



Ministry of
Environment and
Climate Change Strategy

PROTOCOL 9 *FOR CONTAMINATED SITES*

Establishing Local Background Concentrations
in Groundwater

Version 2

Prepared pursuant to Section 64 of the
Environmental Management Act

Approved:

Director of Waste Management

Date

1.0 Definitions

Terms defined in the *Environmental Management Act* (EMA) and Contaminated Sites Regulation (CSR) apply to this protocol in addition to the following:

“contaminant of concern” means a chemical substance found at a site that under Parts 4 and 5 of EMA has been determined to pose an actual or potential unacceptable risk to human health or the environment.

“local background concentration” means the naturally occurring concentration of a substance as determined in accordance with a director’s protocol in an environmental medium in a geographic area.

“qualified professional” means a person who (a) is registered in British Columbia with a professional association, acts under that professional association's code of ethics, and is subject to disciplinary action by that professional association, and (b) through suitable education, experience, accreditation and knowledge may be reasonably relied on to provide advice within their area of expertise.

2.0 Introduction

This protocol describes options for establishing a local background concentration in groundwater for use in the investigation and remediation of a contaminated site, where naturally occurring substance concentrations exceed the generic numerical water standards of the CSR. A local background concentration can be established by either directly applying regional background concentration estimates provided by the ministry for specified inorganic substances or by using the procedures outlined in this protocol to determine site-specific background concentrations in groundwater. Concentrations of a substance that occur naturally in groundwater within a geographic region or locally within a defined groundwater flow system are considered to be representative of background conditions.

Most local groundwater conditions are the result of water/rock interactions that occur within the unsaturated zone and underlying water table. The solid phases present (minerals and organic matter) within a geologic unit play an important role in defining the natural groundwater chemistry and resultant dissolved substance concentrations. Accordingly, a local background groundwater assessment should target discrete hydrogeologic units at a site.

On certain sites, there may be two or more hydrogeologic units that require separate characterization. When completing the background groundwater assessment, it should be indicated if substances occur at naturally elevated concentrations in more than one hydrogeological unit and separate background groundwater determinations should be completed for each unit of interest.

Natural background conditions are typically widespread but may vary spatially according to small differences in subsurface conditions (i.e. variations in mineralogy, organic content, soil gas content, etc.). It is expected that these natural variations can generate differences in measured dissolved concentrations of particular substances, and larger datasets are typically more robust at characterizing this natural variability.

It is the responsibility of the qualified professional to identify sources of contamination and characterize any secondary impacts arising from the contamination that could result in elevated dissolved inorganic concentrations above natural background levels. Additional information presenting examples of elevated dissolved concentrations in various environmental settings is available in the report "[Establishing Regional Background Concentrations in British Columbia \(add hyperlink\)](#)" prepared by CORE6 Environmental Ltd.

It is not the intent of the CSR or this protocol to eliminate the need to remediate a contaminated site which has been contaminated through anthropogenic point sources or anthropogenic non-point sources.

3.0 Regulatory basis for a director's approval

3.1 Deciding if a site is a contaminated site or has been satisfactorily remediated

Groundwater that contains a substance at concentrations above the applicable generic numerical water standard at a site, but below the local background concentration for that substance as determined under this protocol, would not be considered contaminated under Section 11 (3) of the CSR. Similarly, groundwater that has been remediated for a substance to concentrations above the applicable generic numerical water standard for the site but below the local background concentration for that substance as determined under this protocol would be considered satisfactorily remediated under Section 17 (2) (b) of the CSR. This protocol is also used to determine the local background concentration for use in the application of risk-based standards for remediation under Sections 18 and 18.1.

Regional background concentrations in groundwater for substances listed in Table 1 are considered equivalent to local background concentrations of substances in groundwater for the purposes of sections 11 (3) and 17 (2) (b) of the CSR.

Local background concentrations established under this protocol are for purposes of investigating and remediating contaminated sites only. They are not intended and should not be considered to represent safe concentrations for specified water uses or to allow unrestricted water uses at sites where they have been established. Background concentrations established via this protocol are not considered toxicologically-derived standards for the protection of human health and environment.

