

PROTOCOL X8 FOR CONTAMINATED SITES

Site-Specific Numerical Water Quality Standards for VPHw and LEPHw

Prepared pursuant to section 53 of the Contaminated Sites Regulation
under the *Waste Management Act*

Approved: _____
Deputy Director of Waste Management

Date

1.0 DEFINITIONS

“VPHw” means Volatile Petroleum Hydrocarbons in water, and includes volatile petroleum hydrocarbons with the exception of benzene, toluene, ethylbenzene and xylenes.

“LEPHw” means Light Extractable Petroleum Hydrocarbons in water, and includes light extractable petroleum hydrocarbons with the exception of acenaphthene, acridine, anthracene, fluorene, naphthalene and phenanthrene.

“VHw6-10” means Volatile Petroleum Hydrocarbons in water.

“EHw10-19” means Light Extractable Petroleum Hydrocarbons in water.

2.0 INTRODUCTION

Footnotes 33, 34 and 38 of Schedule 6 of the Contaminated Sites Regulation (the Regulation) and the “Protocol for Regulation of Petroleum Hydrocarbons in Water under the Contaminated Sites and Special Waste and Contaminated Sites Regulations” (1) allow the generic Schedule 6 aquatic life protective standards of the Regulation to be modified by developing site-specific standards. As is the case with the generic standards, ministry approved site-specific numerical water quality standards (SSSw) may be used to determine if a site is a contaminated site, or a contaminated site has been satisfactorily remediated.

This protocol provides procedures for the development of SSSw for VPHw and LEPHw for the protection of aquatic life. The BC groundwater model should be used directly to calculate SSSw for other substances listed in Schedule 6 of the Regulation, such as benzene.

The ministry will not approve SSSw developed on the basis of qualitative or subjective rationale. ***Nor will the ministry approve SSSw for VPHw or LEPHw in excess of 15,000 and 5,000 ug/l respectively.*** This is because the approval of SSSw for VPHw and LEPHw in excess of these limits would result in exceedances of Schedule 6 water quality standards for VHw6-10 and EHw10-19 applicable at all sites.

3.0 OVERVIEW OF SITE-SPECIFIC WATER QUALITY STANDARDS DEVELOPMENT

This protocol allows for limited substitution of site-specific values for default parameters in the groundwater model to calculate SSSw for VPHw and LEPHw subfractions (2). It is assumed that a minimum 10 times dilution of groundwater is available in receiving surface water.

The model assumes the contaminant source is 10 metres from aquatic receptors in receiving surface waters. It can be used to calculate soil concentrations that will ensure that soil-derived contaminants in groundwater discharging to receiving waters will not exceed 10 times the corresponding ministry aquatic life water quality criteria.

The groundwater model uses the decay half-life ($t_{1/2}$) and organic:carbon partition coefficient (Koc) to account for biodegradation and contaminant retardation during transport.

4.0 PROCEDURE

The procedure is based on the methodology used in the Canada Wide Standards for Petroleum Hydrocarbon in soils (PHC CWS) scientific rationale (4). For VPH and LEPH, the composition of aliphatic and aromatic subfractions and their half lives, Koc values, and toxicity endpoints are listed in Table 1. The aliphatic and aromatic subfractions in the C16 to C19 range have been omitted due to their low solubility.

Table 1: Koc, Half-lives and Toxicity Values for Subfractions.

Substance	Fraction	Log Koc ¹	T _{1/2} sat ² (days)	Model Start Point ³ (ug/L)
VPHw	Aliphatic C6 - 8	3.6	712	46.5
	Aliphatic C8 - 10	4.5	712	7.6
	Aromatic C8 - 10	3.2	712	140
LEPHw	Aliphatic C10 - 12	5.4	1750	1.18
	Aliphatic C12 - 16	6.7	1750	0.074
	Aromatic C10 - 12	3.4	1750	96
	Aromatic C12 - 16	3.7	1750	55.4

¹ Log Koc values taken from TPHCWG Vol. 3. (3).

² T_{1/2} values taken from (4).

- 3 Model start point values taken from (4) and represent water quality benchmarks using a critical body residue.

The procedure consists of the following steps:

Step 1. Measure or determine site-specific values for the parameters listed in Table 2.

Table 2: Derivation of SSSw for VPHw and/or LEPHw. Set of CSST parameters for which site-specific data may be substituted

Parameter	Definition (units)	Acceptable range for modifying site-specific parameters
x	Distance from source to receptor (m)	$100 \geq x \geq 10$
Y	Source dimension width (m)	>30
Z	Source dimension depth (m)	≥ 3
V	Darcy velocity in saturated zone (m/yr)	5 to 100
n	Porosity of contaminated soil	$0.4 \geq n \geq 0.2$
n_e	Effective porosity	$0.4 \geq n_e \geq 0.1$
d	Depth to unconfined groundwater aquifer (m)	≥ 3
Pb	Dry bulk density of soil (g/cm ³)	unlimited
pH _{soil}	pH of soil	$9 \geq pH \geq 4$
pH _{groundwater}	pH of groundwater	$9 \geq pH \geq 4$
P	Precipitation rate (m/yr)	$P \geq (RO + EV)$
(RO+EV)	Runoff and evapotranspiration rate (m/yr)	unlimited
f_{oc}	Fraction organic carbon in soil	0.001 to 0.02

Step 2. Substitute site-specific values into model.

