disaggregated, sieved (< 2 mm) solid sample is extracted with 10 mL deionised water by shaking for a minimum of 30 minutes, then filtered and analysed using ion chromatography or colourimetry. Higher ratios may be required for certain sample types (peats, fine clays) in order to obtain sufficient liquid for analysis.

Note: 5 g is considered the minimum size for a representative sample. Larger weights may be used but the 2:1 ratio (v/w) of water to soil must be maintained.

The protocol above is employed in Ontario. Other jurisdictions such as Alberta and British Columbia require a saturated paste extract. In the saturated paste extraction, deionised water is added to the sample and the mixture stirred with a spatula until a condition of saturation is reached. The conditions for saturation are:

- The sample paste glistens as it reflects light.
- The sample flows slightly when container is tipped, and slides freely and cleanly off the spatula.
- A trench carved in the soil surface will close readily upon jarring the container.
- There should be no free layer of water on top of the sample.

Allow the sample to stand for at least 4 hours and check to ensure saturation criteria are still met. If free water has accumulated on the surface, add a weighed amount of soil and remix. If the soil has stiffened or does not glisten, add water and mix thoroughly.

Soil with high clay or sand content or organic matter may not meet all four saturation criteria.

Note: Data from fixed ratio extracts and saturated paste extracts may not be comparable. Verify requirements with local regulatory bodies.

In the colourimetric procedure, the chloride ions combine with mercuric thiocyanate to form an undissociated salt, mercuric chloride, and release thiocyanate ions which then complex ferric ions to produce a coloured complex. The absorbance of the coloured solution measured at the appropriate wavelength is proportional to the original concentration of chloride ion in the sample. The analysis is usually carried out using an automated continuous flow, flow injection or discrete analysis system.

Alternatively, ion chromatography can be used. Ion chromatography is a form of liquid chromatography that uses ion-exchange resins to separate atomic or molecular ions based on their interaction with the resin.

Reporting

All results are reported as µg/g dry weight.

Water

Samples can be analysed directly or filtered in the laboratory prior to analysis by colourimetry or ion chromatography (Table 4.2.2.4).

4.2.2.5 Chromium, trivalent (Cr(III))

Parameters

Chromium, trivalent (Cr(III))

Method Principle

Trivalent Chromium is calculated from the difference of total chromium (as determined in Section 4.2.1) and hexavalent chromium (as determined in Section 4.2.2.6). Refer to Section 6.3.2 for details regarding detection limits for subtracted parameters.

Reporting

All results are reported as µg/g dry weight.

4.2.2.6 Chromium, hexavalent (Cr(VI))

Parameters (Synonyms)

Hexavalent Chromium (chromium VI, Cr (VI), Cr^{+6})

Table 4.2.2.6

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3060A **Analysis** SW-846, Method 7196A SW-846, Method 7199	**Sample Preparation** N/A **Analysis** SW-846, Method 7196A SW-846, Method 7199 Method 218.6, Rev 3.3[1] Method 218.7 Method 1636
Standard Methods		Method 3500-Cr
ASTM		Method D5257-11
USGS	I-1232-85	I-1232-85
Centre d'expertise en analyse environnementale		MA. 200 - Spéc. Mét. 1.0

Method Principle

For soil and sediment samples, a minimum 2.5 g sample as received is subjected to an alkaline digestion with continuous stirring prior to analysis. The extract must be analysed within seven days of extraction.

For the determination of dissolved hexavalent chromium, aqueous samples are field filtered and preserved with the ammonium sulphate buffer solution specified in US EPA Method 218.6 (revision 3.3, 1994) or Standard Methods 3500-Cr Chromium (2009) to a pH of 9.3 to 9.7 or sodium hydroxide to achieve the 28 day[2] holding time.

Note: According to US EPA Method 218.7, Cr(VI) is stable provided pH is > 8 and free chlorine is absent. Free chlorine can oxidise soluble Cr(III) species (if present) to Cr(VI). Use the ammonium sulphate buffer solution if free chlorine is expected to be present.

The most common analytical procedure is manual or automated colourimetry. The alkaline digestate (or base-preserved aqueous sample) is acidified and treated with 1,5-diphenylcarbazide (DPC) which reacts with chromium VI to give a reddish-purple colour, the absorption of which is measured spectrophotometrically at a wavelength of 540 nm. Coloured samples produce a positive interference that can be mitigated by background correction.

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[2] US EPA Federal Register Part III. March 12, 2007. 40 CFR Part 122, 136, *et al*. Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; National Primary Drinking Water Regulations; and National Secondary Drinking Water Regulations; Analysis and Sampling Procedures; Final Rule, pages 11218, 11236, 11239 (footnote #20). Footnote 20 states: To achieve the 28-day holding time, use the ammonium sulphate buffer solution specified in EPA Method 218.6. The allowance in this footnote supersedes preservation and holding time requirements in the approved hexavalent chromium methods, unless this supersession would compromise the measurement, in which case requirements in the method must be followed.

Alternatively, ion chromatography may be used for the analysis employing post-column derivatization with DPC and measurement at 540 nm. This procedure provides increased sensitivity and reduced interferences as compared to colourimetry.

4.2.2.7 Colour (true)

Parameters

Colour (true)

Table 4.2.2.7

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** N/A **Analysis** Method 110.1
Standard Methods		Method 2120B Method 2120C
OMOECC		E3219
Hach Company		Method 8025
Centre d'expertise en analyse environnementale		MA. 103 - Col. 2.0

Method Principle

Colour (True Colour) is determined after sample filtration through a 0.45 µm membrane filter by measuring the filtrate spectrophotometrically at 450 - 465 nm using a calibration curve prepared with chloroplatinate standards.

Alternatively, colour may be determined by visual comparison against a series of chloroplatinate standards.

Apparent Colour is determined without sample filtration. Colour is pH dependent. Unless otherwise indicated, reported colour results pertain to the pH of the sample as received, to within ± 1 pH unit.

Reporting

Results are reported as Colour Units (CU).

4.2.2.8 Conductivity

Table 4.2.2.8

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** N/A

Method Reference Source	Soil & Sediment	Water
		Analysis SW-846, Method 9050A
Standard Methods		Method 2510
OMOECC	E3138	E3138
Centre d'expertise en analyse environnementale		MA. 115 - Cond. 1.0

Method Principle

A minimum 5 g portion of a previously dried, disaggregated, sieved (< 2 mm), sample is extracted by shaking with 10 mL deionised water (20 mL for organic soils) for at least 30 minutes. The sample is then analysed using a conductivity meter.

Note: 5 g is considered the minimum size for a representative sample. Larger weights may be used but the 2:1 ratio (v/w) of water to soil must be maintained. Certain soil types may require a higher water:soil ratio in order to have sufficient liquid for measurement. This must be documented on the Certificate of Analysis or analytical report.

Some jurisdictions require analysis of a saturated paste extract. See Section 4.2.2.4, Chloride, for details.

Conductivity will vary pending on the soil:water ratio. Consult local regulatory requirements for the appropriate method.

Water samples are analysed as received.

Conductance, G, is defined as the reciprocal of resistance, R:

$$G = 1/R$$

where the unit of R is ohm and G is ohm^{-1} (sometimes written mho). Conductance of a solution is measured between two spatially fixed and chemically inert electrodes. To avoid polarization at the electrode surfaces the conductance measurement is made with an alternating current signal. The conductance of a solution, G, is directly proportional to the electrode surface area, A, cm^2, and inversely proportional to the distance between the electrodes, L, cm. The constant of proportionality, k, such that:

$$G = k(A/L)$$

is called "conductivity" (preferred to "specific conductance"). It is a characteristic property of the solution between the electrodes. The units of k are 1/ohm-cm or mho per centimeter. Conductivity is customarily reported in micromhos per centimeter (µmho/cm). In the International System of Units (SI) the reciprocal of the ohm is the siemens (S) and conductivity is reported as millisiemens per meter (mS/m); 1 mS/m = 10 mmhos/cm and 1 mS/cm = 1 mmho/cm.

Reporting

The conductivity as measured in the extract is reported. Units may be either µS/cm or dS/m.

4.2.2.9 Cyanide (free)

Parameters

Cyanide (CN^-)

Table 4.2.2.9

Method Reference Source	Soil & Sediment	Water
US EPA	**Analysis** SW-846, Method 9012B SW-846, Method 9014 SW-846, Method 9016 Method OIA-1677	**Analysis** SW-846 Method 9012B SW-846, Method 9014 SW-846, Method 9016 Method OIA-1677
Standard Methods	Method 4500-CN-E Method 4500-CN-I Method 4500-CN-N Method 4500-CN-O	Method 4500-CN-E Method 4500-CN-I Method 4500-CN-N Method 4500-CN-O
OMOECC	**Sample Preparation/Analysis** E3015	**Analysis** E3015
ASTM	D4282 D7237	D4282 D7237
Centre d'expertise en analyse environnementale		MA. 300 - CN 1.2

The CEQG for soil quality states, "Free cyanide refers to the sum of molecular HCN and the cyanide ion, CN^-." Alternatively, "free cyanide" may be defined as the simple and weakly dissociable cyanides that form hydrogen cyanide at pH 4 (Weak Acid Dissociable Cyanide). This definition is employed by OMOECC.

Free cyanide is the form of cyanide that is bioavailable and highly toxic to organisms. Hydrogen cyanide is a colourless, poisonous gas with odour of bitter almonds, which partitions in water as HCN or CN^- (pH dependent). With a pKa of 9.36, free cyanide exists entirely as HCN at pH 7 or less.

Weak Acid Dissociable (WAD) Cyanide is operationally defined as those cyanide species that undergo dissociation to liberate free cyanide when refluxed under weakly acidic conditions (pH 4.5 to 6). WAD CN^- includes free cyanide and weak metal cyanide complexes, and is therefore a conservative estimate of toxicity. Thus, if analysis for WAD cyanide yields a value ≤ the CEQG it may be assumed that free cyanide is also < the CEQG.

WAD CN^- should be ≥ Free Cyanide. Thus, if a WAD cyanide analysis yields a value ≤ the CEQG it may be assumed that free cyanide is also ≤ the CEQG.

Method Principle

Soils and Sediment Sample Preparation

A minimum 10 g sample as received is extracted with 100 mL of 0.05 N aqueous sodium hydroxide at a pH > 12. The sample is shaken for a minimum of six hours, followed by centrifuging and decanting. Sodium hydroxide is used to ensure proper pH is maintained. This is verified by a pH check after the extraction. If the pH is < 10 the extraction should be repeated using a stronger base. Larger sample weights may be used but the 10:1 ratio (v/w) of aqueous sodium hydroxide to soil must be maintained. This extraction procedure is derived from OMOECC method E3015 (note: ASTM D7572 and US EPA Method 9013A describe similar procedures, but the OMOECC method is recommended for consistency).

Water Sample Preparation

Water samples are analysed as received. Particulates should not be included. Particulates that may interfere with the analysis are excluded by centrifugation or filtration in the laboratory, if necessary.

WAD Cyanide Analysis

A portion of the aqueous sample or leachate is introduced directly to the autoanalyser system from an autosampler. Cyanide is separated from water or leachates at weakly acidic pH of 4.5 to 6.0 by manual or automated distillation (without UV oxidation) or by means of a gas permeable membrane. Analysis is either colourimetric or amperometric. Care must be taken in the analysis conditions to prevent thiocyanate interference. Off-line distillation prior to analysis is an acceptable option.

The automated colourimetric method uses barbituric or dimethylbarbituric acid plus isonicotinic acid, or pyridine plus barbituric acid, as colour reagent.

Free Cyanide Analysis

$HCN + CN^-$ are extracted using a microdiffusion cell. The water, wastewater or extract sample is introduced in the outer chamber of the microdiffusion cell and is buffered at pH 6 and placed in the dark for 6 hrs of diffusion. The free cyanide diffuses as HCN gas and is absorbed as CN^- into the sodium hydroxide solution located in the center chamber of the microdiffusion cell. The collected HCN is then analyzed as above.

4.2.2.10 Dissolved Gas Supersaturation

Parameters

Dissolved Gas Supersaturation

Table 4.2.2.10

Method Reference Source	Soil & Sediment	Water
Standard Methods		Method 2810B

Method Principle

This is a field measurement. The method employs an instrument with a variable length of gas permeable tubing connected to a pressure-measuring device. Dimethyl silicone rubber tubing is used commonly because it is highly permeable to dissolved gases, including water vapour. At steady state, the gauge pressure inside the tubing is equal to the difference in gas pressure (ΔP) between the total dissolved gas pressure and the ambient barometric pressure. When the water is in equilibrium with the atmosphere, ΔP equals zero. If ΔP is greater than zero, the water is supersaturated. Conversely, if ΔP is negative the water is undersaturated.

Reporting

Total gas pressure is reported in units of mm Hg.

4.2.2.11 Dissolved Oxygen

Parameters

Dissolved Oxygen (DO)

Table 4.2.2.11

Method Reference Source	Soil & Sediment	Water
Standard Methods		Method 4500-O G

Method Principle

This is a field measurement. Oxygen-sensitive membrane electrodes of the polarographic or galvanic type are composed of two solid metal electrodes in contact with supporting electrolyte separated from the test solution by a selective membrane. The basic difference between the galvanic and the polarographic systems is that in the former the electrode reaction is spontaneous (similar to that in a fuel cell), while in the latter an external source of applied voltage is needed to polarise the indicator electrode. Polyethylene and fluorocarbon membranes are used commonly because they are permeable to molecular oxygen and are relatively rugged. Membrane electrodes are commercially available in some variety. In all these instruments, the “diffusion current” is linearly proportional to the concentration of molecular oxygen. The classic Winkler titration method (Standard Methods 4500-O B) is not easily applied in the field.

4.2.2.12 Fluoride

Parameters

Fluoride

Table 4.2.2.12

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** Method 300.0, Rev 2.1 **Analysis** Method 300.0, Rev 2.1 Method 300.1, Rev 1.0
Standard Methods		Method 4110 B Method 4500-F
OMOECC		E3172
Methods of Soil Analysis Part 3. Chemical Methods. 1996. Sparks, Editor. 850 – 852.	"Sodium Hydroxide Fusion Method for Total Fluorine"	
Centre d'expertise en analyse environnementale		MA. 300 - F 1.2

Method Principle

The CEQG criterion for fluoride in soil is based on total fluoride. In order to determine total fluoride, the sample must be subjected to fusion with sodium hydroxide, prior to dissolution and analysis.

For soluble fluoride in soils, a minimum 5 g portion of the previously dried, disaggregated, sieved (< 2 mm) solid sample is extracted with 10 mL deionised water by shaking for a minimum of 30 minutes, then filtered prior to analysis.

Note: 5 g is considered the minimum size for a representative sample. Larger weights may be used but the 2:1 ratio (v/w) of water to soil must be maintained.

Waters are analysed as received or filtered if necessary.

Analysis may be by specific ion electrode or ion chromatography with conductivity detection. If specific ion electrode is used, a complexing agent such as TISAB buffer is added to the filtrate prior to analysis to maintain constant ionic strength and decomplex any aluminium fluoride complexes.

Reporting

Soils are reported as µg/g dry weight. Waters are reported in units of mg/L.

4.2.2.13 Mercury

Parameters

Mercury (Hg)

Table 4.2.2.13

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** Method 200.2 Rev 2.8 SW-846, Method 3050B SW-846, Method 3051A SW-846, Method 7471B **Analysis** SW-846, Method 7471B SW-846, Method 7474	**Sample Preparation** Method 200.2 Rev 2.8 Method 200.8, Rev 5.4 **Analysis** SW-846, Method 7470A Method 245.1, Rev 3.0 Method 245.2 Method 245.7, Rev 2.0 Method 200.8, Rev 5.4 Method 1631E
Standard Methods		Method 3112 B
ASTM		Method D3223-02
USGS	I-16463-86	I-3462-85
OMOECC	E3059	E3060
British Columbia Ministry of the Environment, Environmental Laboratory Manual	**Sample Preparation** Strong Acid Leachable Metals (SALM) in Soil	
Centre d'expertise en analyse environnementale		MA. 200 - Mét. 1.2

Method Principle

Previously dried, disaggregated, sieved (< 2 mm) soil samples or aqueous samples are digested with a heated, strong, mixed acid solution to convert all forms of mercury to divalent mercury. Excess oxidizing agents are removed by the addition of hydroxylamine. The divalent mercury is then reduced to elemental mercury, sparged from solution and analysed in one of the following ways: manual or automated cold vapour atomic absorption spectrophotometry (CVAAS), or cold vapour atomic fluorescence spectrophotometry (CVAFS). CVAFS, particularly when used in conjunction with a gold trap, provides superior sensitivity to CVAAS.

ICP-MS may also be used for the determination of mercury (US EPA Method 200.8, SW-846 Method 6020A) provided the LRL requirements and DQOs can be met. Additional measures may be required to maintain the mercury in solution and prevent plating out in the sample introduction system (SW-846 Method 6020A).

4.2.2.14 Nitrate + Nitrite, Nitrate, Nitrite

Parameters

Nitrate + Nitrite

Table 4.2.2.14

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** Method 300.0 Rev 2.1 **Analysis** Method 300.0 Rev 2.1 Method 300.1 Rev 1.0
Standard Methods		Method 4110 B Method 4500 NO2 Method 4500 NO3
OMOECC		E3364
Centre d'expertise en analyse environnementale		MA. 300 - Ions 1.3 MA. 300 - NO3 2.0

Method Principle

Nitrate plus nitrite may be determined colourimetrically or by ion chromatography. Samples are analysed as received or after filtration, if necessary to remove particulate.

The automated colourimetric method incorporates a split manifold used to determine both nitrite singly and nitrite and nitrate combined. On one channel, the nitrate is quantitatively reduced to nitrite in a reductor column containing amalgamated copperised cadmium filings. The nitrite yielded by the reduction plus the nitrite already present in the sample is then determined. The nitrite (that was originally present, plus reduced nitrate) is determined by diazotizing with sulphanilamide and coupling with N-(1-naphthyl)-ethylenediamine to form an azo dye, measured colourimetrically at 520 nm, yielding a value for nitrate + nitrite.

In the second channel, nitrite alone is determined by using the same chemistry without the cadmium reduction step, yielding a value for nitrite only.

Nitrate is determined by subtraction of the nitrite result from the nitrate + nitrite value. Refer to Section 6.3.2 regarding detection limits for subtracted parameters.

The ion chromatography method determines nitrate and nitrite individually. Either conductivity or UV detection may be employed. Nitrate + nitrite is the sum of the individual results.

Calculations and Reporting

The CEQG for nitrate is expressed as in units of µg/L as NO_3.

The CEQG for nitrate + nitrite is expressed in units of µg/L as N.

The CEQG for nitrite is expressed in units of µg/L as N.

For nitrate, to convert from units of µg/L as NO_3 to µg/L as N, multiply by 14/62.

For nitrite, to convert from units of µg/L as N to µg/L as NO_2, multiply by 44/14.

4.2.2.15 Nitrogen (total)

Parameters

Nitrogen (total)

Table 4.2.2.15

Method Reference Source	Soil & Sediment	Water
Standard Methods		Method 4500 N
Centre d'expertise en analyse environnementale		MA. 300 - NTPT 2.0

Method Principle

Alkaline oxidation at 100°C to 110°C converts organic and inorganic nitrogen to nitrate. Total nitrogen is determined by analysing the nitrate in the digestate using the analytical techniques described in Section 4.2.2.14. Automated digestions using UV radiation and persulphate may also be used.

Automated combustion techniques that detect evolved nitrogen oxides may also be used.

Alternatively, total Kjeldahl nitrogen (TKN), nitrate, and nitrate (all expressed as N) may be determined separately and summed to provide a Total Nitrogen value. Since not all forms of organic nitrogen are determined by TKN, the Total N value determined in this way may be biased low relative to the alkaline oxidation or combustion procedures. For most environmental samples, however, the bias is not significant.

Reporting

Results are reported in units of µg/L as N.

4.2.2.16 Nutrients (TN & TP), Total Nitrogen & Total Phosphorus

Parameters

Nutrients (Total Nitrogen & Total Phosphorus)

Table 4.2.2.16

Method Reference Source	Soil & Sediment	Water
Standard Methods		Method 4500 N Method 4500 P
Centre d'expertise en analyse environnementale		MA. 300 - NTPT 2.0

Method Principle

Methods for Total Nitrogen are described in Section 4.2.2.15.

Total Phosphorus is the term used to describe the sum of all of the phosphorus present in a sample regardless of form. It includes all forms of orthophosphate, hydrolysable phosphorus (or condensed phosphates in the form of pyrophosphates, metaphosphates, and polyphosphates), and total organic phosphorus.

Total reactive phosphorus (sometimes termed “total orthophosphate”) is a measure of phosphate that responds to colourimetric tests without preliminary hydrolysis or oxidative digestion of the sample. This is primarily a measure of orthophosphate; however, a small fraction of condensed phosphates is usually hydrolyzed unavoidably. Dissolved Reactive Phosphorus (sometimes termed “dissolved orthophosphate”) is determined in the same manner after the sample has been filtered through a 0.45 µm filter.

Acid hydrolysis at boiling temperatures converts condensed phosphates into dissolved orthophosphate. The hydrolysis unavoidably releases some phosphate from organic compounds. The term “acid-hydrolysable phosphorus” is preferred over “condensate phosphorus”.

The phosphate fractions that are converted to orthophosphate only by oxidation destruction of the organic matter present are considered “organic” or “organically bound” phosphorus.

All three forms can occur in both the suspended and dissolved forms.

For Total Phosphorus, the sample as received is subjected to strong acid digestion, which converts all forms of phosphorus to orthophosphate. The digestion may be done off-line or as part of the automated analysis involving UV and persulphate.