4.0 Options, procedures and reporting requirements

Where substances occur naturally in groundwater at elevated concentrations, a local background concentration for that substance can be established using one of the options described below.

4.1 Option 1 – Establishing local background concentrations in groundwater based on regional background concentrations

Local background concentrations of inorganic substances in groundwater have been calculated from the ministry's background groundwater database for three regions in BC: The Lower Mainland Region (includes sub-regions 1 and 2), Southern Vancouver Island Region and the Thompson Okanagan Region. The regional background concentrations in groundwater listed in Table 1, represent the lognormal 95th percentile maximum likelihood of the concentration data collected for sites within each region. The [Background Groundwater Quality Database Webpage](#) provides additional information and access to a database of the individual data points for each monitoring well location, sorted by site-specific locations for each region.

The report "[Establishing Regional Background Concentrations in British Columbia](#)" contains detailed information on the development of the regional background concentrations in groundwater.

Regional background concentrations in groundwater in Table 1 may be used without approval from the director as they are considered representative of local background groundwater at any site located within a particular region. Regional boundaries can be viewed at any scale at the iMapBC website ([iMapBC webpage](#)).

The use of Option 1 to determine local background concentrations in groundwater does not require an approval from the director. Rather, investigation reports prepared in support of applications to the ministry must clearly indicate the use of this approach and the local background concentrations in groundwater that were applied. Furthermore, the establishment of a local background concentration must be referenced in the Summary of Site Condition report and the schedule of any instruments issued for the site.

For substances or regions not listed in Table 1, local background concentrations in groundwater must be established using Option 2, below.

4.2 Option 2 – Establishing local background concentrations in groundwater based on site- specific concentration data

4.2.1 Process overview

Under this option, the local background concentration of a substance in groundwater is calculated using one of the following approaches:

Option 2a. Using site-specific concentration data collected from background groundwater sampling conducted at the site of interest; or

Option 2b. Using site-specific concentration data collected from background groundwater sampling conducted at the site of interest supplemented with relevant concentration data from the ministry's background groundwater database.

Options 2a and 2b require a rigorous approach to background monitoring well siting and selection. The methodology for siting and sampling representative groundwater monitoring wells is presented below in section 4.2.3.

The use of Option 2 requires the submission of a full report (see section 4.2.5 below) detailing the rationale and methods used to determine local background concentrations in groundwater in an application to the ministry for a director's approval. This report may be stand alone or may be a distinct section in another report for the site.

4.2.2 Procedures

Option 2a – Establishing local background concentrations in groundwater based on site-specific data

Under this option, background concentrations in groundwater can be established through the collection of site-specific concentration data from representative background monitoring wells located on or adjacent to the site of interest.

Option 2b - Establishing local background concentrations in groundwater based on site-specific data supplemented by data from the ministry's background groundwater database

Under this option, local background concentrations in groundwater can be established on the basis of site-specific concentration data collected from representative background monitoring wells on, or adjacent to, the site of interest supplemented by relevant concentration data from the ministry's background groundwater database. Relevant concentration data that may be used to supplement site-specific data must be collected within 500 m of the site of interest and within the same part of the groundwater flow system and the same hydrogeological unit.

4.2.3 Methodology for establishing local background concentrations in groundwater

Site Characterization

A minimum level of site characterization is required before pursuing a local background concentration in groundwater at a site. A background investigation must use information gathered from a Stage 2 Preliminary Site Investigation or Detailed Site Investigation as supporting evidence for siting new or relying on existing monitoring wells as representative background monitoring wells. All areas of potential environmental concern (APECs) must be assessed for potential contaminants of concern (PCOCs) to demonstrate that the suspected

naturally occurring inorganic constituents are not attributed to anthropogenic sources. Furthermore, contaminants of concern (COCs) associated with areas of environmental concern (AECs) must be bounded vertically and laterally to ensure that background wells are located outside of the influence of site contamination.

Borehole logs should be available for review along with the screen depths and lithological descriptions to link groundwater concentrations to a particular geologic unit. The direction of groundwater flow, including the vertical component, should be defined and illustrated from site data. A conceptual site model must be developed to demonstrate an adequate understanding of hydrogeological and geochemical conditions that result in the naturally elevated substance concentrations in groundwater.