Step 3. Calculate site-specific water quality standards SSSw for each subfraction shown in Table 1.

Step 4. Measure or determine the representative mass fraction of each subfraction present in dissolved phase.

Step 5. Calculate the VPH and LEPH SSSw values using the following equation:

$$SSSw = \frac{1}{\sum \left(\frac{Mf_i}{SSSw_i} \right)}$$

where:

Mf_i = mass fraction of each subfraction

$SSSw_i$ = SSSw for each subfraction within VPH or LEPH

Step 6. If the SSSw is to be used in the formal determination of a site as contaminated site or to support an application for a certificate of compliance for a site, submit the proposed SSSw for VPHw and/or LEPHw to the ministry for review and approval.

The Appendix shows an example calculation.

5.0 LIMITATIONS

The following limitations and requirements for the development of SSSw for VPHw and LEPHw must be observed:

- All site-specific values must be obtained by methods approved by the ministry (5)
- Several of the general groundwater model variables act as linked parameters in the Contaminated Sites Soil Taskgroup equations (2). Consequently when site-specific data is submitted for the default value used for one of these linked parameters, then site-specific data must also be submitted for the default values used for its corresponding linked variable.
- Derivation of aquatic life protective SSSw is allowed only if groundwater exists in an unconfined aquifer.
- The ministry will not approve proposed SSSw for VPHw or LEPHw in excess of 15,000 and 5,000 ug/L, respectively.
- The model start point values in Table 1 do not represent ambient water quality criteria. They should be used only in combination with a groundwater transport model such as the ministry's in order to establish acceptable groundwater quality at distances greater than 10 metres from a receptor.

6.0 APPROVAL OF PROPOSED SITE-SPECIFIC WATER QUALITY STANDARDS FOR ALL SUBSTANCES.

To obtain ministry approval of proposed site-specific aquatic life protective water quality standards, the following must be submitted to the ministry:

- A list of all site-specific substitution values used in the derivation of the proposed SSSw;
- Documentation of compliance with approved ministry methods used to obtain site-specific data;
- Documentation of compliance with the acceptable range of site-specific parameter modifications made;
- Documentation of compliance with data substitution requirements relating to linked parameters;
- Complete documentation of the calculation and derivation of all SSSw proposed for use at the petroleum hydrocarbons site; and
- A formal written request for the review and approval of the SSSw proposed for use at the site.

7.0 REFERENCES

1. BC Ministry of Water, Land and Air Protection. (2002). *Protocol for Regulation of Petroleum Hydrocarbons in Water under the Special Waste and Contaminated sites Regulation*. Victoria, British Columbia. May 13, 2002.
2. BC Environment. (1996). *Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites*. Victoria, British Columbia. January 31, 1996.
3. TPHCWG. (1997). Volume 3. *Selection of Representative TPH Fractions Based on Fate and Transport Consideration*. Final Draft. Total Petroleum Hydrocarbon Criteria Working Group, Amherst, MA.
4. Canadian Council of Ministers of Environment (CCME). (2000). *Canada-wide Standards for Petroleum Hydrocarbons (pHs) in Soil: Scientific Rationale*
5. BC Environment. (1999). *Technical Guidance on Contaminated Sites 1. Site Characterization and Confirmation Testing*. Victoria, British Columbia. August, 1999.

APPENDIX

Calculation Example : VPHw

Using the BC model for a distance to the source of 14 meters, with a calculated Darcy velocity of 15 m/yr (coarse-grained soil), an hydraulic gradient of 0.05, an infiltration rate of 0.55 m/yr (P-(RO+EV)), foc equal to 0.005, a bulk density of 1.75 g/cm³ and a source with of 30 m, the following SSSwi are derived:

VPHw subfractions	Mass fraction (see table below)	Derived SSSwi (mg/l)
Aliphatic C6 - C8	0.55	3.7
Aliphatic C8 - C10	0.36	420 000
Aromatic C8 - C10	0.09	1.6

The following site specific standard for VPHw (Fraction 1) is derived with the following algorithm:

$$SSSw = \left(\frac{1}{\left(\frac{0.55}{3.7} + \frac{0.36}{420,000} + \frac{0.09}{1.6} \right)} \right) = 4.9\text{mg/l}$$

Recommended composition of designated petroleum "fractions" (Table 3.11 in (4))

TPH Sub-fraction	Fraction 1	Fraction 2	Fraction 3	Fraction 4
Aliphatics				
C ₆ -C ₈	0.55			
C _{>8} -C ₁₀	0.36			
C _{>10} -C ₁₂		0.36		
C _{>12} -C ₁₆		0.44		
C _{>16} -C ₂₁			0.56	
C _{>21} -C ₃₄			0.24	
C _{>34}				0.8
Aromatics				
C _{>7} -C ₈				
C _{>8} -C ₁₀	0.09			
C _{>10} -C ₁₂		0.09		
C _{>12} -C ₁₆		0.11		
C _{>16} -C ₂₁			0.14	
C _{>21} -C ₃₄			0.06	
C _{>34}				0.2
Total	1	1	1	1