Regardless of the phosphorus fraction that is desired, the orthophosphate is determined by manual or automated colourimetry. There are a number of colourimetric procedures, but the most commonly used is the ascorbic acid reduction method. In this method, ammonium molybdate and antimony potassium tartrate react in an acidic medium with dilute solutions of phosphorus to form an antimony-phospho-molybdate complex. This complex is reduced to an intensely blue-coloured complex by ascorbic acid. The colour is proportional to the phosphorus concentration and is measured colourimetrically at 880 nm.

Total phosphorus may also be determined by ICP-OES or ICP-MS provided the LRL requirements can be met. These procedures are less sensitive than the colourimetric versions.

Reporting

Results are reported in units of µg/L as P.

4.2.2.17 Particle Size

Parameters

Soil Classification: Fine, Coarse
Soil Classification: Sand, Silt, Clay

Table 4.2.2.17

Method Reference Source	Soil & Sediment	Water
Soil Sampling and Methods of Analysis, 2nd Edition, Carter and Gregorich, Editors	**Sample Preparation and Analysis** Chapter 55, Particle Size Distribution	
ASTM	D422	

Method Principle

Particle Size Determination: Fine and Coarse

As-received soil samples are sieved using a #200 mesh (0.075 mm) sieve with the aid of water. Care is taken not to break larger particles. The material passing through the sieve is collected in a pan. The sieve and pan are dried and weighed. The percentage of soil retained on and passing through the #200 sieve is calculated. If > 50% passes through the sieve the soil is classified as "fine", otherwise it is classified as "coarse".

O. Reg. 153/04 requires that all particles > 2 mm (#10 mesh) be removed prior to applying the procedure described above. Other jurisdictions may require that fine or coarse determination be based on the entire sample.

Particle Size Determination: Sand, Silt, and Clay

As-received soil samples are passed through a series of sieves ranging from #4 mesh (4.75 mm) to #200 mesh (0.075 mm) or finer. The sieves must include #10 mesh (2 mm). In addition, a second aliquot is subjected to hydrometer analysis where the soil is suspended in water by agitation / inversion with the aid of a dispersing agent. The cylinder is placed upright and a series of hydrometer readings are taken over time.

The sand, silt, clay measurement is always determined on the < 2 mm fraction only. A semilogarithmic curve of percent passing *vs*. particle size is constructed from the measurements and used to calculate the percent sand : silt : clay. The ranges are in accord with the USDA and Canadian Soil Classifications and may be used with the USDA and Canadian Soil Triangles. They are:

Sand: 2 mm – 0.05 mm

Silt: 0.05 mm – 0.002 mm

Clay: < 0.002 mm

Reporting

The proportions retained and passing the #200 sieve are reported in percent. The soil classification as "fine" or "coarse" is also reported.

The sand : silt : clay fractions are reported as percentage with the sum being equal to 100%. The associated graph is also reported.

4.2.2.18 pH by Potentiometry

Parameters

pH in soil, sediment

Table 4.2.2.18

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 9045D **Sample Analysis** SW-846, Method 9045D	**Sample Preparation** N/A **Analysis** Method 150.1
Standard Methods		Method 2310 Method 4500 H^+
OMOECC	E3137	E3218
Centre d'expertise en analyse environnementale		MA. 100 - pH 1.1

Method Principle

Waters are analysed, preferably in the field, using a calibrated pH meter and electrode. For soils, a minimum 10 g portion of the sample, either dried or as received, is extracted by shaking with 20 mL of 0.01 M calcium chloride solution for at least 30 minutes. The aqueous layer is separated from the soil by centrifuging, settling or decanting then analysed using a pH meter and electrode. Higher ratios may be required for certain sample types (peats, fine clays) in order to obtain sufficient liquid for analysis.

Note: 10 g is considered the minimum size for a representative soil sample. Larger weights may be used but the 2:1 ratio (v/w) of aqueous calcium chloride to soil must be maintained.

The pH of a solution is defined as the negative logarithm of the hydrogen ion activity and in dilute solutions, the activity is approximately equal to the concentration of the hydrogen ion. Thus

$$pH = -\log_{10}\left[H^+\right]$$

Since the activity of the hydrogen ion cannot be measured directly, it is measured potentiometrically with a glass electrode in combination with a reference electrode.

Reporting

The pH as measured in the soil extract or aqueous sample is reported in pH units.

4.2.2.19 Reactive Chlorine Species

Parameters

Reactive Chlorine Species

Table 4.2.2.19

Method Reference Source	Soil & Sediment	Water
Standard Methods		SM 4500Cl G
Hach Company		Method 7019

Method Principle

Reactive chlorine species include total residual chlorine, combined residual chlorine, total available chlorine, hypochlorous acid, chloramine, combined available chlorine, free residual chlorine, free available chlorine, chlorine-produced oxidants.

Hypochlorous acid and the hypochlorite ion oxidise N,N-diethyl-p-phenylenediamine (DPD) forming a magenta color. Since the reaction is pH-dependent, a buffer is added. Potassium iodide is added to the reaction to determine combined available chlorine forms and total chlorine. Chloramines oxidise the iodide to iodine then the liberated iodine reacts with DPD to form the magenta color. Because of the instability of chlorine species, this is a field test and the Hach UL DPD kit provides the best sensitivity, although no method can achieve the CEQG of 0.5 µg/L.

Reporting

Results are reported in units of µg/L as Cl_2.

4.2.2.20 Salinity

Parameters

Salinity

Table 4.2.2.20

Method Reference Source	Soil & Sediment	Water
Standard Methods		Method 2520B

Method Principle

Salinity is an important unitless property of industrial and natural waters. It was originally conceived as a measure of the mass of dissolved salts in a given mass of solution. The experimental determination of the salt content by drying and weighing presents some difficulties due to the loss of some components. The only reliable way to determine the true or absolute salinity of a natural water is to make a complete chemical analysis. However, this is time-consuming and cannot yield the precision necessary for accurate work. Thus, to determine salinity, indirect methods involving the measurement of a physical property such as conductivity, density, sound speed, or refractive index, are used. From an empirical relationship of salinity and the physical property determined for a standard solution it is possible to calculate salinity. Because of the simplicity and accuracy of measurement, conductivity is routinely used.

See Standard Methods 2520B for calculation details.

Calculations and Reporting

Salinity is a unitless quantity.

$$\textit{Salinity (valid from 2 to 42)} = a_0 + a_1 R_1^{1/2} + a_2 R_1 + a_3 R_1^{3/2} + a_4 R_1^2 + a_5 R_1^{5/2} + \Delta S$$

$$\textit{Salinity (valid for calculated salinity from 0 to 40)} = S_{PSS} - \frac{a_0}{1 + 1.5X + X^2} - \frac{b_0 f(t)}{1 + Y^{1/2} + Y^{3/2}}$$

$$\Delta S = \frac{t - 15}{t + 0.0162(t - 15)} \times (b_0 + b_1 R_1^{1/2} + b_2 R_1 + b_3 R_1^{3/2} + b_4 R_1^2 + b_5 R_1^{5/2})$$

$$\textit{Conductivity Ratio } R_1 = \frac{C(\textit{sample at } t)}{C(\textit{KCl solution at } t)}$$

$$f(t) = \frac{t - 15}{1 + 0.0162(t - 15)}$$

Where:

a_0 = 0.0080	a_3 = 14.0941	b_0 = 0.0005	b_3 = -0.0375
a_1 = -0.1692	a_4 = -7.0261	b_1 = -0.0056	b_4 = 0.0636
a_2 = 25.3851	a_5 = 2.7081	b_2 = -0.0066	b_5 = -0.0144

C = Conductivity (32.4356 g of KCl in 1 kg of solution produces a salinity of 35)

t = Temperature (°C)

S_{PSS} = Value determined from the Practical Salinity Scale (given in Standard Methods)

$X = 400R_1$

$Y = 100R_1$

4.2.2.21 Sodium Adsorption Ratio (SAR)

Parameter

SAR in soil and sediment

Table 4.2.2.21

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3010A SW-846, Method 3050B **Analysis** SW-846, Method 6010C SW-846, Method 6020A	
Standard Methods		Method 3030 B Method 3030 E

Method Reference Source	Soil & Sediment	Water
Soil Sampling and Methods of Analysis, 2nd Edition, Carter and Gregorich, Editors	15.2.1 Saturation Extract 15.4.4 Sodium Adsorption Ratio calculation	

Method Principle

A 5 g portion of previously dried, disaggregated, sieved sample (< 2 mm) is extracted with 10 mL deionised water by shaking for 30 minutes. For some soil types a higher water:soil ratio may be required to obtain sufficient liquid for measurement. Alternatively, in some jurisdictions, SAR is determined on a saturated paste extract. See Section 4.2.2.4, Chloride, for details.

The aqueous extract is separated from the solid, acidified then analysed using a spectrometric technique. ICP-OES is recommended; alternatives are AAS and ICP-MS.

Calculations and Reporting

The concentrations of sodium, calcium and magnesium are in units of milliequivalents per litre. SAR is determined from the equation below. Since SAR is a ratio, it is unitless.

$$SAR = \frac{[Na^+]}{\sqrt{\frac{1}{2}([Ca^{2+}]+[Mg^{2+}])}}$$

Because SAR is a ratio, the standard approach to calculation of detection limit does not apply. Numerical values for SAR can only be calculated when valid results (above LRL) are available for sodium and for at least one of calcium and magnesium (if one of Ca and Mg are < LRL, use zero for that parameter). Use the following approach to report SAR when these conditions are not met:

1. If both Ca and Mg are below LRL, report SAR as “incalculable”. A “< LRL” value cannot be reported, because SAR increases as Ca and Mg decrease.
2. If Na is below LRL, but one or both of Ca and Mg are above LRL, calculate the maximum possible SAR value using the numerical value of the LRL for Na and the reported results for Ca and Mg (use a value of zero for Ca or Mg if below LRL). Report SAR as less than this calculated maximum value (similar to a LRL).

4.2.2.22 Streambed Substrate

Parameters

Streambed Substrate

Table 4.2.2.22

Method Reference Source	Soil & Sediment	Water
British Columbia Ministry of the Environment, Environmental Protection Division	**Sampling, Sample Preparation and Analysis** Water Quality Sampling Strategy for Turbidity, Suspended and Benthic Sediments Technical Appendix Addendum Apr 1997 http://www.env.gov.bc.ca/wat/wq/BCguidelines/samp_strat/sampstrat.html#analytical	
Environment and Climate Change Canada	**Sampling, Sample Preparation and Analysis** Canadian Aquatic Biomonitoring Network Field Manual, Wadeable Streams 2012	

Method Principle

The method reference provides additional detail on sampling. The criteria for streambed substrate are that the distribution in streambed substrates should not exceed 10% < 2 mm, 19% < 3 mm, and 25% < 6.35 mm. In addition, the geometric mean diameter should not exceed 12 mm.

Samples are dried, disaggregated and passed through a stack of sieves of appropriate sizes. The percentage retained by each sieve is determined gravimetrically and the results plotted. The percentages < 2 mm, < 3 mm, < 6.35 mm, and the geometric mean are determined from the graph.

There is also a criterion for inter-gravel dissolved oxygen, which is determined as per Section 4.2.2.11.

4.2.2.23 Sulphate

Parameters

Sulphate

Table 4.2.2.23

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** Method 300.0 Rev 2.1 Method 375.4 **Analysis** Method 300.0 Rev 2.1 Method 300.1 Rev 1.0 Method 375.4
Manual of Soil Sampling and Methods of Analysis, McKeague, Editor	Method 4.12	
Standard Methods		Method 4500 SO4 E Method 4110 B Method 4500 SO4 F
OMOECC		E3172
Centre d'expertise en analyse environnementale		MA. 300 - Ions 1.3

Method Principle

Samples are analysed as received except if filtration is necessary to remove particulate. Analysis is by either ion chromatography or automated barium sulphate turbidity.

Reporting

Results are reported in units of µg/L as SO_4.

4.2.2.24 Sulphur (elemental)

Parameters

Sulphur (elemental)

Table 4.2.2.24

Method Reference Source	Soil & Sediment	Water
US EPA	**Sample Preparation** SW-846, Method 3540C SW-846 Method 3570	
Canadian Journal of Soil Science Vol. 65, November 1985, Issue 4	Pages 811-813	

Method Principle

Previously dried, disaggregated, sieved (< 2 mm) soil samples are solvent extracted. The extract is then acid digested and the digestate analysed by ICP-OES as per Section 4.2.1. Alternatively,

the sulphur contained in the extract is reacted with sodium cyanide to produce thiocyanate. When mixed with ferric chloride, the thiocyanate displaces the chloride ion and forms a red complex (ferrous thiocyanate). This complex is measured colourimetrically at 465 nm. Highly coloured extracts may interfere. The interference is minimised by measurement and subtraction of a background-only sample. The solvent extract may also be determined by HPLC with UV detection.

Reporting

Results are reported in units of mg/kg as S.

4.2.2.25 Suspended Sediments (Total Suspended Solids)

Parameters

Suspended Sediments

Table 4.2.2.25

Method Reference Source	Soil & Sediment	Water
Standard Methods		SM2540
British Columbia Ministry of the Environment, Environmental Protection Division		Water Quality Sampling Strategy for Turbidity, Suspended and Benthic Sediments Technical Appendix Addendum Apr 1997 http://www.env.gov.bc.ca/wat/wq/BCguidelines/samp_strat/sampstrat.html#analytical
OMOECC		E3188

Method Principle

See Section 4.2.2.21, Streambed Substrate, and the reference contained therein for guidance on sampling. The sample as received is shaken and an aliquot filtered through a previously dried and weighed glass fibre filter. The filter is dried at 105 ± 5°C, reweighed and the suspended sediments (TSS) determined by difference.

Reporting

Results are reported in units of mg/L TSS.

4.2.2.26 Turbidity

Parameters

Turbidity

Table 4.2.2.26

Method Reference Source	Soil & Sediment	Water
EPA		**Sample Preparation** N/A **Analysis** Method 180.1 Rev 2.0
Standard Methods		Method 2130B
British Columbia Ministry of the Environment, Environmental Protection Division		Water Quality Sampling Strategy for Turbidity, Suspended and Benthic Sediments Technical Appendix Addendum Apr 1997 http://www.env.gov.bc.ca/wat/wq/BCguidelines/samp_strat/sampstrat.html#analytical
OMOECC		E3311
Centre d'expertise en analyse environnementale		MA. 103 - Tur. 1.0

Method Principle

Turbidity is measured using a turbidimeter. Turbidimeters with scattered light detectors located at 90° to the incident beam are called nephelometers. Nephelometers are relatively unaffected by small differences in design parameters; therefore, they are specified as the standard instrument for measurement of low turbidities. Nephelometers are calibrated with a series of standards of known turbidity.

Reporting

Results are reported in Nephelometric Turbidity Units (NTU).

4.2.2.27 Total Dissolved Solids

Parameters

Total Dissolved Solids

Table 4.2.2.27

Method Reference Source	Soil & Sediment	Water
Standard Methods		Method 2540C
OMOECC		E3188
Centre d'expertise en analyse environnementale		MA. 100 - S.T. 1.1

Method Principle

An aliquot of sample is filtered using a glass fibre filter and the filtrate evaporated to dryness at 180 ± 2°C in a pre-weighed dish. The dish plus residue is cooled and weighed to constant weight. Total dissolved solids (TDS) is determined by difference. Although usually not permissible for regulatory purposes, TDS may also be calculated by determining and summing the major cations and anions. This also serves as a good QC check.

Reporting

Results are reported in units of mg/L.

4.3 Microbiology

4.3.1 Coliforms

Parameters

Coliforms, fecal (*Escherichia coli*)
Coliforms, total

Table 4.3.1

Method Reference Source	Soil & Sediment	Water
US EPA		**Sample Preparation** Method 1604 Method 2002 **Analysis** Method 1604 Method 2002
Standard Methods		Method 9215 Method 9221 Method 9222 Method 9223
OMOECC		**Sample Preparation** E3371 **Analysis** E3226 E3371 E3407 E3408
Centre d'expertise en analyse environnementale		MA. 700 - Ec-Tm 1.0

Method Principle

There are numerous acceptable methods for the determination of total and fecal coliforms. All methods require stringent sterilization and handling procedures to prevent contamination. The

procedure described below, OMOECC E3407, was selected because it allows for the simultaneous detection and enumeration of Total Coliforms and *Escherichia coli* (*E. coli*) with a single filtration, on a single agar plate (using differential coliform (DC) agar), incubated at one temperature (35 ± 0.5°C) for 24 ± 2 hours.

A vacuum is used to draw a measured volume of liquid through a 47 millimetre diameter, 0.45 µm pore size, white, gridded, cellulose ester (membrane) filter. The pore size of the membrane enables the capture of bacteria. After filtration, the filters are placed onto DC agar plates that are then incubated at 35 ± 0.5°C for 24 ± 2 hours. The DC agar is specifically designed to enable the visual differentiation of coliforms from *E. coli* colonies: *E. coli* are blue, coliforms are red, and non-targets are yellow. Upon completion of the incubation period, the number of coliform and *E. coli* colony forming units (CFUs) are tabulated and reported.

Calculations and Reporting

Results are reported as number of colony forming units / 100 mL.

If no colonies are detected, the result is reported as < 1 CFU/100 mL. If less than 100 mL is filtered, the "<" result is adjusted accordingly, e.g., for a 10 mL non-detect sample, the result is reported as < 10 CFU/100 mL.

$$\frac{\textit{\# of colonies counted x 100}}{\textit{mL sample filtered}} = \textit{\# CFU/100 mL}$$

4.3.2 Cyanobacteria

Parameters

Cyanobacteria* (Blue-green algae)

* Often associated with analysis for chlorophyll *a* and nutrients.

Table 4.3.2

Method Reference Source	Soil & Sediment	Water
		Sample Preparation and Analysis *Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management.* Edited by Ingrid Chorus and Jamie Bartram, © 1999 WHO, ISBN 0-419-23930-8
Standard Methods		Method 10200

Method Reference Source	Soil & Sediment	Water
OMOECC		**Sample Preparation** E3169 E3450 E3469 **Analysis** E3169 E3450 E3469
Centre d'expertise en analyse environnementale		MA. 800 - Cya.dep 1.0

Method Principle

Cyanobacteria can be found in almost every terrestrial and aquatic habitat: in oceans, fresh water - even bare rock and soil. They can occur as planktonic cells or form phototrophic biofilms in fresh water and marine environments; they occur in damp soil, or even on temporarily moistened rocks in deserts. A few are endosymbionts in lichens, plants, various protists, or sponges, and provide energy for the host. Aquatic cyanobacteria are probably best known for the extensive and highly visible blooms that can form in both freshwater and the marine environment and can have the appearance of blue-green paint or scum. The association of toxicity with such blooms has frequently led to the closure of recreational waters when blooms are observed. Because they are photosynthetic and aquatic, cyanobacteria are often called "blue-green algae". This name is convenient for talking about organisms in the water that make their own food, but does not reflect any relationship between the cyanobacteria and other organisms called algae.

Most cyanobacteria can be distinguished from other phytoplankton and particles under the microscope by their morphological features at a magnification of 200-1,000 times by comparison to reference. Cyanobacterial taxonomy, following the established botanical code, differentiates by genera and species. However, this differentiation is subject to some uncertainty, and organisms classified as belonging to the same species may nonetheless have substantial genetic differences, e.g., with respect to microcystin production.

Calculations and Reporting

Identified species are tabulated and enumerated.

5 REPORTING

5.1 Laboratory Reporting Limits (LRLs)

Laboratory Reporting Limit (LRL): The lowest concentration of an analyte reported with a reasonable degree of accuracy and precision, often synonymous with the limit of quantification (LOQ) or practical quantification limit (PQL). The LRL is typically 3-10 times the method detection limig (MDL) but must be ≥ the MDL. The LRL is the concentration at which a single analysis using the methods and matrices listed in this document will consistently detect target analytes when present.

The uncertainty in analyte concentration increases near to the detection limit. Some laboratories may also report concentrations detected between the MDL and the LRL ("J-flagged" results); however, these concentrations should be considered an estimate. Detection limits may be raised due to matrix effects or sample dilution. Other reporting methods, such as reporting to estimated detection limits based on sample signal-to-noise ratio, are acceptable for isotope dilution methods and where dictated by the reference method.

LRLs are ideally at least $1/5^{th}$ the lowest CEQG. However, for several analytes, this is not currently achievable using mainstream analytical methods and instrumentation. For three analytes, reactive chlorine and deltamethrin in water, and toxaphene in sediment, the lowest CEQG is not achievable.

If analytical data is being provided for comparison to a higher guideline, a less sensitive method may be used, provided the LRL is $1/5^{th}$ the higher guideline.

In Table 5.1, Laboratory Reporting Limits Water and Soil/Sediment:

- "Lowest Criterion" column is the lowest CEQG and/or OMOECC guideline for each parameter. N/V indicates no CEQG or OMOECC guideline for that parameter / matrix. In cases where there are both a CEQG and an OMOECC guideline both are listed.
- While other jurisdictions in Canada may also have water or soil criteria for a given analyte, the values for Ontario MOECC are provided here in addition to CCME values because this compendium builds on the recently published OMOECC methods document. The values for Ontario are therefore provided in the absence of CCME values as reference information. Jurisdictions may apply the guidance as required under their respective programs, legislation and regulations.
- At this time, there are draft Federal Interim Groundwater Quality Guidelines out for review. Wherever the draft interim guidelines are lower than the lowest CEQG, they are included in red text, qualified with an asterisk.