Collection of Representative Data

Groundwater data must be collected in accordance with [Technical Guidance Document 8 - Groundwater Investigation and Characterization](#) (TG8) and the CSR and analyzed according to laboratory methods consistent with the [BC Environmental Laboratory Manual](#). Sufficient data must be collected to demonstrate that wells are not impacted by secondary contaminant releases.

The most current groundwater data is considered representative of groundwater conditions. Historical groundwater data may be used provided it meets the requirements of this protocol and is demonstrated to be representative of current conditions.

Monitoring Well Siting Criteria

Monitoring wells must be located near the site of interest, or on the site if it can be demonstrated they are not impacted by anthropogenic sources of contamination in areas where measured groundwater chemistry is representative of natural conditions. To limit the potential influence of site AECs, background monitoring wells should be located upgradient or cross-gradient of AECs. Preference should be given to the collection of background groundwater from monitoring wells installed on undeveloped or vacant land that has not received imported fill, or in naturally wooded areas, parks or larger residential lots.

To demonstrate an absence of anthropogenic influence, background wells must be sampled for PCOCs that could be sourced from site AECs or that could have migrated onto the site from neighboring site APECs.

The history of the site of interest and adjacent land, including current and previous activities, must be carefully considered to a level of detail consistent with a Preliminary Site Investigation. Representative background wells must not be:

- located within the footprint of a former excavation or backfill area,
- screened in fill material of questionable quality (i.e., woodwaste, bricks, asbestos, etc.),

- influenced by secondary contaminant release processes, such as, changes in redox conditions. This includes cross-gradient monitoring wells if they are in close proximity to an AEC or wells down-gradient of a contaminant source, or
- impacted by anthropogenic sources of contamination. Specifically, wells with detectable organic constituents (e.g. petroleum hydrocarbons, volatile organic compounds, etc.,) must not be used as background well locations.

Groundwater data collected from selected background wells must not be used if the detection limit for any substance is higher than the applicable groundwater standard for the site.

Groundwater Data Assessment

Effort should be made to ensure that appropriate and adequate groundwater sampling data is collected from representative background wells to provide a comprehensive estimation of local background conditions. The size of the groundwater dataset must be determined according to the variations observed in site conditions. Consequently, the number of background wells and sampling events required to characterize background conditions at a site will vary depending on the complexity of the hydrogeology and site conditions (i.e. complex stratigraphy, large changes in water levels, tidal impacts, multiple contaminant sources, presence of fine sediments, etc.).

4.2.4 Determination of local background concentrations in groundwater

Data Requirements

All wells found to be representative of background conditions should be identified and used to characterize local background concentrations in groundwater. Once representative background groundwater monitoring wells have been selected or sited and, if needed, permission to install the monitoring well and sample it has been obtained, the following requirements must be met:

- a) collect samples from a minimum of three representative background monitoring wells,
- b) develop each monitoring well to minimize suspended sediments in the collected groundwater samples,
- c) a minimum of two sampling events required, one during the wet and one during the dry seasons (e.g. seasonal high and low water table), to help capture any seasonal variability in the natural groundwater chemistry.

Calculation of Local Background Concentrations

Where collective background concentration data fall within a single statistical population, the representative local background concentration in groundwater for a substance is the 95th percentile concentration of the data set. The calculation must be conducted in two steps. Step 1 involves calculating the 95th percentile concentration of the data collected from each individual background monitoring well. If there are less than three sampling results, then the maximum value must be used. Step 2 involves calculating the 95th percentile of the values calculated for the combined background monitoring wells. Outliers must be identified using statistical methods and verified as the result of sampling and/or analytical error and removed

from the data set. Where data variability is large and the data do not fall within a single population, conservative estimates must be used to determine local background concentrations (i.e. use the minimum concentration of the data set as the background concentration), or additional background wells must be installed and sampled to increase the size of the data set.