Table 5.1 Laboratory Reporting Limits – Water and Soil/Sediment

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Section 2.1.1 and 4.1.1 Acid/Base/Neutral Extractable Organic Compounds (ABNs)							
Aniline	Organic Other Organics SVOC	62-53-3	ABN	2.2	0.4	N/V	N/A
Biphenyl, 1,1'-	Organic ABN	92-52-4	ABN	0.5 OMOECC	0.1	0.05 OMOECC	0.05
Bis(2-chloroethyl)ether	Organic ABN	111-44-4	ABN	5 OMOECC	1	0.5 OMOECC	0.5
Bis(2-chloroisopropyl)ether	Organic ABN	39638-32-9	ABN	4 OMOECC	1	0.5 OMOECC	0.5
Chloroaniline, p-	Organic ABN	106-47-8	ABN	10 OMOECC	10	0.5 OMOECC	0.5
Di(2-ethylhexyl) phthalate	Organic Phthalate esters	117-81-7	ABN	16 CCME 10 OMOECC	2	5	5
Dichlorobenzidine, 3,3'-	Organic ABN	91-94-1	ABN	0.5 OMOECC	0.5	1 OMOECC	1
Diethyl phthalate	Organic ABN	84-66-2	ABN	2 OMOECC	2	0.5 OMOECC	0.5
Dimethylphenol, 2,4-	Organic ABN	105-67-9	NCP or ABN	10 OMOECC	2	0.2 OMOECC	0.2
Dimethylphthalate	Organic ABN	131-11-3	ABN	2 OMOE	2	0.5 OMOECC	0.5
Di-n-butyl phthalate	Organic Phthalate esters	84-74-2	ABN	19	4	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Dinitrophenol, 2,4-	Organic ABN	51-28-5	NCP or ABN	10 OMOECC	10	2 OMOECC	0.2
Dinitrotoluene, 2,4- (2,6-)	Organic ABN	121-14-2	ABN	5 OMOECC	5	0.5 OMOECC	0.5
Di-n-octyl phthalate	Organic Phthalate esters	117-84-0	ABN	N/V	2	N/V	N/A
Phenol	Organic Aromatic hydroxy compounds	108-95-2	NCP or ABN	5 OMOECC	1	0.5 OMOECC	0.5
Phenolic compounds, non-chlorinated	Organic Non-halogenated aromatic hydroxy compounds		NCP or ABN	N/V	N/A	0.1	0.1
Phenols (mono- & dihydric)	Organic Aromatic hydroxy compounds	108-95-2	NCP or ABN	2	0.8	3.8	1
Phthalic acid esters	Organic Phthalate esters		ABN	N/V	N/A	30	0.5

Section 2.1.2 and 4.1.2 Chlorophenols (CPs)

Chlorophenol, 2-	Organic Volatile Organic Compounds CP or ABN	95-57-8	CP or ABN	2 OMOECC	0.5	0.1 OMOECC	0.1
Dichlorophenol, 2,4-	Organic Monocyclic aromatic compounds Chlorinated phenols	120-83-2	CP or ABN	N/V	N/A	0.05 CCME 0.1 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols		CP or ABN	0.2	0.2	0.05	0.05
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols		CP or ABN	7	1	0.05	0.05
Pentachlorophenol (PCP)	Organic Monocyclic aromatic compounds Chlorinated phenols	87-86-5	CP or ABN	0.5 CCME 0.5 OMOECC	0.1	7.6 CCME 0.1 OMOECC	0.1
Tetrachlorophenol, 2,3,4,6-	Organic Monocyclic aromatic compounds Chlorinated phenols	58-90-2	CP or ABN	N/V	N/A	0.05	0.05
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	25167-83 -3	CP or ABN	1	0.2	0.05	0.05
Trichlorophenol, 2,4,5-	Organic Volatile Organic Compounds CP or ABN	95-95-4	CP or ABN	0.2 OMOECC	0.2	0.1 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Trichlorophenol, 2,4,6-	Organic Monocyclic aromatic compounds Chlorinated phenols	88-06-2	CP or ABN	0.2 OMOECC	N/A	0.05 CCME 0.1 OMOECC	0.05
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols		CP or ABN	18	1	0.05	0.05

Section 2.1.3 and 4.1.3
1,4-Dioxane

Dioxane, 1,4-	Organic Volatile Organic Compounds	123-91-1	ABN or VOC	NRG CCME 50 OMOECC	20	0.2 OMOECC	20

Polychlorinated dibenzo-p-dioxins/dibenzo furans	Organic Polyaromatic compounds Polychlorinated dioxins and furans		PCDD	0.015 ng/L TEQ OMOECC	0.015 ng/L TEQ	0.85 ng/kg TEQ CCME 7 ng/kg TEQ OMOECC	0.8 ng/kg TEQ

Section 2.1.4 and 4.1.4 Glycols

Diethylene glycol	Organic Glycols	111-46-6	Glycol	N/V	5000	N/V	N/A
Ethylene glycol	Organic Glycols	107-21-1	Glycol	192 000 190000*	5000	960	50
Propylene glycol	Organic Glycols	57-55-6	Glycol	500 000	10000	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Section 2.1.5 and 4.1.5 Organochlorine Pesticides (OCs)							
Aldrin	Organic Pesticides Organochlorine compounds	309-00-2	OC Pesticides	3* 0.01 OMOECC	0.01	0.002 OMOECC	0.01
Chlordane alpha-Chlordane beta-Chlordane	Organic Pesticides Organochlorine compounds	57-74-9 5103-71-9 5566-34-7	OC Pesticides	0.004* 0.06 OMOECC	0.0002	0.0045 CCME 0.007 OMOECC	0.001
Dichloro diphenyl dichloroethane, 2,2-Bis(p-chlorophenyl)-1,1-dichloroethane	Organic Pesticides Organochlorine compounds	72-54-8	OC pesticides	1.8 OMOECC	0.1	0.00122 CCME 0.008 OMOECC	0.001
Dichloro diphenyl ethylene, 1,1-Dichloro-2,2-Bis(p-chlorophenyl)-ethene	Organic Pesticides Organochlorine compounds	72-55-9	OC pesticides	10 OMOECC	0.1	0.00207 CCME 0.005 OMOECC	0.001
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane	Organic Pesticides Organochlorine compounds	50-29-3	OC pesticides	0.001* 0.05 OMOECC	0.02	0.00119 CCME 0.007 OMOECC	0.001
Dieldrin	Organic Pesticides Organochlorine compounds	60-57-1	OC pesticides	0.056* 0.05 OMOECC	0.02	0.00071 CCME 0.002 OMOECC	0.001

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Endosulfan	Organic Pesticides Organochlorine compounds	115-29-7 195-59-6 33213-65-9	OC pesticides	0.002 CCME 0.05 OMOECC	0.002	0.04 OMOECC	0.01
Endrin	Organic Pesticides Organochlorine compounds	72-20-8	OC pesticides	0.036* 0.05 OMOECC	0.02	0.00267 CCME 0.003 OMOECC	0.001
Heptachlor	Organic Pesticides Organochlorine compounds	76-44-8	OC pesticides	0.0038* 0.01 OMOECC	0.002	0.05 OMOECC	0.05
Heptachlor epoxide	Organic Pesticides/Herbicides/Fungicides OC Pesticides	1024-57-3	OC pesticides	0.01 OMOECC	0.01	0.0006 CCME 0.005 OMOECC	0.05
Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	118-74-1	OC pesticides	0.52 CCME 0.01 OMOECC	0.01	0.05 CCME 0.01 OMOECC	0.05
Hexachlorobutadiene (HCBD)	Organic Halogenated aliphatic compounds	87-68-3	OC pesticides	1.3 CCME 0.01 OMOECC	0.2	0.01 OMOECC	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Hexachlorocyclohexane, gamma- (γ-HCH, Lindane, γ-BHC)	Organic Pesticides Organochlorine compounds	58-89-9	OC pesticides	0.01 CCME 0.01 OMOECC	0.01	0.00032 CCME 0.01 OMOECC	0.0001
Hexachloroethane	Organic Pesticides/Herbicides/Fungicides OC Pesticides	67-72-1	OC pesticides	0.01 OMOECC	0.01	0.01 OMOECC	0.01
Methoxychlor	Organic Pesticides/Herbicides/Fungicides OC Pesticides	72-43-5	OC pesticides	0.05 OMOECC	0.05	0.05 OMOECC	0.05
Metolachlor	Organic Pesticides Organochlorine compounds	51218-45-2	ABN or OC pesticides	7.8	0.1	N/V	N/A
Pentachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	608-93-5	ABN or OC pesticides	6	1	0.05	0.01
Tetrachlorobenzene, 1,2,3,4-	Organic Monocyclic aromatic compounds Chlorinated benzenes	634-66-2	ABN or OC pesticides	1.8	0.36	0.05	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Tetrachlorobenzene, 1,2,3,5-	Organic Monocyclic aromatic compounds Chlorinated benzenes	634-90-2	ABN or OC pesticides	N/V	N/A	0.05	0.01
Tetrachlorobenzene, 1,2,4,5-	Organic Monocyclic aromatic compounds Chlorinated benzenes	95-94-3	ABN or OC pesticides	N/V	N/A	0.05	0.01
Toxaphene	Organic Pesticides Organochlorine compounds	8001-35-2	OC pesticide	0.0002*	0.05‡	0.0001	0.005‡

Section 2.1.6 and 4.1.6 Organotin Compounds

Tributyltin	Organic Organotin compounds	56-35-9	Organotin	0.001	0.001	N/V	N/A
Tricyclohexyltin	Organic Organotin compounds	3047-10-7	Organotin	250	0.005	N/V	N/A
Triphenyltin	Organic Organotin compounds	56-35-9	Organotin	0.022	0.005	N/V	N/A

Sections 1.1.7 and 4.1.7 Perfluorinated Sulphonic Acids, Perfluorinated Carboxylic Acids

Perfluorooctanesulphonate (PFOS)	Perfluorinated Sulphonic Acids	1763-23-1	PFOS	0.3	0.02	N/V	N/A

Section 2.1.8 and 4.1.8 Pesticides and Herbicides (P&H)

Atrazine	Organic Pesticides Triazine compounds	1912-24-9	P&H	1.8	0.3	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Bromacil	Organic Pesticides	314-40-9	P&H	0.2	0.1	N/V	N/A
Bromoxynil	Organic Pesticides Benzonitrile compounds	1689-84-5	P&H	0.33	0.1	N/V	N/A
Captan	Organic Pesticides	133-06-2	P&H	1.3	0.5	N/V	N/A
Carbaryl	Organic Pesticides Carbamate pesticides	63-25-2	P&H	0.2	0.1	N/V	N/A
Chlorothalonil	Organic Pesticides	1897-45-6	P&H	0.18	0.1	N/V	N/A
Chlorpyrifos	Organic Pesticides Organophosphorus compounds	2921-88-2	P&H	0.002	0.003	N/V	N/A
Cyanazine	Organic Pesticides Triazine compounds	21725-46-2	P&H	0.5 0.5*	0.1	N/V	N/A
Deltamethrin	Organic Pesticides	52918-63-5	P&H	0.0004	0.0009‡	N/V	N/A
Dicamba	Organic Pesticides Aromatic Carboxylic Acid	1918-00-9	P&H	0.006	0.006	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Diclofop-methyl	Organic Pesticides	51338-27-3	P&H	0.18	0.1	N/V	N/A
Didecyl dimethyl ammonium chloride (DDAC)	Organic Pesticides	7173-51-5	P&H	1.5	1	N/V	N/A
Dimethoate	Organic Pesticides Organophosphorus compounds	60-51-5	P&H	3	0.6	N/V	N/A
Dinoseb	Organic Pesticides	88-85-7	P&H	0.05	0.05	N/V	N/A
Linuron	Organic Pesticides	330-55-2	P&H	0.071	0.07	N/V	N/A
Methoprene	Organic Pesticides/Herbicides/Fungicides	40596-69-8	P&H	0.09	0.05	N/V	N/A
Metribuzin	Organic Pesticides Triazine compounds	21087-64-9	P&H	0.5	0.1	N/V	N/A
Permethrin	Organic Pesticides Organochlorine compounds	52645-53-1	P&H	0.001	0.004	N/V	N/A
Picloram	Organic Pesticides	1918-02-1	P&H	29	10	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Simazine	Organic Pesticides Triazine compounds	122-34-9	P&H	0.5	0.1	N/V	N/A
Tebuthiuron	Organic Pesticides	34014-18-1	P&H	0.27	0.05	N/V	N/A
Trifluralin	Organic Pesticides Dinitroaniline pesticides	1582-09-8	P&H	0.2	0.01	N/V	N/A

Section 2.1.8 and 4.1.8 Pesticides and Herbicides (P&H)
Section 2.1.8.1 and 4.1.8.1 Carbamates

Aldicarb	Organic Pesticides Carbamate pesticides	116-06-3	P&H or Carbamate	0.15	0.03	N/V	N/A
Carbamate, 3-Iodo-2-propynyl butyl	Organic Pesticides Carbamate pesticides	55406-53-6	P&H or Carbamate	1.9	1	N/V	N/A
Carbofuran	Organic Pesticides Carbamate pesticides	1564-66-2	P&H or Carbamate	1.8	0.4	N/V	N/A
Imidacloprid	Organic Pesticides/Herbicides/Fungicides Carbamate	138261-41-3	P&H or Carbamate	0.23	0.1	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Triallate	Organic Pesticides Carbamate pesticides	2303-17-5	P&H or Carbamate	0.24	0.1	N/V	N/A

Section 2.1.8 and 4.1.8 Pesticides and Herbicides (P&H)
Section 2.1.8.2 Glyphosate

Glyphosate	Organic Pesticides Organophosphorus compounds	1071-83-6	P&H or Glyphosate	280	10	N/V	N/A

Section 2.1.8 and 4.1.8 Pesticides and Herbicides (P&H)
Section 2.1.8.3 Phenoxy Herbicides

Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid, MCPA)	Organic Pesticides	94-74-6	P&H or ABN or Phenoxyacid Herbicide	0.025	0.02	N/V	N/A
Phenoxy Herbicides, (Dichlorophenoxyacetic Acid, 2,4- (2,4-D))	Organic Pesticides		P&H or ABN or Phenoxyacid Herbicide	4	0.8	N/V	N/A

Section 2.1.9 and 4.1.9 Petroleum Hydrocarbons (PHCs)

Petroleum hydrocarbons F1	Organic Other Organics PHC	N/A	PHC	750 OMOECC	100	30 CCME** 17 OMOECC	10

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Petroleum hydrocarbons F2	Organic Other Organics PHC	N/A	PHC	150 OMOECC	150 or 1/5th the lowest Guideline, whichever is higher	150 CCME** 10 OMOECC	30
Petroleum hydrocarbons F3	Organic Other Organics PHC	N/A	PHC	500 OMOECC	500	300 CCME** 240 OMOECC	50
Petroleum hydrocarbons F4†	Organic Other Organics PHC	N/A	PHC	500 OMOECC	500	2800 CCME** 120 OMOECC	50
Petroleum hydrocarbons F4G†	Organic Other Organics PHC	N/A	PHC	N/V	N/A	2800 CCME** 120 OMOECC	500

Section 2.1.10 and 4.1.10 Polychlorinated Biphenyls (PCBs)

Aroclor 1254	Organic Polyaromatic compounds Polychlorinated biphenyls	**27323-18-8**	PCB	N/V	N/A	0.06	0.03
Polychlorinated biphenyls	Organic Polyaromatic compounds Polychlorinated biphenyls	1336-36-3	PCB	0.2 OMOECC	0.1	0.0215 CCME 0.07 OMOECC	0.02

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Section 2.1.11 and 4.1.11 Polychlorinated Dibenzo-p-Dioxins/Dibenzofurans (Dioxins/Furans, PCDDs/PCDFs)							
Polychlorinated dibenzo-p-dioxins/dibenzo furans	Organic Polyaromatic compounds Polychlorinated dioxins and furans		PCDD	0.015 ng/L TEQ OMOECC	0.015 ng/L TEQ	0.85 ng/kg TEQ CCME 7 ng/kg TEQ OMOECC	0.8 ng/kg TEQ
Section 2.1.12 and 4.1.12 Polycyclic Aromatic Hydrocarbons (PAHs)							
Acenaphthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	83-32-9	PAH or ABN	5.8 CCME 4.1 OMOECC	0.5	0.00671 CCME 0.05 OMOECC	0.005
Acenaphthylene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	208-96-8	PAH or ABN	1 OMOECC	0.2	0.00587 CCME 0.093 OMOECC	0.005
Acridine	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	260-94-6	PAH or ABN	4.4 CCME 0.05*	0.05	N/V	N/A
Anthracene	Organic Other Organics SP	120-12-7	PAH or ABN	0.012 CCME 0.1 OMOECC	0.01	0.0469 CCME 0.05 OMOECC	0.005

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Benz(a)anthracene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	56-55-3	PAH or ABN	0.018	0.01	0.0317 CCME 0.095 OMOECC	0.005
Benzo(a)pyrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	50-32-8	PAH or ABN	0.015 CCME 0.01* 0.01 OMOECC	0.01	0.0319 CCME 0.05 OMOECC	0.005
Benzo(b)fluoranthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	205-99-2	PAH or ABN	0.1 OMOECC	0.05	0.16 CCME b+j+k 0.3 OMOECC	0.005
Benzo(k)fluoranthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	207-08-9	PAH or ABN	0.1 OMOECC	0.05	0.16 CCME b+j+k 0.05 OMOECC	0.005
Benzo[ghi]perylene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	191-24-2	PAH or ABN	0.2 OMOECC	0.04	0.17 OMOECC	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Chrysene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	218-01-9	PAH or ABN	0.1 OMOECC	0.1	0.0571 CCME 0.18 OMOECC	0.01
Dibenz(a,h)anthracene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	53-70-3	PAH or ABN	0.2 OMOECC	0.008	0.00622 CCME 0.06 OMOECC	0.005
Fluoranthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	206-44-0	PAH or ABN	0.04 CCME 0.04 OMOECC	0.01	0.111 CCME 0.24 OMOECC	0.01
Fluorene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	86-73-7	PAH or ABN	3 CCME 120 OMOECC	0.1	0.0212 CCME 0.05 OMOECC	0.005
Indeno(1,2,3-c,d)pyrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	193-39-5	PAH or ABN	0.2 OMOECC	0.05	2.7 CCME 0.11 OMOECC	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Methylnaphthalenes, 1- and 2-	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	91-57-6 90-12-0	PAH or ABN	2 OMOECC	2	0.0202 CCME 0.05 OMOECC	0.01
Naphthalene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	91-20-3	PAH or ABN	1.1 CCME 7 OMOECC	0.2	0.0346 CCME 0.05 OMOECC	0.01
Phenanthrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	85-01-8	PAH or ABN	0.4 CCME 0.1 OMOECC	0.08	0.0419 CCME 0.19 OMOECC	0.01
Pyrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	129-00-0	PAH or ABN	0.025 CCME 0.2 OMOECC	0.02	0.053 CCME 0.1 OMOECC	0.01
Quinoline	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	91-22-5	PAH or ABN	3.4 CCME	0.3	0.1	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Section 2.1.13 and 4.1.13 Trihalomethanes (THMs)							
Dibromochloromethane (Chlorodibromomethane)	Organic Halogenated aliphatic compounds Halogenated methanes	124-48-1	THM or VOC	2 OMOECC	2	0.05 OMOECC	0.05
Dichlorobromomethane (Bromodichloromethane)	Organic Halogenated aliphatic compounds Halogenated methanes	75-27-4	THM or VOC	100 CCME 2 OMOECC	1	0.05 OMOECC	0.05
Tribromomethane (Bromoform)	Organic Halogenated aliphatic compounds Halogenated methanes	75-25-2	VOC	100	2	0.05 OMOECC	0.05
Trichloromethane (Chloroform)	Organic Halogenated aliphatic compounds Halogenated methanes	67-66-3	VOC	1.8 CCME 2 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Section 2.1.14 and 4.1.14 Volatile Organic Compounds I (VOCs)							
Acetone	Organic Volatile Organic Compounds	67-64-1	VOC	30 OMOECC	6	0.5 OMOECC	0.5