4.2.5 Reporting requirements

Applications for a director's approval of local background concentrations in groundwater developed under Option 2 must be accompanied by a [Contaminated Sites Services Application Form](#) and include a report containing, at a minimum, site investigation results and confirmation statements as follows:

- a) the geographical location of the site of interest (i.e., latitude and longitude, PIDs, etc.),
- b) a complete history of land use(s) at the subject site and surrounding sites,
- c) physical characterization of the site,
- d) groundwater sampling procedures used,
- e) representative background monitoring well selection rationale and location (i.e. a figure showing the well locations),
- f) summary of the regional/local hydrogeology of the subject site and conceptual site model,
- g) documentation of each contaminant of concern in soil and groundwater considered and demonstration that they have not impacted representative background monitoring wells (i.e. are not present above detection limits),
- h) analytical results obtained for background substances and related parameters presented in graphical form on figures and in tabular form,
- i) the statistical significance of the results obtained,
- j) conclusions forthcoming from the assessment of the site background groundwater quality.
- k) the person carrying out the background groundwater investigations and preparing the report is a qualified professional with experience in the assessment of groundwater flow systems and groundwater quality of the type encountered at the site,
- l) the investigation has been carried out in accordance with best professional practice in groundwater investigations and TG8,
- m) the analytical methods acceptable to the director have been used, and
- n) the estimated background concentration for the substance or substances of interest is representative of local background conditions.

5.0 Director's approval on local background concentrations – notification on site registry

Applications for a director's approval are subject to ministry service fees as indicated in Schedule 3 of the CSR. The director will provide information relating to local background concentrations in groundwater for the site to the site registrar in compliance with Section 43 of EMA.

6.0 Alternate approaches

Scientifically defensible modifications to the options outlined in this protocol may be considered by the director. Such requests must be accompanied by a completed [Contaminated Sites Services Application Form](#) and a supporting technical report prepared by a qualified professional that, at a minimum, meets the intent, technical rigor and documentation requirements of the options set out above.

Table 1. Regional estimates for local background concentrations in groundwater for inorganic substances

Region	Lower Mainland Sub-Region 1	Lower Mainland Sub-Region 2	Thompson Okanagan Region	Southern Vancouver Island Region
Substance	Background concentration	Background concentration	Background concentration	Background concentration
Aluminium	332	177	234	107
Antimony	2	3	3	2
Arsenic	38	13	13	9
Barium	490	170	244	249
Beryllium	0.56	3.27	1.3	2
Boron	820	670	880	640
Cadmium	0.97	0.56	0.33	1
Chromium	12	3.9	19	3
Cobalt	62, 62	18	16	14
Copper	14	13	32	8
Hardness ¹	6300	530	3,000,000	1700
Iron	290,000	6,900	12,000	270
Lead	2.1	3.0	6.7	3.0
Lithium	28	19	96	33
Manganese	26,000	3,600	7,600	3,000
Mercury	0.49	0.36	0.57	0.29
Molybdenum	9	58	45	17
Nickel	110	100	44	52
Selenium	4.4	4.9	120	6
Silver	0.20	0.25	0.98	0.27
Sodium	900,000	2,000,000	1,600,000	1,700,000
Strontium	1,300	670	47,000	760
Thallium	0.33	0.42	0.68	0.50
Titanium	110	94	330	78
Uranium	11	18	87	12*
Vanadium	19	26	30	5*
Zinc	44	43	29	17*

- Notes: - 95th percentile concentration not calculated when there is ≤ 10 background sites
 * 95th percentile calculated according to a normal distribution where a lognormal distribution cannot be applied
 n number of background sites used
Bold italics Concentrations greater than the CSR Sch. 3.2 Drinking Water Standard
Bold Concentrations greater than the most stringent CSR Sch. 3.2 Aquatic Life Freshwater (FW) or Marine and Estuarine Water Standard
 1 Hardness is reported in mg/l
 2 The interim cobalt value of 20 ug/L for the remaining regions of the province remains in effect.

Revision history

Approved Date	Effective Date	Document Version	Notes
January 15, 2004	January 15, 2004	V1	New Document
		V2	Major revisions of the content, added 4 regions/sub-regions and 33 substances

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