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Benzene	Organic Monocyclic aromatic compounds	71-43-2	VOC	110 CCME 88* 0.5 OMOECC	5	0.0068 CCME 0.02 OMOECC	0.005
Dichlorobenzene, 1,2-	Organic Monocyclic aromatic compounds Chlorinated benzenes	95-50-1	VOC	0.7 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichlorobenzene, 1,3-	Organic Monocyclic aromatic compounds Chlorinated benzenes	541-73-1	VOC	150 CCME 42* 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichlorobenzene, 1,4-	Organic Monocyclic aromatic compounds Chlorinated benzenes	106-46-7	VOC	26 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichlorodifluoromethane	Organic Volatile Organic Compounds	75-71-8	VOC	2 OMOECC	2	0.05 OMOECC	0.05
Dichloroethane, 1,1-	Organic Halogenated aliphatic compounds Chlorinated ethanes	75-34-3	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloroethane, 1,2-	Organic Halogenated aliphatic compounds Chlorinated ethanes	107-06-2	VOC	5 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	**Chemical Groups**	**CAS RN**	**Parameter Group**	**Lowest Water Criterion (µg/L)**	**Recommended Maximum LRL – Water (µg/L)**	**Lowest Soil/Sediment Criterion (mg/kg)**	**Recommended Maximum LRL - Soil/Sediment (mg/kg)**
Dichloroethene, 1,1-	Organic Halogenated aliphatic compounds Chlorinated ethenes	75-35-4	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloroethene, 1,2- *(cis-* + *trans-*)	Organic Halogenated aliphatic compounds Chlorinated ethenes	156-59-2	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloromethane (Methylene chloride)	Organic Halogenated aliphatic compounds Halogenated methanes	75-09-2	VOC	50 CCME 5 OMOECC	10	0.1 CCME 0.05 OMOECC	0.1
Dichloropropane, 1,2-	Organic Halogenated aliphatic compounds Halogenated methanes	78-87-5	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloropropene, 1,3- (*cis-* + *trans-*)	Organic Halogenated aliphatic compounds Halogenated methanes	542-75-6	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Ethylbenzene	Organic Monocyclic aromatic compounds	100-41-4	VOC	2.4 CCME 0.5 OMOECC	2	0.018 CCME 0.05 OMOECC	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Ethylene dibromide (Dibromoethane, 1,2-)	Organic Volatile Organic Compounds	106-93-4	VOC	0.2 OMOECC	0.2	0.05 OMOECC	0.05
Hexane, n-	Organic Volatile Organic Compounds	110-54-3	VOC	5 OMOECC	5	0.49 CCME 0.05 OMOECC	0.1
Methyl ethyl ketone (MEK)	Organic Volatile Organic Compounds	78-93-3	VOC	20 OMOECC	20	0.5 OMOECC	0.5
Methyl isobutyl ketone (MIBK)	Organic Volatile Organic Compounds	108-10-1	VOC	20 OMOECC	20	0.5 OMOECC	0.5
Methyl tertiary-butyl ether (MTBE)	Organic Non-halogenated aliphatic compounds Aliphatic ether	1634-04-4	VOC	5000 CCME 340* 15 OMOECC	10	0.05 OMOECC	0.05
Monobromomethane (Bromomethane, Methyl bromide)	Organic Halogenated aliphatic compounds Halogenated methanes	74-83-9	VOC	0.89 OMOECC	N/A	0.05 OMOECC	0.05
Monochlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	108-90-7	VOC	1.3 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Monochloromethane (Methyl chloride)	Organic Halogenated aliphatic compounds Halogenated methanes	74-87-3	VOC	N/V	N/A	N/V	N/A
Styrene	Organic Monocyclic aromatic compounds	100-42-5	VOC	72 CCME 0.5 OMOECC	1	0.1 CCME 0.05 OMOECC	0.05
Tetrachloroethane, 1,1,1,2-	Organic Volatile Organic Compounds	630-20-6	VOC	1.1 OMOECC	0.5	0.05 OMOECC	0.05
Tetrachloroethane, 1,1,2,2-	Organic Halogenated aliphatic compounds Chlorinated ethanes	79-34-6	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Tetrachloroethene, 1,1,2,2- (PCE, Tetrachloroethylene)	Organic Halogenated aliphatic compounds Chlorinated ethenes	127-18-4	VOC	110 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Tetrachloromethane (Carbon tetrachloride)	Organic Halogenated aliphatic compounds Halogenated methanes	56-23-5	VOC	5 CCME 0.56* 0.2 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Thiophene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	110-02-1	VOC	N/V	N/A	0.1	0.05
Toluene	Organic Monocyclic aromatic compounds	108-88-3	VOC	2 CCME 0.8 OMOECC	0.5	0.08 CCME 0.2 OMOECC	0.05
Trichlorobenzene, 1,2,3-	Organic Monocyclic aromatic compounds Chlorinated benzenes	87-61-6	ABN or VOC	8	1	0.05	0.05
Trichlorobenzene, 1,2,4-	Organic Monocyclic aromatic compounds Chlorinated benzenes	120-82-1	ABN or VOC	5.4 CCME 0.5 OMOECC	1	0.05	0.05
Trichlorobenzene, 1,3,5-	Organic Monocyclic aromatic compounds Chlorinated benzenes	108-70-3	ABN or VOC	N/V	N/A	0.05	0.05
Trichloroethane, 1,1,1-	Organic Halogenated aliphatic compounds Chlorinated ethanes	71-55-6	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Trichloroethane, 1,1,2-	Organic Halogenated aliphatic compounds Halogenated methanes	79-00-5	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Trichloroethene, 1,1,2- (TCE, Trichloroethylene)	Organic Halogenated aliphatic compounds Chlorinated ethenes	79-01-6	VOC	21 CCME 0.5 OMOECC	1	0.01 CCME 0.05 OMOECC	0.01
Trichlorofluoromethane	Organic Volatile Organic Compounds	75-69-4	VOC	150 OMOECC	1	0.05 OMOECC	0.05
Vinyl chloride	Organic Volatile Organic Compounds	75-01-4	VOC	0.5 OMOECC	0.5	0.02 OMOECC	0.02
Xylenes	Organic Monocyclic aromatic compounds	1330-20-7	VOC	30 CCME 72 OMOECC	5	2.4 CCME 0.05 OMOECC	0.1

Section 2.1.15 and 4.1.15 Volatile Organic Compounds II: Benzene, Ethylbenzene, Toluene, Xylenes (BTEX)

Benzene	Organic Monocyclic aromatic compounds	71-43-2	VOC	110 CCME 88* 0.5 OMOECC	5	0.0068 CCME 0.02 OMOECC	0.005
Ethylbenzene	Organic Monocyclic aromatic compounds	100-41-4	VOC	2.4 CCME 0.5 OMOECC	2	0.018 CCME 0.05 OMOECC	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Toluene	Organic Monocyclic aromatic compounds	108-88-3	VOC	2 CCME 0.8 OMOECC	0.5	0.08 CCME 0.2 OMOECC	0.05
Xylenes	Organic Monocyclic aromatic compounds	1330-20-7	VOC	30 CCME 72 OMOECC	5	2.4 CCME 0.05 OMOECC	0.1

Section 2.1.16 and 4.1.16 Organics Single Analysis Parameters
Section 2.1.16.1 and 4.1.16.1 Diisopropanolamine

Diisopropanolamine (DIPA)	Organic Other Organics SP	110-97-4	ORP	1600	10	180	20

Section 2.1.16 and 4.1.16 Organics Single Analysis Parameters
Section 2.1.16.2 and 4.1.16.2 Fraction of Organic Carbon (FOC)

Fraction Organic Carbon	**Organic Volatile Organic Compounds ORP**	N/A	ORP	N/V OMOECC	N/A	N/V OMOECC	N/A

Section 2.1.16 and 4.1.16 Organics Single Analysis Parameters
Section 2.1.16.3 and 4.1.16.3 Methyl Mercury

Methylmercury	Organic Other Organics SP	22967-92-6	ORP	0.004 CCME 0.12 OMOECC	0.0008	0.033 (tissue) CCME	0.006

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Section 2.1.16 and 4.1.16 Organics Single Analysis Parameters Section 2.1.16.4 and 4.1.16.4 Nonylphenol and its Ethoxylates							
Nonylphenol and its ethoxylates	Organic Nonylphenol and its ethoxylates	84852-15-3	ORP	0.7	0.1 NP 0.1 NPO group	1	0.1
Section 2.1.16 and 4.1.16 Organics Single Analysis Parameters Section 2.1.16.5 and 4.1.16.5 Sulfolane							
Sulfolane (Bondelane)	Organic Organic sulphur compound	126-33-0	ORP	500	100	0.8	0.2
Section 2.2 and 4.2 Inorganics Parameters Group Section 2.2.1 and 4.2.1 Metals							
Aluminium	**Inorganic Metals**	**7429-90-5**	**Metals**	**5**	**3**	**N/V**	
Antimony	**Inorganic Metals**	**7440-36-0**	**Metals**	**1.5 OMOECC**	**1**	**20 CCME 1 OMOECC**	**2**
Arsenic	**Inorganic Metals**	**7440-38-2**	**Metals**	**5 CCME 13 OMOECC**	**1**	**5.9 CCME 6 OMOECC**	**1**
Barium	**Inorganic Metals**	**7440-39-3**	**Metals**	**610 OMOECC**	**10**	**500 CCME 210 OMOECC**	**10**
Beryllium	**Inorganic Metals**	**7440-41-7**	**Metals**	**100 CCME 5.3* 0.5 OMOECC**	**1**	**4 CCME 2.5 OMOECC**	**0.8**

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Boron	**Inorganic Metals**	**7440-42-8**	**Metals**	**1500 CCME 500* 1700 OMOECC**	**50**	**36 OMOECC**	**5**
Cadmium	**Inorganic Metals**	**7440-43-9**	**Metals**	**0.017, 0.005 µg/L (10 mg/L hardness) CCME 0.5 OMOECC**	**0.01**	**0.6 CCME 0.6 OMOECC**	**0.1**
Calcium	**Inorganic Metals**	**7789-78-8**	**Metals**	**1 000 000**	**1000**	**N/V**	**N/A**
Chromium	**Inorganic Metals**	**7440-47-3**	**Metals**	**11 OMOECC**	**1**	**37.3 CCME 26 OMOECC**	**1**
Cobalt	**Inorganic Metals**	**7440-48-4**	**Metals**	**50 CCME 3.8 OMOECC**	**10**	**40 CCME 19 OMOECC**	**2**
Copper	**Inorganic Metals**	**7440-50-8**	**Metals**	**2 CCME 5 OMOECC**	**1**	**18.7 CCME 16 OMOECC**	**5**
Iron	**Inorganic Metals**	**7439-89-6**	**Metals**	**300**	**60**	**N/V**	**N/A**
Lead	**Inorganic Metals**	**7439-92-1**	**Metals**	**1 CCME 1.9 OMOECC**	**0.2**	**30.2 CCME 31 OMOECC**	**1**
Lithium	**Inorganic Metals**	**7439-93-2**	**Metals**	**2500**	**20**	**N/V**	**N/A**
Magnesium	**Inorganic Metals**	**7439-95-4**	**Metals**	**N/V**	**1000**	**N/V**	**N/A**
Manganese	**Inorganic Metals**	**7439-96-5**	**Metals**	**200**	**20**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Molybdenum	**Inorganic Metals**	**7439-98-7**	**Metals**	**73 CCME 23 OMOECC**	**1**	**5 CCME 2 OMOECC**	**1**
Nickel	**Inorganic Metals**	**7440-02-0**	**Metals**	**25 CCME 14 OMOECC**	**2**	**50 CCME 16 OMOECC**	**2**
Selenium	**Inorganic Metals**	**7782-49-2**	**Metals**	**1 CCME 5 OMOECC**	**0.5**	**1 CCME 1.2 OMOECC**	**1**
Silver	**Inorganic Metals**	**7440-22-4**	**Metals**	**0.1 CCME 0.3 OMOECC**	**0.1**	**20 CCME 0.5 OMOECC**	**1**
Sodium	**Inorganic Metals and ORP**	**7440-23-5**	**Metals**	**490000 OMOECC**	**500**	**N/V**	**N/A**
Thallium	**Inorganic Metals**	**7440-28-0**	**Metals**	**0.8 CCME 0.5 OMOECC**	**0.2**	**1 CCME 1 OMOECC**	**0.4**
Tin	**Inorganic Metals**	**7440-31-5**	**Metals**	**N/V**		**5**	**1**
Uranium	**Inorganic Metals**	**7440-61-1**	**Metals**	**10 CCME 8.9 OMOECC**	**1**	**23 CCME 1.9 OMOECC**	**1**
Vanadium	**Inorganic Metals**	**7440-62-2**	**Metals**	**100 CCME 3.9 OMOECC**	**1**	**130 CCME 86 OMOECC**	**5**
Zinc	**Inorganic Metals**	**7440-66-6**	**Metals**	**30 CCME 10* 160 OMOECC**	**5**	**123 CCME 120 OMOECC**	**10**

Section 2.2 and 4.2 Inorganics Parameters Group
Section 2.2.2 and 4.2.2 Inorganic Single Analysis Parameters (ORPs)

Ammonia (total)	**Inorganic Inorganic nitrogen compounds**	**N/A**	**ORP**	**21**	**10**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Ammonia (un-ionised)	**Inorganic Inorganic nitrogen compounds**	**7664-41-7**	**ORP**	**19**	**10**	**N/V**	**N/A**
Boron HWS	**Inorganic Metals**		**Metals**	**NA**		**2 CCME**	**0.4**
Chloride	**Inorganic Wet**	**16877-00-6**	**ORP**	**100 000 CCME 790 000 OMOECC**	**5000**	**N/V**	**N/A**
Chromium, trivalent (Cr(III))	**Inorganic Metals**	**16065-83-1**	**ORP Metals**	**4.9**	**2**	**N/V**	**N/A**
Chromium, hexavalent (Cr(VI))	**Inorganic Metals**	**18540-29-9**	**ORP**	**CCME 1 25 OMOECC**	**1**	**0.4 CCME 0.66 OMOECC**	**0.4**
Colour (true)	**Inorganic Wet Physical**	**N/A**	**ORP**	**Narrative**	**3000**	**N/V**	**N/A**
Conductivity	**Inorganic Wet Physical**	**N/A**	**ORP**	**N/V**	**5 µS/cm**	**2 dS/m CCME 0.47 dS/m OMOECC**	**0.1 dS/m**
Cyanide	**Inorganic Wet**	**57-12-5**	**ORP**	**5 (as free CN) CCME 1* 5 OMOECC**	**1**	**0.9 CCME 0.051 OMOECC**	**0.05**
Dissolved Gas Supersaturation	**Inorganic Physical**	**N/A**	**ORP**	**8 ΔP mm Hg**	**8 ΔP mm Hg**	**N/V**	**N/A**
Dissolved Oxygen (DO)	**Inorganic Physical**	**N/A**	**ORP**	**5500**	**2000**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Fluoride	**Inorganic Wet**	**N/A**	**ORP**	**120**	**50**	**200**	**10**
Mercury	**Inorganic Metals**	**7439-97-6**	**ORP**	**0.016 CCME 0.1 OMOECC**	**0.01**	**0.130 CCME 0.16 OMOECC**	**0.05**
Nitrate	**Inorganic Inorganic nitrogen compounds**	**84145-82-4 14797-55-8**	**ORP**	**13 000**	**20**	**N/V**	**1**
Nitrate + Nitrite	**Inorganic Inorganic nitrogen compounds**	**N/A**	**ORP**	**100 000**	**20**	**N/V**	**N/A**
Nitrite	**Inorganic Inorganic nitrogen compounds**	**14797-65-0**	**ORP**	**60 NO2-N**	**20**	**N/V**	**1**
Nitrogen (total)	**Inorganic Inorganic Nitrogen Compounds**	**7727-37-9**	**ORP**	**250 OMOECC**	**50**	**N/V**	**10**
Nutrients (TN & TP)	**Inorganic Wet**		**ORP**	**Guidance Framework*****	**TN 50 TP 10**	**N/V**	**N/A**
Particle Size	**Inorganic Physical**	**N/A**	**N/A**	**N/V**	**N/A**	**N/V**	**0.5%**
Phosphorus	**Inorganic Wet**	**N/A**	**ORP**	**Guidance Framework*****	**10**	**N/V**	**N/A**
pH	**Inorganic Acidity, alkalinity and pH**	**N/A**	**Wet**	**Freshwater: 6.5 to 9.0 Marine: 7.0 to 8.7 6.5 to 8.7***	**na**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Reactive Chlorine Species	**Inorganic** **Reactive chlorine compunds**	**N/A**	**ORP**	**0.5**	**3**‡	**N/V**	**N/A**
Salinity	**Inorganic** **Physical**	**N/A**	**ORP**	**36%**		**N/V**	**N/A**
Sodium adsorption ratio	**Inorganic**	**N/A**	**ORP**	**NA**		**5 CCME** **1 OMOECC**	**1**
Streambed substrate	**Inorganic** **Physical** **Turbidity, clarity and suspended solids** **Total particulate matter**	**N/A**	**ORP**	**10% < 2 mm, 19% < 3 mm, 25% < 6.35 mm**		**N/V**	**N/A**
Sulphate	**Inorganic** **Inorganic sulphur compounds**	**18785-72-3**	**ORP**	**1 000 000**	**5 mg/L**	**N/V**	**N/A**
Sulphur (elemental)	**Inorganic** **Inorganic sulphur compounds**	**7704-34-9**	**ORP**	**N/V**		**500**	**100**
Suspended sediments	**Inorganic** **Physical** **Turbidity, clarity and suspended solids** **Total particulate matter**	**N/A**	**ORP**	**5 mg/L over background**	**2 mg/L**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CAS RN	Parameter Group	Lowest Water Criterion (µg/L)	Recommended Maximum LRL – Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Turbidity	**Inorganic Physical Turbidity, clarity and suspended solids Total particulate matter**	**N/A**	**ORP**	**1 NTU**	**0.5 NTU**	**N/V**	**N/A**
Total dissolved solids (salinity)	**Inorganic Physical Turbidity, clarity and suspended solids**	**N/A**	**ORP**	**500 000**	**10 mg/L**	**N/V**	**N/A**

Section 2.3 and 4.3 Microbiology
Section 2.3.1 and 4.3.1 Coliforms

Coliforms, fecal (Escherichia coli)	**Inorganic Biological**	**N/A**	**Bacti**	**100 per 100 mL**	**< 1**	**N/V**	**N/A**
Coliforms, total	**Inorganic Biological**	**N/A**	**Bacti**	**1000 per 100 mL**	**< 1**	**N/V**	**N/A**

Section 2.3 and 4.3 Microbiology
Section 2.3.2 and 4.3.2 Cyanobacteria

Cyanobacteria (Blue-green algae)	**Inorganic Biological**	**N/A**	**Bacti**	**heavy growth, blue green algae**	**100**	**N/V**	**N/A**

CAS RN = Chemical Abstracts Service Registry Number

N/A = Not applicable or not available.

N/V = No value listed for standard.

ORP = other regulated parameters (listed in Section 2.1.16 or 2.2.2)

‡LRL is greater than the lowest criterion for that matrix.

†The larger result obtained for F4 and F4G is compared to the LRL.

*Lowest Criterion from Guidance Document on Federal Interim Water Quality Guidelines for Federal Contaminated Sites May 2010, Table 1

** Lowest Soil Criterion obtained from CCME Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil, Endorsed by CCME, April 30-May 1, 2001, Winnipeg. Table 1 Revised January 2008

*** CCME Summary Table http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html? and attached factsheet

5.2 Reporting Requirements

To ensure legally defensible data, the Certificate of Analysis provided by the laboratory must contain sufficient detail to ensure traceability to site and define the methods of conducting the analysis and abnormalities, if any.

Certificates of Analysis or analytical reports shall include at least the following:

▪ Submitted site and client information, including sample identifiers, location, *etc*.	
▪ Time Markers:	– Date and time sampled (for each sample) (if provided) – Date extracted or digested (for each sample/test) (if required) – Date analysed (for each sample/test) – Date reported – Comment that report supersedes previous reports when corrected reports are generated and differences identified
▪ Data Reportables:	– Temperature of samples upon receipt including whether the samples are frozen – Presence of custody seals and whether intact – Any other issues impacting sample integrity – Chain of custody for samples submitted to the laboratory or transhipped between laboratories
▪ QC Reportables:	In order that the QP can properly assess the quality of the analytical data, unless requested otherwise, all associated QC is reported as follows: – Laboratory duplicate analyses (including % recovery, relative percent difference (RPD) or absolute difference for each parameter) – Field/travel blank(s) (where applicable) – Method blank(s) – Laboratory control sample analyses – Matrix spike analyses (where applicable) (including % recovery) – Reference materials (where applicable) (including % recovery) – Surrogate recoveries (where applicable) (including % recovery) QC reportables must include flags of QC exceedances.

▪ Analysis Reportables:	– Analytical data · Recommended that data be reported in the same units as the regulation · Soil/sediment data is typically reported as dry weight, unless otherwise requested – Laboratory Reporting Limits (LRLs) – Units – Data qualifiers (interference, dry weight, etc) – If requested, the analytical uncertainty associated with each measurement – The title of the analytical method as described in the scope of accreditation including the reference method upon which the analytical method is based
▪ Remarks/Comments:	– Report any unusual behaviour noted in any step of the analytical process (such as sample inhomogeneity, headspace in a volatile organic compound (VOC) sample, *etc*.) – Any other regulatory required comments (e.g., CCME performance criteria compliance)
▪ Subcontract Analyses:	– Analysis conducted in third party laboratories, including sister laboratories, must be so indicated

5.3 Sample Dilution

When the concentration of one or more parameters in a multicomponent scan (or the single analyte in a one-component test) exceeds the concentration of the respective highest calibration standard or upper calibration range, sample dilution is required to more accurately quantify the parameter. When this is required, the reported detection limit (LRL) for each target analyte must be adjusted (increased) in direct proportion to the dilution factor (DF).

The dilution factor is determined as follows:

$$DF = \frac{Final\ Volume\ of\ Diluted\ Sample\ (mL)}{Sample\ Aliquot\ Volume\ (mL)}$$

LRL_d (the revised LRL for the diluted sample) is routinely determined as follows:

$$LRL_d = DF \times LRL$$

At minimum, the LRL_d must be no less than the dilution factor times the method detection limit (DF x MDL). Situations that require reporting LRL_d (as a result of dilution) may not satisfy LRL reporting limits. Such increases in LRL are acceptable, as long as all parameter results are at or below the applicable regulatory guideline. Each laboratory must fully document all sample dilutions and appropriately qualify the data.

Analytical note: When dilutions are required due to exceedance of calibration range, the post-dilution concentration of the highest reported parameter should be no less than 20% of the highest calibration standard in the method. This will avoid loss of precision and accuracy and unnecessarily high reporting limits for other parameters that did not require dilution.

In multicomponent analytical scans, it is also permissible to report results of the undiluted sample for analytes within the calibration range (if review shows the data to be valid).

5.3.1 Elevated Non-target Analyte or Matrix Interferences Resulting in LRLs above the Standard

Where matrix interferences or elevated target/non-target compounds are present, sample dilution is required. The dilution may result in some target analytes being reported with adjusted LRLs (as per the calculation in Section 5.3) above the pertinent CEQG.

In these cases results are reported as “less than (<)” with a raised LRL, corresponding to the level of interference, which may result in an LRL above the regulatory guideline.

In these cases, the QP must review the analytes where the LRLs exceed the regulatory guideline and establish whether the compounds are contaminants of concern. If they are contaminants of concern, consult with the laboratory. Additional effort or non-routine testing may be required to achieve the required LRLs. Note, however, that in cases involving very “dirty” samples it may not be possible to accurately quantify some analytes at the regulatory guideline.

6 REQUIRED QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

This section provides the method specific quality assurance and quality control (QA/QC) requirements with respect to the sample processing, analysis and reporting of analytical data.

6.1 Accreditation

CCME recommends the use of laboratories that are accredited for the required tests by an internationally recognised accreditation body [e.g., Standards Council of Canada (SCC), Canadian Association for Laboratory Accreditation (CALA), or Ministère du Développement durable, de l'Environnement, de la Faune et des Parcs (MDDEP)] in accordance with the International Standard ISO/IEC17025:2005 – *General Requirements for the Competence of Testing and Calibration Laboratories* (as amended from time to time). Consult with the appropriate jurisdiction for local regulatory requirements.

6.2 Initial Method Validation

All analytical methods providing data in support of the CEQG must be properly validated and proven fit for purpose. The validation data must be available for inspection on request.

In the event that the technique employed has been in place for a significant period of time, ongoing method performance data may be used to demonstrate the method is valid and fit for purpose. Method blanks, laboratory duplicate samples, laboratory control samples and matrix spikes must all meet the performance criteria outlined in Tables 6-1 to 6-16. A minimum of 30 data points for each measure is required. MDLs and uncertainty data must be available, current and fit-for-purpose. The MDLs as determined per Section 6.3 must be less than or equal to the LRLs in Table 5.1.

In addition, single-blind proficiency testing (PT) samples (if available) must demonstrate ongoing acceptable performance.

At a minimum, initial validation must include the items outlined in Section 6.2.1. Further guidance is provided in the "Ontario Ministry of the Environment Protocol for the Acceptance of Alternate Methods (PAAM) Version 1.4 January 2005".

6.2.1 Initial Demonstration of Acceptable Precision, Accuracy, Selectivity and Specificity

This section outlines recommended elements for initial method validations. Laboratories may use other validation procedures providing they can demonstrate to an equal or better standard that a method is fit for purpose in terms of MDL, precision, accuracy, and ruggedness.

For test methods that have been in place for a significant period of time, statistical evaluation of long-term quality control data is a better measure of test performance than Initial Method Validation (refer to Section 6.2).

Minimum elements of initial method validations for accuracy, precision, and ruggedness should include:

Water

A minimum of two sets of five aliquots of real or synthetic water (not containing the analytes of interest) are spiked with the analytes of interest in the routinely used sample containers. One set is spiked at approximately 5 to 10 times the LRL, the other set at or above midrange. The samples are carried through the entire analytical process. A minimum of two method blanks must also be carried through the entire process.

Soil and Sediment

A minimum of two different soil types should be analysed. If possible, one should be a clay matrix, the other an organic matrix (containing more than three percent total organic carbon (> 3% TOC)). Well-homogenised composite samples are prepared and a minimum of five aliquots of each soil type is spiked with all the analytes of interest at approximately 5 to 10 times the LRL and at or above the midrange (20 samples total). If suitable reference materials are available, they are generally preferred over spikes for validation purposes.. The samples are carried through the entire analytical process. A minimum of two method blanks must also be carried through the entire process.

Analysis and Acceptability Criteria

If possible, the analyses should be split between two or more analysts in order to demonstrate acceptable method ruggedness.

The RSD of the replicates and matrix spike recovery are calculated. (Conductivity and pH are exempt from requiring matrix spikes.) The RSD and recoveries (of each analyst if available) must meet the limits specified in Tables 6-1 to 6-16, as appropriate. If the native concentration of some analytes is greater than the matrix spike concentration for some parameters, the matrix spike limits do not apply. If certified reference materials (CRMs) are used, either the published CRM acceptance limits or the limits from Tables 6-1 to 6-16 should be met (around the certified values of the CRM), whichever is larger. In the case of empirical methods, the certified value of the CRM must be appropriate for the method in order to be applicable.

6.3 Initial Assessment of Method Detection Limits

Method detection limits (MDLs) must be determined for every regulated parameter analysed (except pH or other parameters where MDL may be irrelevant). If more than one instrument is used for a test, MDLs must be established for each instrument, or must be evaluated in a way that takes into account all instruments that are used for the test.

For routine test methods, MDLs are re-determined at a minimum every two years or whenever major changes are made to the method or instrument(s).

The MDL must be less than or equal to the laboratory reporting limit (LRL) for each parameter. In cases where multiple instruments are used to conduct an analysis, the LRL must be equal to or greater than the highest individual instrument.

The minimum standard for initial assessment of MDL is described below. Variants of this procedure have been widely used for many years in the environmental lab community. However, it is recognised that MDLs obtained from this protocol generally are lower than can be achieved on routine samples on a day-to-day basis, primarily because they do not account for positive bias

in Method Blanks or for day-to-day variation in performance of test methods and instruments, nor do they adequately address false negatives.

In 2007, the US EPA Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs produced a report containing a substantially different and more defensible approach to determining MDL and LOQ. See Appendix D of the reference report for the detailed protocol. It is expected that a new protocol based on this report will eventually supersede the current US EPA MDL protocols. Report link:

<http://water.epa.gov/scitech/methods/cwa/det/upload/final-report-200712.pdf>.

The key elements of this protocol are that a 99% confidence MDL is calculated based on standard deviation assessments derived from long term method blanks (e.g., over 12-24 months) and/or long term low level spikes (Laboratory Control Samples), rather than using single-batch MDL spike studies. Use of between run data provides a more realistic estimate of method detection capabilities under routine operating conditions.

The minimum standard for determination of the MDL is the procedure described below, as established by the Ontario Ministry of the Environment and Climate Change. Alternative MDL evaluation technologies, such as described above, will typically result in higher estimates of MDLs compared to this procedure.

1. Prepare a sample (usually reagent water or blank soil) fortified at a level 1–10 times the expected MDL for the analytes of interest. If the resultant calculated MDL is not within this range, the determination must be repeated until the calculated MDL concentration is 1–10 times the spike concentration.
2. Take a minimum of eight aliquots of the sample and process each through the entire analytical method. If a blank measurement is required to calculate the measured level of analyte, obtain a separate blank measurement for each sample aliquot analysed.
3. Calculate a result (x) for each sample or sample/blank pair.
4. Calculate the conventional standard deviation (S_1) of the replicate measurements as follows:

$$S_1 = \sqrt{\frac{\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2}{n-1}}$$

where: x_i = analytical results in the final method reporting units for the n replicate aliquots (i = 1 to n)

$\bar{x}$ = average of the "*n*" replicate measurements

Outliers identified using Grubbs test or Dixon's Q test (95% confidence level, 2 sided test) may be deleted, but a minimum of seven data points must remain.

An alternative is to use previously determined within-run replicate analysis data and calculate the standard deviation (S_2) of the replicate measurements as follows:

$$S_2 = \sqrt{\frac{\sum_{i=1}^{n}\left(x_1 - x_2\right)_i^2}{2n}}$$

where: x_1, x_2 = the two replicate results for each of the n replicate pairs (minimum n = 40)

5. Compute the MDL as follows:

$$MDL = t_{(n-1,\ \alpha=0.01)}S$$

where: $t_{(\ n-1,\ \alpha\ =\ 0.01\ )}$ = the Student's *t* distribution appropriate for a 99% confidence level given the degrees of freedom n−1

α = traditionally called the level of significance of the test and is considered to be a measure of the maximum probability of a Type I error for all distributions consistent with the null hypothesis.

S = standard deviation as determined above

Table of Student's t Values at the 99 Percent Confidence Level (1 sided test)

Number of Replicates	Degree of Freedom (n-1)	t (n-1)
7	6	3.143
8	7	2.998
9	8	2.896
10	9	2.821
11	10	2.764
16	15	2.602
21	20	2.528
26	25	2.485
31	30	2.457
∞	∞	2.326

6.3.1 Determination of MDL for Summed Parameters

For summed parameters such as total xylenes, the MDL is the square root of the sum of the squares of the individual component MDLs. For example, if the MDL for *o*-xylene is 0.02 and *m*/*p*-xylene is 0.03, the total xylenes MDL will be 0.04:

$$MDL_{total\ xylenes} = \sqrt{(MDL^2_{o-xylene}) + MDL^2_{m/p-xylene}} = \sqrt{0.0004 + 0.0009} = 0.04$$

The same principles apply to the determinations of LRLs for summed parameters (i.e., reported LRLs should be computed in this manner, especially where LRLs are increased due to dilutions or other issues).

6.3.2 Determination of MDL or LRL for Subtracted Parameters

Because of measurement uncertainty considerations, special circumstances for detection limit treatment apply when a parameter is determined by subtraction of one result from another. If parameter C_3 is defined as $C_1 - C_2$, the MDL and LRL for parameter C_1 are normally used for C_3.

However, when the magnitude of C_2 approaches C_1 (i.e., if C_2 is $\geq$ 1/3 of C_1), the uncertainty of C_3 increases significantly. When the uncertainty of a test result exceeds the magnitude of the result itself, the confidence of detection becomes uncertain. Therefore, in this circumstance, the detection limit should be increased to the value of the uncertainty of the subtracted parameter, as follows:

$$MDL \text{ or } LRL \text{ for } C_3 = \sqrt{[\,(U_{C1})^2 + (U_{C2})^2\,]}$$

where:

U_{C1} = The laboratory's 95% confidence Measurement Uncertainty (MU) estimate for C_1

U_{C2} = The laboratory's 95% confidence Measurement Uncertainty (MU) estimate for C_2.

6.3.3 Calculation of Toxic Equivalence MDL

The concentrations of the seventeen most toxic dioxin and furan isomers are used to calculate a toxic equivalence factor (TEF). The same principle described in 6.3.1 is used except the MDL is multiplied by the TEF then squared. The TEF MDL is the square root of the sum of squares of the individual MDLs times the TEF values. An example is given in the following table. This protocol is also used for calculation of MDL for other parameters determined by sum or difference (PCB or PAH toxic equivalence, THM, *etc*.)

Example: Calculation of Toxic Equivalence MDL

CONGENER	I-TEF*	MDL**	MDL x TEF	(MDL x TEF)
2378 TCDF	0.1	8.9	0.89	0.7921
12378PCDF	0.03	9.3	0.279	0.077841
23478PCDF	0.03	7.8	0.234	0.054756
123478 HxCDF	0.1	8.5	0.85	0.7225
123678 HxCDF	0.1	7.2	0.72	0.5184
234678 HxCDF	0.1	8.6	0.86	0.7396
123789 HxCDF	0.1	8.6	0.86	0.7396
1234678 HpCDF	0.01	12	0.12	0.0144
1234789 HpCDF	0.01	8.4	0.084	0.007056
OCDF	0.0003	15	0.0045	0.00002025
2378 TCDD	1	1.8	1.8	3.24
12378 PCDD	1	5.7	5.7	32.49
123478 HxCDD	0.1	3.7	0.37	0.1369
123678 HxCDD	0.1	6.2	0.62	0.3844
123789 HxCDD	0.1	23	2.3	5.29
1234678 HpCDD	0.01	9.5	0.095	0.009025
OCDD	0.0003	46	0.0138	0.00019044
			Sum of Squares	**45.22**
		MDL = Square Root of Sum of Squares		**6.72**

The MDL for each of the seventeen "toxic congeners" is determined from eight spiked samples. The standard deviation of the mean is multiplied by Student *t* value (3 if eight samples are analysed).

The MDL for each of the seventeen congeners is multiplied by its TEF to convert its value to equivalents of 2,3,7,8-TCDD.

These values are then squared and summed. The square root of the sum of squares is the MDL value for the 2,3,7,8-TCDD toxic equivalent quantity (TEQ).

* I-TEF = international toxic equivalent factor

** MDL = method detection limit for each individual congener

6.4 Measurement Uncertainty

Uncertainty of measurement must be estimated and documented. There are several guidelines for the estimation of measurement uncertainty including those published by OMOECC, the International Organization for Standardization (ISO) and EURACHEM/Cooperation on International Traceability in Analytical Chemistry (CITAC). Accreditation agencies such as CALA and SCC also have published policies on measurement uncertainty. All sources of uncertainty must be evaluated, but only those exceeding one-third the largest source need to be included in estimating combined uncertainty. If method performance data are used to estimate uncertainty, studies should be conducted such that the number and range of effects, concentrations and matrices are varied to ensure that the conditions encountered under normal use of the method are represented.

Uncertainty of measurement must be estimated for all analytes and expressed as expanded uncertainty (U) at 95% confidence (k=2).

Measurand: The specific quantity subject to measurement, such as the concentration of an analyte.

Uncertainty: A non-negative parameter associated with the result of a measurement that characterises the dispersion of the values that could reasonably be attributed to the measurand.

Uncertainty Component: Uncertainty of a result may rise from many possible sources. Each of the separate contributions to uncertainty is referred to as an uncertainty component.

Standard Uncertainty: Uncertainty components are evaluated by the appropriate method and each is expressed as a standard deviation and is referred to as a standard uncertainty.

Combined Standard Uncertainty: Standard uncertainty components are combined to produce an overall value of uncertainty known as the combined standard uncertainty. It is an estimated standard deviation equal to the positive square root of the sum of variances of all uncertainty components.

$$\mu_c = \sqrt{\sum \mu_i^2}$$

where: μ_c = combined uncertainty of the result

μ_i = uncertainty of the individual component

Expanded Uncertainty: Expanded uncertainty (U) is obtained by multiplying the combined standard uncertainty by a coverage factor "**k**" to provide an interval within which the value of the measurand is believe to lie, with a specified level of confidence (e.g., 95%).

$$U = \mu_c \times k$$

where: μ_c = combined uncertainty of the result

k = 2 (for 95% confidence level)

6.5 Periodic Re-evaluation of Performance

The performance of all routine and accredited test methods should be re-evaluated at least every two years, or whenever significant changes are made to test methods or instruments. Re-validation should include, at minimum, a re-evaluation of MDLs, and a re-evaluation of precision, accuracy, and ruggedness, to ensure currency of data regarding test method uncertainty.

The preferred procedure for re-validation of unchanged test methods is to statistically evaluate all QC data generated by a test method over a recent period (e.g., from within 6 months to 2 years). If it is impractical to review all QC data over the evaluation period, a minimum of 30 recent data points should be assessed.

MDLs may be determined using long term method blank data and/or long term low level LCS data, as appropriate, or may be re-estimated using the approach outlined in Section 6.3. If the approach described in Section 6.3 is used, recent method blank data should still be assessed to ensure that false positive results are not occurring at more than the expected rate.

Statistical evaluations of method blanks, laboratory duplicate samples, laboratory control samples and matrix spikes must demonstrate that the laboratory's test method meets the performance criteria outlined in Tables 6-1 to 6-16.

6.6 Quality Control Samples

The laboratory quality control (QC) samples routinely analysed are method blanks, laboratory control samples, laboratory duplicate samples and matrix spikes. In addition, surrogates standards are employed for organic analysis. The acceptance limits for these QC samples are the metrics by which the quality of the associated laboratory data is demonstrated. The duplicate, matrix spike and surrogate criteria in the following tables are achievable for most homogeneous environmental samples. They may not be achievable for non-homogenous samples or very complex matrices.

Note: All applicable QC samples as tabulated below must be analysed *when sufficient sample is available.* Tests for water-insoluble extractable organics in water require multiple containers and the containers cannot be subsampled. The QP is responsible for the submission of multiple samples. If multiple containers are not submitted matrix spike and laboratory duplicate sample QCs cannot be provided.

Laboratory QC may be supplemented by various field QC samples such as blind field duplicates, field blanks, equipment rinsate blanks and field or trip spikes. In general, acceptance limits for field QC are broader than laboratory QC, typically, 1.5 to 2 times the laboratory QC limits

As well as these QC samples, there are additional data quality related requirements associated with all analytical methods, such as number of calibration standards, calibration curve frequency and acceptance criteria, continuing calibration verification (CCV) frequency and acceptance criteria, and gas chromatography-mass spectrometry (GC-MS) tuning criteria. The acceptance criteria specified in the reference method for these elements should be met. If there are deviations from the reference, they must be documented and valid reasons given.

Trip (aka Travel) Blank: is a sample of methanol preservative, reagent water, or blank soil, transported unopened to and from the sampling location and carried through the entire sampling and analytical process, including all sample preparation steps. It is recommended that a Trip Blank be submitted with each batch of pre-weighed methanol or bisulphate vials to verify that no VOCs were introduced during the the vial preparation process, in the preservatives put in the vials, or in the sample transportation process, as applicable. It will also ensure that the vials did not arrive from the supplier already contaminated with VOCs.

M**ethod Blank:** is a sample of reagent water or blank soil (if available free of analytes of interest) carried through the entire analytical process, including all sample preparation steps.

L**aboratory Control Sample (LCS):** is a sample of reagent water or blank soil spiked with the analytes of interest and carried through the entire analytical process including all sample preparation steps. In general, the LCS will be a second source standard and should have a concentration near the midpoint of the calibration range.

$$LCS\ Recovery\ (\%) = \frac{(measured\ concentration)}{(design\ concentration)} \times 100\%$$

Matrix Spike: is a second aliquot of a soil or water sample spiked, usually about mid range, with all analytes determined in the analysis or, where applicable, with representative analytes, and carried through the entire analytical process including all sample preparation steps. Note that for soil tests where the extraction is not intended to recover all the native analyte (chloride, cyanide, HWS boron), the spike is added post extraction. In general, the matrix spike will be a second source standard and have a concentration near the midpoint of the calibration range. Reference materials may be used in place of matrix spikes where appropriate provided the matrix is similar to the samples and the reference material contains all analytes in the test.

$$\textit{Matrix Spike Recovery (\%)} = \frac{\textit{([sample spike] – [unspiked sample])}}{\textit{([spike])}} \times 100\%$$

Because matrix spikes are also affected by sample heterogeneity, the issues discussed in laboratory duplicate samples below may apply.

Laboratory Duplicate Sample: is a second aliquot of a soil or water sample taken from the same sample container as the original sample and carried through the entire analytical process, including all sample preparation steps. Note that since most water sample tests for extractable organic analytes consume the entire sample, duplicates for extractable organic analytes are actually field duplicates and can only be analysed if sufficient additional sample bottles are provided to the lab.

$$\textit{Duplicate RPD (\%)} = \frac{\textit{([sample] - [sample duplicate])}}{\textit{([sample] + [sample duplicate])/2}} \times 100\%$$

For organic analyses, soils are analysed as received. As such, duplicates are primarily a measure of sample homogeneity. If samples are visibly non-homogeneous, and acceptance criteria are exceeded, repeat analysis is not necessarily required. Data are reported flagged as “exceedance due to sample heterogeneity”.

For water samples requiring organics analysis, the criteria in the following tables are routinely achievable for homogeneous samples. Since water analyses for water-insoluble extractable organics are “whole bottle” tests, laboratory duplicate samples are essentially field duplicates, subject to sampling as well as analytical variability. No action is required if criteria in the following tables are not met. Data may be reported flagged as “field duplicate”.

For most inorganic tests, both soil and water samples are homogenised and duplicate subsamples taken from the original container and processed, so the above stipulations do not apply.

Surrogates: are used for organic tests. All samples are spiked with compounds (usually deuterated analogues) representative of the analytes being determined but not found in environmental samples. The surrogates are spiked into the sample prior to any sample preparation steps and carried through the entire analytical process.

$$\textit{Surrogate Recovery (\%)} = \frac{\textit{(measured concentration)}}{\textit{(theoretical concentration)}} \times 100\%$$

Internal Standards: are used for many organic tests (e.g., ABNs, VOCs). A known amount of compound(s) (not present in the samples, but closely matching the chemical behaviour of the compound(s) of interest) is added to every sample (including all QC samples) prior to analysis to quantitate by comparing the response ratio of the test parameter ion relative to an internal standard.

Continuing Calibration Verification (CCV): CCVs are analyzed at the beginning of a sequence whenever an initial calibration is not performed. It is also recommended that a CCV be analyzed every 20 samples and at the end of the analytical sequence (bracketing CCV), especially for methods where the external standard calibration technique is used.

The CCV is evaluated to determine whether the instrument was within acceptable calibration throughout period in which samples were analysed (i.e., to verify that the initial calibration was applicable during the sample analyses). In general, failure of the CCV indicates that the initial calibration is no longer valid and should trigger recalibration and the reanalysis of the associated samples in the analytical sequence.

Acceptance Limits and Qualifiers: The pre-established ranges of acceptability tabulated below are in accord with the reference methods outlined in Section 3 of this document.

Multi-element Scan Qualifiers: As the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multi-element scans, for the LCS and matrix spike, up to 10% of the analytes (rounded down) may exceed the quoted limits by up to 10% absolute and the spike may be considered acceptable. For example, in a polycyclic aromatic hydrocarbon (PAH) scan of seventeen analytes with matrix spike acceptance limits of 50–140%, 10% or one analyte may have a recovery outside of 50–140% by 10% absolute, i.e., a recovery of 40–150%. Recurring non-random issues with specific parameters must be addressed, and will be highlighted by ongoing re-validation assessments.

Duplicate Qualifiers: For duplicates, as the measured result approaches the LRL, the uncertainty associated with the RPD increases dramatically. To account for this, duplicate acceptance criteria are either the tabulated RPD acceptance limits or within 2 x LRL (for low level data). For example, if the LRL is 10, duplicates of 15 and 30 would be acceptable (difference of 15, acceptance 2 x LRL = 20). Note the duplicate RPD in this example is 67%.

Matrix Spike Qualifiers: For matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. (It is not possible to accurately quantitate a small difference between two large numbers). Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

Calculated Parameters: For calculated parameters, acceptance limits should reflect the uncertainty (μ_i) in each measurement (see Section 6.3.2). This is especially important for parameters calculated by difference such as $F1_{-\mathrm{BTEX}}$.

For example, in a sample with a summed BTEX concentration of 10 mg/L and an F1 concentration of 11 mg/L, each with an μ_i of 20% or about 2 mg/L, the μ_i of the $F1_{-BTEX}$ reported result is 1 mg/L ± 2.8, a component uncertainty of 280%:

$$\mu_{F1_{-BTEX}} = \sqrt{\left(2^2 + 2^2\right)} = 2.8 = 280\%.$$

In this example, the detection limit for the reported $F1_{-BTEX}$ result should be raised to 2.8 mg/L (as described in Section 6.3.2) since the subtracted result of 1 mg/L is highly uncertain. Furthermore, in this example the routine QC acceptance limits for BTEX and F1 obviously cannot apply to $F1_{-BTEX}$. For additive parameters, the impact is much less. Thus, for parameters calculated by subtraction, QC acceptance limits are only applied to the individual components.

Table 6-1: Performance Criteria – Acid/Base Neutral Extractable Organic Compounds (ABNs), Chlorophenols (CPs), Perfluorooctanesulphonate (PFOS), Polycyclic Aromatic Hydrocarbons (PAHs)

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method Blank	Laboratory contamination evaluation	• Extracted with every batch or every 20 samples, whichever is more frequent • Matrix-specific (e.g., water, soil) • Target analytes should be less than the reporting limit (LRL)	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples, whichever is more frequent • Separate-source standard • LCS percent recovery should be between 50–140% for all compounds except 30–130% for difficult compounds such as 3,3-dichlorobenzidene, 2,4-dimethylphenol, DNP	**YES:** Re-extract/re-analyse all associated samples, if possible. If not, report the data flagged for all failing analytes.
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Extracted with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 50–140% for all compounds except 30–130% for difficult compounds such as 3,3-dichlorobenzidene, 2,4-dimethylphenol, DNP	**YES**: If recovery is outside of specified limits, repeat if necessary. See 6.6 Matrix Spike. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤30% for waters and ≤ 50% for solids.	**YES**: If RPD is within method specifications – no action required. If RPD fails, repeat analysis may be required for soils, no action required for waters, see 6.6 Laboratory Duplicate Samples
Surrogates	Accuracy in sample matrix	• Surrogates should represent analytes of interest and be representative of compound class of target analytes (e.g., use deuterated PAH if analysing for PAHs, use phenolic surrogates if analysing for pentachlorophenol) • Percent recoveries in soil and water should be between 50–140% for all compounds. Surrogates are optional for isotope dilution methods	**YES**: If recovery is outside of specified limits laboratory must report recovery and qualify the result
Internal Standards (IS)	Laboratory accuracy, method accuracy in sample matrix	• Minimum of 3 at retention times across GC run • Area counts in samples must be between 50–200% of the area counts in associated continuing calibration standard (CCV) (Section 5.10 of SW 846 Method 8270D). Retention times of internal standards should be within ± 6 seconds of retention times in the associated CCV	**NO:** If one or more internal standards are outside limits, reanalyse sample unless obvious interference present

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Quantitation	N/A	• Quantitation must be based on IS calibration • Laboratory must use the average response factor or regression curve generated from the associated initial calibration for quantitation of each analyte • For GC-MS methods at least 1 qualifier ion (recommend 2) must be used and meet ratio requirements. See SW-846 for guidance. At low concentrations ratios may be expanded but the qualifier(s) must be present for positive identification	**NO**

Table 6-2: Performance Criteria – 1,4-Dioxane

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method Blanks	Laboratory contamination evaluation	• Prepared with every batch or every 20 samples, whichever is more frequent • Matrix-specific (e.g., water, soil) • Target analytes should be less than the reporting limit (LRL)	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard • LCS percent recovery should be between 70–130% waters 60-140% soils	**YES:** Re-prepare/reanalyse all associated samples, if possible. If not, report the data flagged for all failing analytes
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Extracted with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 50–140% soil and water	**YES:** If recovery is outside of specified limits, repeat if necessary. See 6.6 Matrix Spike. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤30% for waters and ≤50% for solids	**YES**: If RPD is within method specifications – no action required. If RPD fails, repeat analysis may be required for soils, no action required for waters, see 6.6 Laboratory Duplicate Samples
Surrogates	Accuracy in sample matrix	• Surrogates should represent analytes of interest and be representative of compound class of target analytes • Percent recoveries in soil should be between 50–140%, soil and water. Surrogates are optional for isotope dilution methods.	**YES:** If recovery is outside of specified limits laboratory must report recovery and qualify the result
Quantitation	N/A	• Laboratory must use the average response factor or regression curve generated from the associated initial calibration for quantitation of each analyte • At least 1 qualifier ion must be used and meet ratio requirements. See SW-846 for guidance. At low concentrations ratios may be expanded but the qualifier must be present for positive identification	**NO**

Table 6-3: Performance Criteria – Diisopropanolamine; Glycols; Nonylphenol and its Ethoxylates; Organochlorine (OC) Pesticides; Organotin Compounds; Pesticides and Herbicides – Carbamates, Glyphosate, Phenoxy Herbicides; Polychlorinated Biphenyls; Sulfolane

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method Blanks	Laboratory contamination evaluation	• Extracted with every batch or every 20 samples, whichever is more frequent • Matrix-specific (e.g., water, soil) • Target analytes should be less than the reporting limit (LRL)	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard • LCS percent recovery should be between 50–140% for soil and water	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged for all failing analytes
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Extracted with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 50–140% for soil and water	**YES:** If recovery is outside of specified limits, repeat if necessary. See 6.6 Matrix Spike. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤30% for waters and ≤50% for solids	**YES**: If RPD is within method specifications – no action required. If RPD fails, repeat analysis may be required for soils, no action required for waters, see 6.6 Laboratory Duplicate Samples
Surrogates	Accuracy in sample matrix	• Surrogates should represent analytes of interest and be representative of compound class of target analytes • Percent recoveries should be between 50–140% for soil and water	**YES:** If recovery is outside of specified limits laboratory must report recovery and qualify the result

Table 6-4: Performance Criteria – Petroleum Hydrocarbons – F1-F4 (PHCs)

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method Blanks	Laboratory contamination evaluation	• Extracted with every batch or every 20 samples, whichever is more frequent • Matrix-specific (e.g., water, soil) • Target analytes should be less than the reporting limit (LRL)	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Certified standard prepared from gasoline or diesel/motor oil as appropriate. • LCS percent recovery should be 60-140% for soil and water	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged for all failing analytes
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Extracted with every batch or every 20 samples, whichever is more frequent • Certified standard prepared from gasoline or diesel/motor oil as appropriate. • Percent recoveries should be between 60–140% for soil and water	**YES:**:If recovery is outside of specified limits, repeat if necessary. See 6.6 Matrix Spike. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤30% for waters and ≤30% for solids (based on analysis of 2 methanol aliquots from a single field preserved sample). ≤ 40% for solids if separate soil aliquots are analyzed	**YES**: If RPD is within method specifications – no action required. If RPD fails, repeat analysis may be required for soils, no action required for waters, see 6.6 Laboratory Duplicate Samples
Surrogates	Accuracy in sample matrix	• Surrogates should represent analytes of interest and be representative of compound class of target analytes • Percent recoveries should be between 60–140% for soil and water	**YES:** If recovery is outside of specified limits laboratory must report recovery and qualify the result

Table 6-5: Performance Criteria – Polychlorinated Dibenzo-p-Dioxins/Dibenzofurans

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method Blanks	Laboratory contamination evaluation	• Extracted with every batch or every 20 samples, whichever is more frequent • Matrix-specific (e.g., water, soil) • Target analytes should be less than the reporting limit (LRL)	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard • LCS percent recovery should be between 70–140% or as per US EPA Method1613B for soil and water	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged for all failing analytes
Matrix Spike (or Reference Material as per Section 6.3) (optional)	Laboratory method accuracy with matrix effects, sample homogeneity	• Extracted with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 50–150% for soil and water	**YES:** If recovery is outside of specified limits, repeat if necessary. See 6.6 Matrix Spike. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤30% for waters and ≤40% for solids	**YES**: If RPD is within method specifications – no action required. If RPD fails, repeat analysis may be required for soils, no action required for waters, see 6.6 Laboratory Duplicate Samples
Labelled Standard Recovery	Accuracy in sample matrix	• Surrogates should represent analytes of interest and be representative of compound class of target analytes • Percent recoveries should be as per US EPA Method 1613B for soil and water	**YES:** If recovery is outside of specified limits laboratory must report recovery and qualify the result

Table 6-6: Performance Criteria – Volatile Organic Compounds (VOCs), Trihalomethanes (THMs), BTEX

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Field and Travel Blanks	Methanol vial integrity and contamination evaluation	• Prepared with every batch of preweighed methanol vials. • Travel blank is reweighed at the lab and compared to tarred weight to determine any loss of methanol. Field Blank is analyzed. • Target analytes should be less than the reporting limit (LRL). Note: acetone, methylene chloride, toluene and hexane are common laboratory artifacts. If any are > LRL the laboratory must comment on the impact on data quality.	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Method Blanks	Laboratory contamination evaluation	• Prepared with every batch or every 20 samples, whichever is more frequent • Matrix-specific (e.g., water, soil) • Target analytes should be less than the reporting limit (LRL). Note: acetone, methylene chloride, toluene and hexane are common laboratory artifacts. If any are > LRL the laboratory must comment on the impact on data quality.	**YES:** If an analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard • LCS percent recovery should be between 50–140% for compounds that are gaseous at 20°C* and ketones, 60–130% for all others, soil and water	**YES:** Re-prepare/reanalyse all associated samples, if possible. If not, report the data flagged for all failing analytes
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Extracted with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 50–140% soil and water	**YES:** If recovery is outside of specified limits, repeat if necessary. See 6.6 Matrix Spike. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤30% for waters and ≤50% for solids. RPD should be ≤ 50% for compounds that are gaseous at 20°C*.	**YES:** If RPD is within method specifications – no action required. If RPD fails, repeat analysis may be required, see 6.6 Laboratory Duplicate Samples
Surrogates	Accuracy in sample matrix	• Surrogates should represent analytes of interest and be representative of compound class of target analytes • Percent recoveries in soil should be between 50–140%, soil and water	**YES:** If recovery is outside of specified limits laboratory must report recovery and qualify the result
Internal Standards (IS)	Laboratory analytical accuracy and method accuracy in sample matrix	• Minimum of 2, 3 recommended, at retention times across GC run if the full VOC lists is being run. Only 1 IS required for the BTEX subset. • Area counts in samples should be between 50–200% of the area counts in associated continuing calibration standard (Section 5.10 SW 846 Method 8260B) • Retention times of internal standards should be within ± 6 seconds of retention times in associated continuing calibration standard	**NO:** If one or more internal standards are outside limits, reanalyse sample unless obvious interference present

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Quantitation	N/A	• Quantitation must be based on IS calibration • Laboratory must use the average response factor or regression curve generated from the associated initial calibration for quantitation of each analyte • At least 1 qualifier ion (recommend 2) must be used and meet ratio requirements. See SW-846 for guidance. At low concentrations ratios may be expanded but the qualifier must be present for positive identification	**NO**
* dichlorodifluoromethane, monochloromethane, vinyl chloride, monobromomethane, monochloroethane			

Table 6-7: Performance Criteria – Fraction Organic Carbon (FOC)

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Should be matrix-matched (same concentration of reagents as calibration and QC standards) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard (soil or water) • LCS percent recovery should be between 70–130%	**YES:** Re-prepare/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Analysed with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 70–130% in soil and water	**YES:** If recovery is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result.
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 20% for water and ≤ 35% for soils	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

Table 6-8: Performance Criteria – Methyl Mercury

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Should be matrix-matched (same concentration of reagents as calibration and QC standards) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard (soil or water) • LCS percent recovery should be between 70–130% for soil, water and tissue	**YES:** Re-prepare/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Analysed with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 60–140% soil and water	**YES:** If recovery is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 30% for water and ≤ 40% for soils and tissues	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

Table 6-9: Performance Criteria – Ammonia (Total and Un-ionised); Chromium, Hexavalent Cr(VI); Cyanide (CN^-)

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Should be matrix-matched (same concentration of reagents as calibration and QC standards) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard (soil or water) • LCS percent recovery should be between 80–120%.	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike* (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Analysed with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 70–130% soil and water.	**YES:** If recovery is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 20% for water and ≤ 35% for soils.	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

*Matrix spikes for hexavalent chromium and cyanide are spiked post-extraction. Hexavalent chromium can react with the soil matrix and free cyanide will complex with soil iron, both producing anomalously low recoveries.

Table 6-10: Performance Criteria – Boron, Hot Water Soluble (HWS); Chloride; Fluoride; Mercury; Metals; Nitrate; Nitrate + Nitrite; Nitrite; Nutrients (TN & TP); Phosphorus; Sulphate

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Should be matrix-matched (same concentration of reagents as calibration and QC standards) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard (soil or water), spiked post extraction for HWSB and chloride in soil • LCS percent recovery should be between 80–120%. HWBS 70–130%	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Analysed with every batch or every 20 samples, whichever is more frequent • Separate or same source standard, spiked post extraction for soil parameters prepared by aqueous or weak acid / base leach • Percent recoveries should be between 70–130% soil and water. HWSB 60–140% (soil)	**YES:** If recovery is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 20% for water and ≤ 30% for soils. ≤ 40% for HWSB, Ag, Al, Ba, Hg, K, Mo, Na, Pb, Sn, Sr, Ti soil.	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

Table 6-11: Performance Criteria – Dissolved Oxygen (DO)

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank*	Laboratory contamination evaluation	• Every instrument calibration • Residual should be less than LRL	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	N/A	N/A
Matrix Spike	Laboratory method accuracy with matrix effects, sample homogeneity	N/A	N/A
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 20% for water.	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
*Zero DO sample. (Add excess sodium sulphite, Na_2SO_3, and a trace of cobalt chloride, $CoCl_2$, to bring DO to zero.)			

Table 6-12: Performance Criteria –Conductivity (EC), Salinity

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard (soil or water) • LCS percent recovery should be between 90–110% for water and 80-120% for soil.	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike	Laboratory method accuracy with matrix effects, sample homogeneity	N/A	N/A
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 10% for water and < 20% for soil.	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

Table 6-13: Performance Criteria – pH

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	N/A	N/A
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard (soil or water) • Second source buffer accuracy should be ± 0.2 pH units for soil and water	**YES:** reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Reference materials (in-house or otherwise) are recommended for soils • Target should be ± 0.3 pH units of certified target or long-term average	N/A
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • Within 0.3 pH units for soil and water	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

Table 6-14: Performance Criteria –Colour (True); Reactive Chlorine Species*; Suspended Sediments (Total Suspended Solids); Turbidity; Total Dissolved Solids

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Should be matrix-matched (same concentration of reagents as calibration and QC standards) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard • LCS percent recovery should be between 80–120%	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike	Laboratory method accuracy with matrix effects, sample homogeneity	• NA	**YES:** If recovery is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 20% for water	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

*LCS does not apply to Reactive Chlorine Species

Table 6-15: Performance Criteria – Sulphur (elemental)

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Preparation) Blank	Laboratory contamination evaluation	• Every batch or every 20 samples whichever is more frequent • Should be matrix-matched (same concentration of reagents as calibration and QC standards) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected (reinjection, reanalysis) the data are reported flagged
Laboratory Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch or every 20 samples whichever is more frequent • Separate-source standard • LCS percent recovery should be between 80–120%	**YES:** Re-extract/reanalyse all associated samples, if possible. If not, report the data flagged
Matrix Spike (or Reference Material as per Section 6.3)	Laboratory method accuracy with matrix effects, sample homogeneity	• Analysed with every batch or every 20 samples, whichever is more frequent • Separate or same source standard • Percent recoveries should be between 70–130%	**YES:** If recovery is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch or every 20 samples, whichever is more frequent • RPD should be ≤ 30% for soils	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result

Table 6-16: Performance Criteria – Coliforms Total, Coliforms Fecal (*Escherichia coli*)*

Required QA/QC Parameter	Data Quality Objective	Required Performance Standard	Included in Analytical Report/Certificate of Analysis
Method (Negative Control)	Laboratory contamination evaluation	• Every batch • Should be matrix-matched (same reagents as samples and controls) and prepared with samples in batch • Target analytes should be less than the reporting limit (LRL)	**YES:** If the analyte fails, corrective action is required. If it cannot be corrected, (reanalysis), the data are reported flagged
Positive Control Sample (LCS)	Laboratory method accuracy without matrix effects	• Every batch • Separate-source standard • Positive control should be within established limits	**YES:** Re-analyse all associated samples, if possible. If not, report the data flagged
Matrix Spike	Laboratory method accuracy with matrix effects, sample homogeneity	• NA	N/A
Laboratory Duplicate Sample	Sample homogeneity, laboratory method precision	• Analysed with every batch. • Range (difference) of logarithm of counts should be ≤ 3.27 x average range as determined experimentally for the matrix.	**YES:** If RPD is outside of specified limits, repeat if possible. If not or if the repeat also fails report recovery and qualify the result
Counting Variability	Analyst Precision	• Minimum monthly analyst(s) count the same plates several times • RPD should be ≤ 5% for a single analyst, 10% between analysts	**No:** If outside specifications, additional training required.

* There are several other checks and controls on media and laboratory conditions. For details, see SM 22, 9020.

7 REFERENCES

American Society for Testing and Materials (ASTM). 2010. Annual Book of ASTM Standards.

American Society for Testing and Materials (ASTM). 2010. Method D6418 – 09: Standard Practice for Using the Disposable EnCore Sampler for Sampling and Storing Soil for Volatile Organic Analysis. Annual Book of ASTM Standards Volume 11.04.

CALA Laboratory Accreditation. 2010. P19 CALA Measurement Uncertainty Policy, Revision 1.10, May 2010 <http://www.cala.ca/P19_CALA_Unce_Pol.pdf>.

Canadian Council of Ministers of the Environment (CCME) 1999. Canadian Environmental Qualtiy Guidelines, Winnipeg. http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html

Canadian Council of Ministers of the Environment (CCME). 2001. Reference Method for the Canada-Wide Standards for Petroleum Hydrocarbons (CWS-PHC) in Soil – Tier 1 Method. Endorsed by CCME, April 30-May 1, 2001, Winnipeg, http://www.ccme.ca/en/resources/contaminated_site_management/phc_cws_in_soil.html

Canadian Council of Ministers of the Environment (CCME). 2010. Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health. Polycyclic Aromatic Hydrocarbons (PAHs). Canadian Environment Quality Guidelines factsheet 2008. Revised 2010. Excerpt from Publication No. 1299, ISBN 1-896997-34-1. http://ceqg-rcqe.ccme.ca/download/en/320.

Canadian Council of Ministers of the Environment (CCME). 2002. Canadian Water Quality Guidelines for the Protection of Aquatic Life. Nonylphenol and its Ethoxylates. factsheet http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html?

Carter, M.R. and E.G. Gregorich, Editors. 2008. Soil Sampling and Methods of Analysis, Canadian Society of Soil Science. 2nd Edition.

Chorus, I and J. Bartram, Editors. 1999. Toxic Cyanobacteria in Water: A guide to their public health consequences, monitoring and management. © 1999 WHO. E & FN Spon, an imprint of Routledge.

Duinker, J.C., D.E. Schulz, and G. Petrick. 1991. Analysis and interpretation of chlorobiphenyls: Possibilities and problems. Chemosphere 23:1009–1028.

Dux, James P. 1986. Handbook of Quality Assurance for the Analytical Chemistry Laboratory. Van Nostrand Reinhold Company Inc.

Environment Canada. 2007. Guide for Reporting to the National Pollutant Release Inventory, Appendix 6 Dioxin and Furan Toxic Equivalents NATO/CCMS, 1998 < http://www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=28C24172->

EURACHEM/Cooperation on International Traceability in Analytical Chemistry (CITAC). 2000. Quantifying Uncertainty in Analytical Measurement. 2nd Ed.

Federal Advisory Committee on Detection and Quantitation Approaches and Uses in Clean Water Act Programs. 2007. Final Report 12/28/07, Report of the Federal Advisory Committee,on Detection and Quantitation Approaches and Uses in Clean Water Act Programs, Submitted to the US Environmental Protection Agency December 2007. http://water.epa.gov/scitech/methods/cwa/det/upload/final-report-200712.pdf

Gupta, UC. 1967. A simplified method for determining hot water soluble boron in podzol soils. Soil Science 103: 424-428.

Hach Company. 2012. Method 8025. Color, True and Apparent, Low Range. DOC316.53.01252.

Hach Company. 2002. Method 7019, Harp, J.D. Current Technology of Chlorine Analysis for Water and Wastewater. Technical Information Series, Booklet No. 17.

Health Canada. 2011. Supplemental Guidance on Human Health Risk Assessment for Country Foods (HHRA). Federal Contaminated Site Risk Assessment in Canada. Available at <www.healthcanada.gc.ca>.

Ikonomou MG, Fernandez MP, He T, Cullon D. 2002. Gas chromatography–high-resolution mass spectrometry based method for the simultaneous determination of nine organotin compounds in water, sediment and tissue. Journal of Chromatography A 975(2):319-333.

ISO/IEC 17025. 2005. General Requirements for the Competence of Testing and Calibration Laboratories. International Standard, 2nd Ed. 2005-05-15.

Joint Committee for Guides in Metrology (JCGM). 2008. International vocabulary of metrology – Basic and general concepts and associated terms (VIM). 3rd Edition. JCGM 200:2008 with minor corrections.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of HexavalentChromium, Cr(VI), by UV-Visible Spectrophotometry, in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of Chlorinated Herbicides by Gas Chromatography (GC) in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of Chlorinated Pesticides by Gas Chromatography (GC) in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of Polychlorinated Biphenyls (PCBs) by Gas Chromatography (GC) in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of Semivolatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of Total Cyanide and Physiologically Available Cyanide (PAC) in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

Massachusetts Department of Environmental Protection Bureau of Waste Site Cleanup. 2010. Quality Control Requirements and Performance Standards for the Analysis of Volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC/MS) in Support of Response Actions under the Massachusetts Contingency Plan (MCP). Revision No. 1. July 1, 2010.

McKeague, JA, Editor. 1976. Manual of Soil Sampling and Methods of Analysis. Soil Research Institute.

Meridian. 2011. Sampling and Laboratory Analysis of Country Food. Prepared under Contract No. 4500245190 for Health Canada. Contaminated Sites Division. Healthy Environments and Consumer Safety. March 2011.

Ontario Ministry of the Environment (MOE). 2009. Practices for the Collection and Handling of Drinking Water Samples. Version 2.0. April 1, 2009.

Ontario Ministry of the Environment (MOE). 2004. Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act. March 9, 2004.

Ontario Ministry of the Environment (MOE). Protocol for the Acceptance of Alternate Methods (PAAM). Version 1.4. January 2005.

Ontario Ministry of the Environment (MOE). 2010. Protocol of Accepted Drinking Water Testing Methods. Version 2.0. May 2010.

Ontario Ministry of the Environment (MOE). 2011. Protocol for Sampling and Analysis of Industrial/Municipal Waste Water. Version 2.0. January 2011.

Ontario Ministry of the Environment (MOE). Laboratory Services Branch. Quality Management Section. LaSB Procedures Manual. LSBSOP.030. Laboratory Services Branch (LaSB). .Guidelines for the Determination and Documentation of Uncertainty of Chemical Measurements.

Servos, M.R., R.J. Maguire, D.T. Bennie, H-B. Lee, P.M. Cureton, N. Davidson, R. Sutcliffe and D.F.K. Rawn. 2000. Canadian Environmental Protection Act. Priority Substances List. Supporting document for nonylphenol and its ethoxylates. Environment Canada, Toxics Pollution Prevention Directorate, Commercial Chemicals Evaluation Branch, Ottawa. Unpub. doc.

Sparks, D.L., Editor. 1996. Methods of Soil Analysis, Part 3. Chemical Methods. American Society of Agronomy - Soil Science Society of America.

Standards Council of Canada. 2011. Laboratory Accreditation Program (PALCAN), Policy on Calibration and Measurement Traceability. CAN-P-1626, 2011-11-29.

Standard Methods for the Examination of Water and Wastewater. 2012. Rice, E.W., Baird, R. B., Eaton, A.D., & Clesceri, L.S., eds. American Public Health Association, American Water Works Association, & Water Environment Federation.

Standard Methods for the Examination of Water and Wastewater. 2012. Rice, E.W., Baird, R. B., Eaton, A.D., & Clesceri, L.S., eds. American Public Health Association, American Water Works Association, & Water Environment Federation. Volatile Organic Compounds – Purge & trap Capillary-Column Gas Chromatographic/Mass Spectrometric Method.

United States Environmental Protection Agency (US EPA). 2007. Federal Register Part III. March 12, 2007. 40 CFR Part 122, 136, 141, 143, 430, 455, and 465 . Guidelines Establishing Test Procedures for the Analysis of Pollutants Under the Clean Water Act; National Primary Drinking Water Regulations; and National Secondary Drinking Water Regulations; Analysis and Sampling Procedures; Final Rule. Page 11218, 11236, 11239. <http://www.epa.gov/fedrgstr/EPA-WATER/2007/March/Day-12/w1073.htm>.

United States Environmental Protection Agency (US EPA). SW-846. Test Methods for Evaluating Solid Waste, Physical/Chemical Methods. < http://www.epa.gov/osw/hazard/testmethods/sw846/index.htm>.

United States Environmental Protection Agency (US EPA). Contract Laboratory Program. Office of Superfund Remediation and Technology Innovations. Multi-Media. Multi-concentration Organic Analytical Service for Superfund (OLM04.3). EPA Publication 540-F-03-005.

United States Environmental Protection Agency (US EPA). Method 524.2 Measurement of Purgeable Organic Compounds in Water by Capillary Column Gas Chromatography/Mass Spectrometry. Version 4.1. Ed. J.W. Munch. National Exposure Research Laboratory. Office of Research and Development.

United States Environmental Protection Agency (US EPA). Solid Waste and Emergency Response (5305W), Office of Solid Waste. RCRA Waste Sampling Draft Technical Guidance; Planning, Implementation, and Assessment. EPA Publication EPA530-D-02-002.

United States Geological Survey (USGS) of the United States Department of the Interior, (www.usgs.gov) and the National Water Quality Laboratory (USGS-NWQL). <http://nwql.usgs.gov>.

van den Berg, Martin, *et al*. 2006. Review. The 2005 World Health Organization Reevaluation of Human and Mammalian Toxic Equivalency Factors for Dioxins and Dioxin-Like Compounds. Toxicological Sciences 93(2): 223-241.

APPENDICES

Appendix 1. Alphabetical List of Compounds / Regulatory Criteria / Laboratory Reporting Limits

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Acenaphthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	83-32-9	PAH or ABN	5.8 CCME 4.1 OMOECC	0.5	0.00671 CCME 0.05 OMOECC	0.005
Acenaphthylene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	208-96-8	PAH or ABN	1 OMOECC	0.2	0.00587 CCME 0.093 OMOECC	0.005
Acetone	Organic Volatile Organic Compounds	67-64-1	VOC	30 OMOECC	6	0.5 OMOECC	0.5
Acridine	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	260-94-6	PAH or ABN	4.4 CCME 0.05*	0.05	N/V	N/A
Aldicarb	Organic Pesticides Carbamate pesticides	116-06-3	P&H or Carbamate	0.15	0.03	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Aldrin	Organic Pesticides Organochlorine compounds	309-00-2	OC pesticides	3* 0.01 OMOECC	0.01	0.002 OMOECC	0.01
Aluminium	**Inorganic Metals**	**7429-90-5**	**Metals**	**5**	**3**	**N/V**	**N/A**
Ammonia (total)	**Inorganic Inorganic nitrogen compounds**	**N/A**	**ORP**	**21**	**10**	**N/V**	**N/A**
Ammonia (un-ionised)	**Inorganic Inorganic nitrogen compounds**	**7664-41-7**	**ORP**	**19**	**10**	**N/V**	**N/A**
Aniline	Organic Other Organics SVOC	62-53-3	ABN	2.2	0.4	N/V	N/A
Anthracene	Organic Other Organics SP	120-12-7	PAH or ABN	0.012 CCME 0.1 OMOECC	0.01	0.0469 CCME 0.05 OMOECC	0.005
Antimony	**Inorganic Metals**	**7440-36-0**	**Metals**	**1.5 OMOECC**	**1**	**20 CCME 1 OMOECC**	**2**
Aroclor 1254	Organic Polyaromatic compounds Polychlorinated biphenyls	**27323-18-8**	PCB	N/V	N/A	0.06	0.03

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Arsenic	**Inorganic Metals**	**7440-38-2**	**Metals**	**5 CCME 13 OMOECC**	**1**	**5.9 CCME 6 OMOECC**	**1**
Atrazine	Organic Pesticides Triazine compounds	1912-24-9	P&H	1.8	0.3	N/V	N/A
Barium	**Inorganic Metals**	**7440-39-3**	**Metals**	**610 OMOECC**	**10**	**500 CCME 210 OMOECC**	**10**
Benzene	Organic Monocyclic aromatic compounds	71-43-2	VOC	110 CCME 88* 0.5 OMOECC	5	0.0068 CCME 0.02 OMOECC	0.005
Benz(a)anthracene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	56-55-3	PAH or ABN	0.018	0.01	0.0317 CCME 0.095 OMOECC	0.005
Benzo(a)pyrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	50-32-8	PAH or ABN	0.015 CCME 0.01* 0.01 OMOECC	0.01	0.0319 CCME 0.05 OMOECC	0.005
Benzo(b)fluoranthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	205-99-2	PAH or ABN	0.1 OMOECC	0.05	0.16 CCME b+j+k 0.3 OMOECC	0.005

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Benzo(k)fluoranthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	207-08-9	PAH or ABN	0.1 OMOECC	0.05	0.16 CCME b+j+k 0.05 OMOECC	0.005
Benzo[ghi]perylene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	191-24-2	PAH or ABN	0.2 OMOECC	0.04	0.17 OMOECC	0.01
Beryllium	**Inorganic Metals**	**7440-41-7**	**Metals**	**100 CCME 5.3* 0.5 OMOECC**	**1**	**4 CCME 2.5 OMOECC**	**0.8**
Biphenyl, 1,1'-	Organic ABN	92-52-4	ABN	0.5 OMOECC	0.1	0.05 OMOECC	0.05
Bis(2-chloroethyl)ether	Organic ABN	111-44-4	ABN	5 OMOECC	1	0.5 OMOECC	0.5
Bis(2-chloroisopropyl)ether	Organic ABN	39638-32-9	ABN	4 OMOECC	1	0.5 OMOECC	0.5
Boron	**Inorganic Metals**	**7440-42-8**	**Metals**	**1500 CCME 500* 1700 OMOECC**	**50**	**36 OMOECC**	**5**
Boron HWS	**Inorganic Metals**		**Metals**	**N/V**	**N/A**	**2 CCME**	**0.4**
Bromacil	Organic Pesticides	314-40-9	P&H	0.2	0.1	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Bromoxynil	Organic Pesticides Benzonitrile compounds	1689-84-5	P&H	0.33	0.1	N/V	N/A
Cadmium	**Inorganic Metals**	**7440-43-9**	**Metals**	**0.017, 0.005 µg/L (10 mg/L hardness) CCME 0.5 OMOECC**	**0.01**	**0.6 CCME 0.6 OMOECC**	**0.1**
Calcium	**Inorganic Metals**	**7789-78-8**	**Metals**	**1 000 000**	**1000**	**N/V**	**N/A**
Captan	Organic Pesticides	133-06-2	P&H	1.3	0.5	N/V	N/A
Carbamate, 3-Iodo-2-propynyl butyl	Organic Pesticides Carbamate pesticides	55406-53-6	P&H or Carbamate	1.9	1	N/V	N/A
Carbaryl	Organic Pesticides Carbamate pesticides	63-25-2	P&H	0.2	0.1	N/V	N/A
Carbofuran	Organic Pesticides Carbamate pesticides	1564-66-2	P&H or Carbamate	1.8	0.4	N/V	N/A
Chlordane alpha-Chlordane beta-Chlordane	Organic Pesticides Organochlorine compounds	57-74-9 5103-71-9 5566-34-7	OC pesticides	0.004* 0.06 OMOECC	0.0002	0.0045 CCME 0.007 OMOECC	0.001

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Chloride	**Inorganic Wet**	**16877-00-6**	**ORP**	**100 000 CCME 790 000 OMOECC**	**5000**	**N/V**	**N/A**
Chloroaniline, p-	Organic ABN	106-47-8	ABN	10 OMOECC	10	0.5 OMOECC	0.5
Chlorophenol, 2-	Organic Volatile Organic Compounds CP or ABN	95-57-8	CP or ABN	2 OMOECC	0.5	0.1 OMOECC	0.1
Chlorothalonil	Organic Pesticides	1897-45-6	P&H	0.18	0.1	N/V	N/A
Chlorpyrifos	Organic Pesticides Organophosphorus compounds	2921-88-2	P&H	0.002	0.003	N/V	N/A
Chromium	**Inorganic Metals**	**7440-47-3**	**Metals**	**11 OMOECC**	**1**	**37.3 CCME 26 OMOECC**	**1**
Chromium, hexavalent (Cr(VI))	**Inorganic Metals**	**18540-29-9**	**ORP**	**CCME 1 25 OMOECC**	**1**	**0.4 CCME 0.66 OMOECC**	**0.4**
Chromium, trivalent (Cr(III))	**Inorganic Metals**	**16065-83-1**	**ORP Metals**	**4.9**	**2**	**N/V**	**N/A**
Chrysene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	218-01-9	PAH or ABN	0.1 OMOECC	0.1	0.0571 CCME 0.18 OMOECC	0.01

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Cobalt	**Inorganic Metals**	**7440-48-4**	**Metals**	**50 CCME 3.8 OMOECC**	**10**	**40 CCME 19 OMOECC**	**2**
Coliforms, fecal (Escherichia coli)	**Inorganic Biological**	**N/A**	**bacti**	**100 per 100 mL**	**< 1**	**N/V**	**N/A**
Coliforms, total	**Inorganic Biological**	**N/A**	**bacti**	**1000 per 100 mL**	**< 1**	**N/V**	**N/A**
Colour (true)	**Inorganic Wet Physical**	**N/A**	**ORP**	**Narrative**	**3000**	**N/V**	**N/A**
Conductivity	**Inorganic Wet Physical**	**N/A**	**ORP**	**N/V**	**5 µS/cm**	**2 dS/m CCME 0.47 dS/m OMOECC**	**0.1 dS/m**
Copper	**Inorganic Metals**	**7440-50-8**	**Metals**	**2 CCME 5 OMOECC**	**1**	**18.7 CCME 16 OMOECC**	**5**
Cyanazine	Organic Pesticides Triazine compounds	21725-46-2	P&H	0.5 0.5*	0.1	N/V	N/A
Cyanide	**Inorganic Wet**	**57-12-5**	**ORP**	**5 (as free CN) CCME 1* 5 OMOECC**	**1**	**0.9 CCME 0.051 OMOECC**	**0.05**
Cyanobacteria (Blue-green algae)	**Inorganic Biological**	**N/A**	**bacti**	**heavy growth, blue green algae**	**100**	**N/V**	**N/A**
Deltamethrin	Organic Pesticides	52918-63-5	P&H	0.0004	0.0009‡	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Di(2-ethylhexyl) phthalate	Organic Phthalate esters	117-81-7	ABN	16 CCME 10 OMOECC	2	16 CCME 10 OMOECC	2
Dibenz(a,h)anthracene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	53-70-3	PAH or ABN	0.2 OMOECC	0.008	0.00622 CCME 0.06 OMOECC	0.005
Dibromochloromethane (Chlorodibromomethane)	Organic Halogenated aliphatic compounds Halogenated methanes	124-48-1	THM or VOC	2 OMOECC	2	0.05 OMOECC	0.05
Dicamba	Organic Pesticides Aromatic Carboxylic Acid	1918-00-9	P&H	0.006	0.006	N/V	N/A
Dichloro diphenyl dichloroethane, 2,2-Bis (p-chlorophenyl)-1,1-dichloroethane	Organic Pesticides Organochlorine compounds	72-54-8	OC pesticides	1.8 OMOECC	0.1	0.00122 CCME 0.008 OMOECC	0.001
Dichloro diphenyl ethylene, 1,1-Dichloro-2,2-bis(p-chlorophenyl)-ethene	Organic Pesticides Organochlorine compounds	72-55-9	OC pesticides	10 OMOECC	0.1	0.00207 CCME 0.005 OMOECC	0.001

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Dichloro diphenyl trichloroethane; 2,2-Bis(p-chlorophenyl)-1,1,1-trichloroethane	Organic Pesticides Organochlorine compounds	50-29-3	OC pesticides	0.001* 0.05 OMOECC	0.02	0.00119 CCME 0.007 OMOECC	0.001
Dichlorobenzene, 1,2-	Organic Monocyclic aromatic compounds Chlorinated benzenes	95-50-1	VOC	0.7 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichlorobenzene, 1,3-	Organic Monocyclic aromatic compounds Chlorinated benzenes	541-73-1	VOC	150 CCME 42* 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichlorobenzene, 1,4-	Organic Monocyclic aromatic compounds Chlorinated benzenes	106-46-7	VOC	26 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichlorobenzidine, 3,3'-	Organic ABN	91-94-1	ABN	0.5 OMOECC	0.5	1 OMOECC	1
Dichlorobromomethane (Bromodichloromethane)	Organic Halogenated aliphatic compounds Halogenated methanes	75-27-4	THM or VOC	100 CCME 2 OMOECC	1	0.05 OMOECC	0.05
Dichlorodifluoromethane	Organic Volatile Organic Compounds	75-71-8	VOC	2 OMOECC	2	0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Dichloroethane, 1,1-	Organic Halogenated aliphatic compounds Chlorinated ethanes	75-34-3	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloroethane, 1,2-	Organic Halogenated aliphatic compounds Chlorinated ethanes	107-06-2	VOC	5 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloroethene, 1,1-	Organic Halogenated aliphatic compounds Chlorinated ethenes	75-35-4	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloroethene, 1,2- *(cis*- + *trans*-)	Organic Halogenated aliphatic compounds Chlorinated ethenes	156-59-2	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloromethane (Methylene chloride)	Organic Halogenated aliphatic compounds Halogenated methanes	75-09-2	VOC	50 CCME 5 OMOECC	10	0.1 CCME 0.05 OMOECC	0.1
Dichlorophenol, 2,4-	Organic Monocyclic aromatic compounds Chlorinated phenols	120-83-2	CP or ABN	N/V	N/A	0.05 CCME 0.1 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Dichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols		CP or ABN	0.2	0.2	0.05	0.05
Dichloropropane, 1,2-	Organic Halogenated aliphatic compounds Halogenated methanes	78-87-5	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Dichloropropene, 1,3- (*cis*- + *trans*-)	Organic Halogenated aliphatic compounds Halogenated methanes	542-75-6	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Diclofop-methyl	Organic Pesticides	51338-27-3	P&H	0.18	0.1	N/V	N/A
Didecyl dimethyl ammonium chloride (DDAC)	Organic Pesticides	7173-51-5	P&H	1.5	1	N/V	N/A
Dieldrin	Organic Pesticides Organochlorine compounds	60-57-1	OC pesticides	0.056* 0.05 OMOECC	0.02	0.00071 CCME 0.002 OMOECC	0.001
Diethyl phthalate	Organic ABN	84-66-2	ABN	2 OMOECC	2	0.5 OMOECC	0.5
Diethylene glycol	Organic Glycols	111-46-6	Glycol	N/V	5000	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Diisopropanolamine (DIPA)	Organic Other Organics SP	110-97-4	ORP	1600	10	180	20
Dimethoate	Organic Pesticides Organophosphorus compounds	60-51-5	P&H	3	0.6	N/V	N/A
Dimethylphenol, 2,4-	Organic ABN	105-67-9	ABN or NCP	10 OMOECC	2	0.2 OMOECC	0.2
Dimethylphthalate	Organic ABN	131-11-3	ABN	2 OMOECC	2	0.5 OMOECC	0.5
Di-n-butyl phthalate	Organic Phthalate esters	84-74-2	ABN	19	4	N/V	N/A
Dinitrophenol, 2,4-	Organic ABN	51-28-5	ABN or NCP	10 OMOECC	10	2 OMOECC	0.2
Dinitrotoluene, 2,4-(2,6-)	Organic ABN	121-14-2	ABN	5 OMOECC	5	0.5 OMOECC	0.5
Di-n-octyl phthalate	Organic Phthalate esters	117-84-0	ABN	N/V	2	N/V	N/A
Dinoseb	Organic Pesticides	88-85-7	P&H	0.05	0.05	N/V	N/A
Dioxane, 1,4-	Organic Volatile Organic Compounds	123-91-1	ABN or VOC	NRG CCME 50 OMOECC	20	0.2 OMOECC	20
Dissolved Gas Supersaturation	**Inorganic Physical**	**N/A**	**ORP**	**8 ΔP mm Hg**	**8 ΔP mm Hg**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Dissolved Oxygen (DO)	**Inorganic Physical**	**N/A**	**ORP**	**5500**	**2000**	**N/V**	**N/A**
Endosulphan	Organic Pesticides Organochlorine compounds	115-29-7 195-59-6 33213-65-9	OC pesticides	0.002 CCME 0.05 OMOECC	0.002	0.04 OMOECC	0.01
Endrin	Organic Pesticides Organochlorine compounds	72-20-8	OC pesticides	0.036* 0.05 OMOECC	0.02	0.00267 CCME 0.003 OMOECC	0.001
Ethylbenzene	Organic Monocyclic aromatic compounds	100-41-4	VOC	2.4 CCME 0.5 OMOECC	2	0.018 CCME 0.05 OMOECC	0.01
Ethylene dibromide (dibromoethane, 1,2-)	Organic Volatile Organic Compounds	106-93-4	VOC	0.2 OMOECC	0.2	0.05 OMOECC	0.05
Ethylene glycol	Organic Glycols	107-21-1	Glycols	192 000 190000*	5000	960	50
Fluoranthene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	206-44-0	PAH or ABN	0.04 CCME 0.04 OMOECC	0.01	0.111 CCME 0.24 OMOECC	0.01

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Fluorene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	86-73-7	PAH or ABN	3 CCME 120 OMOECC	0.1	0.0212 CCME 0.05 OMOECC	0.005
Fluoride	**Inorganic** **Wet**	**N/A**	**ORP**	**120**	**50**	**200**	**10**
Fraction Organic Carbon	**Organic** **Volatile Organic Compounds** **ORP**	N/A	ORP	N/V OMOECC	N/A	N/V OMOECC	N/A
Glyphosate	Organic Pesticides Organophosphorus compounds	1071-83-6	P&H or Glyphosate	280	10	N/V	N/A
Heptachlor	Organic Pesticides Organochlorine compounds	76-44-8	OC pesticides	0.0038* 0.01 OMOECC	0.002	0.05 OMOECC	0.05
Heptachlor epoxide	Organic Pesticides/Herbicides/Fungicides OC Pesticides	1024-57-3	OC pesticides	0.01 OMOECC	0.01	0.0006 CCME 0.005 OMOECC	0.05

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Hexachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	118-74-1	OC pesticides	0.52 CCME 0.01 OMOECC	0.01	0.05 CCME 0.01 OMOECC	0.05
Hexachlorobutadiene (HCBD)	Organic Halogenated aliphatic compounds	87-68-3	OC pesticides	1.3 CCME 0.01 OMOECC	0.2	0.01 OMOECC	0.01
Hexachlorocyclohexane, gamma- (γ-HCH, Lindane, γ-BHC)	Organic Pesticides Organochlorine compounds	58-89-9	OC pesticides	0.01 CCME 0.01 OMOECC	0.01	0.00032 CCME 0.01 OMOECC	0.0001
Hexachloroethane	Organic Pesticides/Herbicides/Fungicides OC Pesticides	67-72-1	OC pesticides	0.01 OMOECC	0.01	0.01 OMOECC	0.01
Hexane, n-	Organic Volatile Organic Compounds	110-54-3	VOC	5 OMOECC	5	0.49 CCME 0.05 OMOECC	0.1
Imidacloprid	Organic Pesticides/Herbicides/Fungicides Carbamate	138261-41-3	P&H or Carbamate	0.23	0.1	N/V	N/A

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Indeno(1,2,3-c,d)pyrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	193-39-5	PAH or ABN	0.2 OMOECC	0.05	2.7 CCME 0.11 OMOECC	0.01
Iron	**Inorganic Metals**	**7439-89-6**	**Metals**	**300**	**60**	**N/V**	**N/A**
Lead	**Inorganic Metals**	**7439-92-1**	**Metals**	**1 CCME 1.9 OMOECC**	**0.2**	**30.2 CCME 31 OMOECC**	**1**
Linuron	Organic Pesticides	330-55-2	P&H	0.071	0.07	N/V	N/A
Lithium	**Inorganic Metals**	**7439-93-2**	**Metals**	**2500**	**20**	**N/V**	**N/A**
Magnesium	**Inorganic Metals**	**7439-95-4**	**Metals**	**N/V**	**1000**	**N/V**	**N/A**
Manganese	**Inorganic Metals**	**7439-96-5**	**Metals**	**200**	**20**	**N/V**	**N/A**
Mercury	**Inorganic Metals**	**7439-97-6**	**ORP**	**0.016 CCME 0.1 OMOECC**	**0.01**	**0.130 CCME 0.16 OMOECC**	**0.05**
Methoprene	Organic Pesticides/Herbicides/Fungicides	40596-69-8	P&H	0.09	0.05	N/V	N/A
Methoxychlor	Organic Pesticides/Herbicides/Fungicides OC Pesticides	72-43-5	OC pesticides	0.05 OMOECC	0.05	0.05 OMOECC	0.05

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Methyl ethyl ketone (MEK)	Organic Volatile Organic Compounds	78-93-3	VOC	20 OMOECC	20	0.5 OMOECC	0.5
Methyl isobutyl ketone (MIBK)	Organic Volatile Organic Compounds	108-10-1	VOC	20 OMOECC	20	0.5 OMOECC	0.5
Methyl tertiary-butyl ether (MTBE)	Organic Non-halogenated aliphatic compounds Aliphatic ether	1634-04-4	VOC	5000 CCME 340* 15 OMOECC	10	0.05 OMOECC	0.05
Methylchlorophenoxyacetic acid (4-Chloro-2-methyl phenoxy acetic acid; 2-Methyl-4-chloro phenoxy acetic acid, MCPA)	Organic Pesticides	94-74-6	P&H or ABN or Phenoxyacid Herbicide	0.025	0.02	N/V	N/A
Methylmercury	Organic Other Organics SP	22967-92-6	ORP	0.004 CCME 0.12 OMOECC	0.0008	0.033 (tissue) CCME	0.006
Methylnaphthalenes, 1- and 2-	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	91-57-6 90-12-0	PAH or ABN	2 OMOECC	2	0.0202 CCME 0.05 OMOECC	0.01
Metolachlor	Organic Pesticides Organochlorine compounds	51218-45-2	OC pesticides or ABN	7.8	0.1	N/V	N/A

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Metribuzin	Organic Pesticides Triazine compounds	21087-64-9	P&H	0.5	0.1	N/V	N/A
Molybdenum	**Inorganic Metals**	**7439-98-7**	**Metals**	**73 CCME 23 OMOECC**	**1**	**5 CCME 2 OMOECC**	**1**
Monobromomethane (Bromomethane, Methyl bromide)	Organic Halogenated aliphatic compounds Halogenated methanes	74-83-9	VOC	0.89 OMOECC		0.05 OMOECC	0.05
Monochlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	108-90-7	VOC	1.3 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Monochloromethane (Methyl chloride)	Organic Halogenated aliphatic compounds Halogenated methanes	74-87-3	VOC	N/V	N/A	N/V	N/A
Monochlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols		CP or ABN	7	1	0.05	0.05
Naphthalene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	91-20-3	PAH or ABN	1.1 CCME 7 OMOECC	0.2	0.0346 CCME 0.05 OMOECC	0.01

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Nickel	**Inorganic** **Metals**	**7440-02-0**	**Metals**	**25 CCME** **14 OMOECC**	**2**	**50 CCME** **16 OMOECC**	**2**
Nitrate	**Inorganic** **Inorganic nitrogen compounds**	**84145-82-4** **14797-55-8**	**ORP**	**13 000**	**20**	**N/V**	**1**
Nitrate + Nitrite	**Inorganic** **Inorganic nitrogen compounds**	**N/A**	**ORP**	**100 000**	**20**	**N/V**	**N/A**
Nitrite	**Inorganic** **Inorganic nitrogen compounds**	**14797-65-0**	**ORP**	**60 NO2-N**	**20**	**N/V**	**1**
Nitrogen (total)	**Inorganic** **Inorganic Nitrogen Compounds**	**7727-37-9**	**ORP**	**250 OMOECC**	**50**	**N/V OMOECC**	**10**
Nonylphenol and its ethoxylates	Organic Nonylphenol and its ethoxylates	84852-15-3	ORP	0.7	0.1 NP 0.1 NPO group	1	0.1
Nutrients (TN & TP)	**Inorganic** **Wet**		**ORP**	**Guidance Framework**	**TN 50** **TP 10**	**N/V**	**N/A**
Particle Size	**Inorganic** **Physical**	**N/A**	**N/A**	**N/V**	**N/A**	**N/V**	**0.5%**
Pentachlorobenzene	Organic Monocyclic aromatic compounds Chlorinated benzenes	608-93-5	OC pesticides or ABN	6	1	0.05	0.01

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Pentachlorophenol (PCP)	Organic Monocyclic aromatic compounds Chlorinated phenols	87-86-5	CP or ABN	0.5 CCME 0.5 OMOECC	0.1	7.6 CCME 0.1 OMOECC	0.1
Perfluorooctanesulphonate (PFOS)	Perfluorinated Sulphonic Acids	1763-23-1	PFOS	0.3	0.02	N/V	N/A
Permethrin	Organic Pesticides Organochlorine compounds	52645-53-1	P&H	0.001	0.004	N/V	N/A
Petroleum hydrocarbons F1	Organic Other Organics PHC	N/A	PHC	750 OMOECC	100	30 CCME** 17 OMOECC	10
Petroleum hydrocarbons F2	Organic Other Organics PHC	N/A	PHC	150 OMOECC	150	150 CCME** 10 OMOECC	30
Petroleum hydrocarbons F3	Organic Other Organics PHC	N/A	PHC	500 OMOECC	500	300 CCME** 240 OMOECC	50
Petroleum hydrocarbons F4[†]	Organic Other Organics PHC	N/A	PHC	500 OMOECC	500	2800 CCME** 120 OMOECC	50
Petroleum hydrocarbons F4G[†]	Organic Other Organics PHC	N/A	PHC	N/V	N/A	2800 CCME** 120 OMOECC	500

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pH	**Inorganic Acidity, alkalinity and pH**	**N/A**	**ORP**	**Freshwater: 6.5 to 9.0 Marine: 7.0 to 8.7 6.5 to 8.7***	**N/A**	**N/V**	**N/A**
Phenanthrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	85-01-8	PAH or ABN	0.4 CCME 0.1 OMOECC	0.08	0.0419 CCME 0.19 OMOECC	0.01
Phenol	Organic Aromatic hydroxy compounds	108-95-2	ABN or NCP	5 OMOECC	1	0.5 OMOECC	0.5
Phenolic compounds, non-chlorinated	Organic Non-halogenated aromatic hydroxy compounds	N/A	ABN or NCP	N/V	N/A	0.1	0.1
Phenols (mono- & dihydric)	Organic Aromatic hydroxy compounds	108-95-2	ABN or NCP	2	0.8	3.8	1
Phenoxy Herbicides, (Dichlorophenoxyacetic Acid, 2,4- (2,4-D))	Organic Pesticides		P&H or ABN or Phenoxyacid Herbicide	4	0.8	N/V	N/A
Phosphorus	**Inorganic Wet**	**N/A**	**ORP**	**Guidance Framework**	**10**	**N/V**	**N/A**

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Phthalic acid esters	Organic Phthalate esters		ABN	N/V	N/A	N/V	N/A
Picloram	Organic Pesticides	1918-02-1	P&H	29	10	N/V	N/A
Polychlorinated biphenyls	Organic Polyaromatic compounds Polychlorinated biphenyls	1336-36-3	PCB	0.2 OMOECC	0.1	0.0215 CCME 0.07 OMOECC	0.02
Polychlorinated dibenzo-p-dioxins/dibenzo furans	Organic Polyaromatic compounds Polychlorinated dioxins and furans		PCDD	0.015 ng/L TEQ OMOECC	0.015 ng/L TEQ	0.85 ng/kg TEQ CCME 7 ng/kg TEQ OMOECC	0.8 ng/kg TEQ
Propylene glycol	Organic Glycols	57-55-6	Glycols	500 000	10000	N/V	N/A
Pyrene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	129-00-0	PAH or ABN	0.025 CCME 0.2 OMOECC	0.02	0.053 CCME 0.1 OMOECC	0.01
Quinoline	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	91-22-5	PAH or ABN	3.4 CCME	0.3	0.1	0.05
Reactive Chlorine Species	**Inorganic Reactive chlorine compunds**	**N/A**	**ORP**	**0.5**	**3**[‡]	**N/V**	**N/A**
Salinity	**Inorganic Physical**	**N/A**	**ORP**	**36%**	N/A	**N/V**	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Selenium	**Inorganic Metals**	**7782-49-2**	**Metals**	**1 CCME 5 OMOECC**	**0.5**	**1 CCME 1.2 OMOECC**	**1**
Silver	**Inorganic Metals**	**7440-22-4**	**Metals**	**0.1 CCME 0.3 OMOECC**	**0.1**	**20 CCME 0.5 OMOECC**	**1**
Simazine	Organic Pesticides Triazine compounds	122-34-9	P&H	0.5	0.1	N/V	N/A
Sodium	**Inorganic Metals and ORP**	**7440-23-5**	**Metals**	**490000 OMOECC**	**500**	**N/V OMOECC**	
Sodium adsorption ratio	**Inorganic**	**N/A**	**ORP**	**N/V**	N/A	**5 CCME 1 OMOECC**	**1**
Streambed substrate	**Inorganic Physical Turbidity, clarity and suspended solids Total particulate matter**	**N/A**	**ORP**	**10% < 2 mm, 19% < 3 mm, 25% < 6.35 mm**	N/A	**N/V**	**N/A**
Styrene	Organic Monocyclic aromatic compounds	100-42-5	VOC	72 CCME 0.5 OMOECC	1	0.1 CCME 0.05 OMOECC	0.05
Sulfolane (Bondelane)	Organic Organic sulphur compound	126-33-0	ORP	500	100	0.8	0.2
Sulphate	**Inorganic Inorganic sulphur compounds**	**18785-72-3**	**ORP**	**1 000 000**	**5 mg/L**	**N/V**	**N/A**
Sulphur (elemental)	**Inorganic Inorganic sulphur compounds**	**7704-34-9**	**ORP**	**N/V**	**N/A**	**500**	**100**

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Suspended sediments	**Inorganic Physical Turbidity, clarity and suspended solids Total particulate matter**	**N/A**	**ORP**	**5 mg/L over background**	**2 mg/L**	**N/V**	**N/A**
Tebuthiuron	Organic Pesticides	34014-18-1	P&H	0.27	0.05	N/V	N/A
Tetrachlorobenzene, 1,2,3,4-	Organic Monocyclic aromatic compounds Chlorinated benzenes	634-66-2	OC pesticides or ABN	1.8	0.36	0.05	0.01
Tetrachlorobenzene, 1,2,3,5-	Organic Monocyclic aromatic compounds Chlorinated benzenes	634-90-2	OC pesticides or ABN	N/V	N/A	0.05	0.01
Tetrachlorobenzene, 1,2,4,5-	Organic Monocyclic aromatic compounds Chlorinated benzenes	95-94-3	OC pesticides or ABN	N/V	N/A	0.05	0.01
Tetrachloroethane, 1,1,1,2-	Organic Volatile Organic Compounds	630-20-6	VOC	1.1 OMOECC	0.5	0.05 OMOECC	0.05
Tetrachloroethane, 1,1,2,2-	Organic Halogenated aliphatic compounds Chlorinated ethanes	79-34-6	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Tetrachloroethene, 1,1,2,2- (PCE, Tetrachloroethylene)	Organic Halogenated aliphatic compounds Chlorinated ethenes	127-18-4	VOC	110 CCME 0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Tetrachloromethane (Carbon tetrachloride)	Organic Halogenated aliphatic compounds Halogenated methanes	56-23-5	VOC	5 CCME 0.56* 0.2 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Tetrachlorophenol, 2,3,4,6-	Organic Monocyclic aromatic compounds Chlorinated phenols	58-90-2	CP or ABN	N/V	N/A	0.05	0.05
Tetrachlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols	25167-83 -3	CP or ABN	1	0.2	0.05	0.05
Thallium	**Inorganic Metals**	**7440-28-0**	**Metals**	**0.8 CCME 0.5 OMOECC**	**0.2**	**1 CCME 1 OMOECC**	**0.4**
Thiophene	Organic Polyaromatic compounds Polycyclic aromatic hydrocarbons	110-02-1	VOC	N/V	N/A	0.1	0.05
Tin	**Inorganic Metals**	**7440-31-5**	**Metals**	**N/V**	**N/A**	**5**	**1**
Toluene	Organic Monocyclic aromatic compounds	108-88-3	VOC	2 CCME 0.8 OMOECC	0.5	0.08 CCME 0.2 OMOECC	0.05
Total dissolved solids (salinity)	**Inorganic Physical Turbidity, clarity and suspended solids**	**N/A**	**Physical**	**500 000**	**10 mg/L**	**N/V**	**N/A**

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Toxaphene	Organic Pesticides Organochlorine compounds	8001-35-2	OC pesticides	0.0002*	0.05‡	0.0001	0.005‡
Triallate	Organic Pesticides Carbamate pesticides	2303-17-5	P&H or Carbamate	0.24	0.1	N/V	N/A
Tribromomethane (Bromoform)	Organic Halogenated aliphatic compounds Halogenated methanes	75-25-2	VOC	100	2	0.05 OMOECC	0.05
Tributyltin	Organic Organotin compounds	56-35-9	Organotin	0.001	0.001	N/V	N/A
Trichlorobenzene, 1,2,3-	Organic Monocyclic aromatic compounds Chlorinated benzenes	87-61-6	VOC or ABN	8	1	0.05	0.05
Trichlorobenzene, 1,2,4-	Organic Monocyclic aromatic compounds Chlorinated benzenes	120-82-1	VOC or ABN	5.4 CCME 0.5 OMOECC	1	0.05	0.05
Trichlorobenzene, 1,3,5-	Organic Monocyclic aromatic compounds Chlorinated benzenes	108-70-3	VOC or ABN	N/V	N/A	0.05	0.05
Trichloroethane, 1,1,1-	Organic Halogenated aliphatic compounds Chlorinated ethanes	71-55-6	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Trichloroethane, 1,1,2-	Organic Halogenated aliphatic compounds Halogenated methanes	79-00-5	VOC	0.5 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Trichloroethene, 1,1,2- (TCE, Trichloroethylene)	Organic Halogenated aliphatic compounds Chlorinated ethenes	79-01-6	VOC	21 CCME 0.5 OMOECC	1	0.01 CCME 0.05 OMOECC	0.01
Trichlorofluoromethane	Organic Volatile Organic Compounds	75-69-4	VOC	150 OMOECC	1	0.05 OMOECC	0.05
Trichloromethane (Chloroform)	Organic Halogenated aliphatic compounds Halogenated methanes	67-66-3	VOC	1.8 CCME 2 OMOECC	0.5	0.1 CCME 0.05 OMOECC	0.05
Trichlorophenol, 2,4,5-	Organic Volatile Organic Compounds CP or ABN	95-95-4	CP or ABN	0.2 OMOECC	0.2	0.1 OMOECC	0.05
Trichlorophenol, 2,4,6-	Organic Monocyclic aromatic compounds Chlorinated phenols	88-06-2	CP or ABN	0.2 OMOECC	N/A	0.05 CCME 0.1 OMOECC	0.05
Trichlorophenols	Organic Monocyclic aromatic compounds Chlorinated phenols		CP or ABN	18	1	0.05	0.05
Tricyclohexyltin	Organic Organotin compounds	3047-10-7	Organotin	250	0.005	N/V	N/A
Trifluralin	Organic Pesticides Dinitroaniline pesticides	1582-09-8	P&H	0.2	0.01	N/V	N/A
Triphenyltin	Organic Organotin compounds	56-35-9	Organotin	0.022	0.005	N/V	N/A

Chemical Name (Inorganics in Bold)	Chemical Groups	CASRN	Analytical Parameter Groups	Lowest Water Criterion (µg/L)	Recommended Maximum LRL - Water (µg/L)	Lowest Soil/Sediment Criterion (mg/kg)	Recommended Maximum LRL - Soil/Sediment (mg/kg)
Turbidity	**Inorganic Physical Turbidity, clarity and suspended solids Total particulate matter**	**N/A**	**ORP**	**1 NTU**	**0.5 NTU**	**N/V**	**N/A**
Uranium	**Inorganic Metals**	**7440-61-1**	**Metals**	**10 CCME 8.9 OMOECC**	**1**	**23 CCME 1.9 OMOECC**	**1**
Vanadium	**Inorganic Metals**	**7440-62-2**	**Metals**	**100 CCME 3.9 OMOECC**	**1**	**130 CCME 86 OMOECC**	**5**
Vinyl chloride	Organic Volatile Organic Compounds	75-01-4	VOC	0.5 OMOECC	0.5	0.02 OMOECC	0.02
Xylenes	Organic Monocyclic aromatic compounds	1330-20-7	VOC	30 CCME 72 OMOECC	5	2.4 CCME 0.05 OMOECC	0.1
Zinc	**Inorganic Metals**	**7440-66-6**	**Metals**	**30 CCME 10* 160 OMOECC**	**5**	**123 CCME 120 OMOECC**	**10**

CAS RN = Chemical Abstracts Service Registry Number

N/A = Not applicable or not available.

N/V = No value listed for standard.

ORP = other regulated parameters (listed in Section 2.1.16 or 2.2.2)

‡ LRL is greater than the lowest criterion for that matrix.

†The larger result obtained for F4 and F4G is compared to the LRL.

*Lowest Criterion from Guidance Document on Federal Interim Water Quality Guidelines for Federal Contaminated Sites May 2010, Table 1

** Lowest Soil Criterion obtained from CCME Canada-Wide Standards for Petroleum Hydrocarbons (PHC) in Soil, Endorsed by CCME, April 30-May 1, 2001, Winnipeg. Table 1 Revised January 2008

*** CCME Summary Table http://www.ccme.ca/en/resources/canadian_environmental_quality_guidelines/index.html? and attached factsheet

Appendix 2. Participants and Affiliations

Project Leader

Barry Loescher, PhD
Quality Systems Specialist, Maxxam Analytics

Participants

Government Agencies	Name	Position
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Environment and Climate Change Canada National Laboratory for Environmental Testing	Ed Sverko	Head - Organic Analysis Laboratory
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Ontario Ministry of the Environment and Climate Change Laboratory Services Branch	Renee Luniewski	Issues / Project Coordinator
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Private Laboratories	Name	Position
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Alberta Innovates Technology Futures, Environmental Analytical Services	Brian Fahlman	Team Lead – Organic Environmental Monitoring
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ALS Group Laboratory Testing Services	Kim Jensen	National Technical Manager, Canada
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Private Laboratories	Name	Position
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Exova Canada Inc.	Chris Swyngedouw, PhD	Scientist
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