REPORT ON:

Review of CSST (1996) Soil Matrix Derivation Approach and Related Policy Decisions

Volume II: SABCS Review and Recommendations for Revision of the CSST (1996) Policy Decision Summary

Submitted to the:

British Columbia
Ministry of Environment

November 2009

Prepared by:
Science Advisory Board for Contaminated Sites in British Columbia (SABCS)
c/o Department of Chemistry, University of Victoria
Victoria, British Columbia

With the assistance
of
UMA Engineering Ltd. (now AECOM)
Victoria, B.C.

Acknowledgements

The report herein on *Review of CSST(1996) Soil Matrix Derivation Approach and Related Policy Decisions* in two Volumes and a Synopsis is presented for the information and benefit of the Contaminated Sites community in British Columbia. It is hoped that it will be of interest to practitioners in other jurisdictions as well.
The work builds on an earlier review of the CSST(1996) soil standard derivation protocols carried out in 2005 by the SABCS through a Task Force chaired by Dr. Jean Cho working with the able assistance of Golder Associates .This initial review was submitted to the Ministry of Environment in British Columbia ,and is posted on the SABCS documents page. With further funding from the Ministry , work on the current Review was initiated in late 2005 with input from a panel of contaminated sites experts from Canada and the United States The resulting report was augmented in further work starting in 2007.A Task Force with SABCS members Dr. Dennis Konasewich and Marc Cameron, and Dr .Glyn Fox of the Ministry of Environment worked with a contractor AECOM (previously UMA Engineering Ltd).The AECOM leader was Dr. Doug Bright.

Particular recognition goes to Dennis Konasewich whose leadership and efforts in 2008 and 2009 in bringing the project to completion are gratefully acknowledged by the SABCS. The contributions of the members of the task group to the review are also much appreciated.

Expert reviewers commenting on both an interim report in 2008 and this final work particularly on Volume I have assisted in clarification and documentation. We note the contribution of Sanya Petrovic of Health Canada, Ross Wilson, Steve Hilts of Teck Cominco, Patrick Allard of Azimuth Consulting Group , Blair McDonald, Trish Miller and Audrey Wagenaar of Golder Associates, Dr. Anne Fairbrother of Exponent, and Sam Reimer of SLR, Dr. Howard Bailey of Nautilus Environmental, contributed valuable input to the completion of the section relating to the protection of soil invertebrates and plants. Helpful discussions with Cindy Ott of-URS Canada Inc. are appreciated. Valuable discussions with Dr .Goran Krstic of the Fraser Health Authority on human health aspects are acknowledged.

The SABCS acknowledges with appreciation grant funding from the government of British Columbia through the Ministry Of Environment throughout the course of the project that has made this work possible.

Science Advisory Board for Contaminated Sites in British Columbia
November, 2009

Disclaimer

Practitioners and others with interests in contaminated sites should be aware that this report has not been adopted in whole or in part by the Ministry of Environment of British Columbia. While every effort has been made to incorporate the best available science, it should be used solely as scientific review and commentary by the reader and applied in practice solely at the readers discretion and responsibility. This disclaimer is consistent with SABCS Policy

Request for Comment

The Science Advisory Board for Contaminated Sites in British Columbia is soliciting comment on the documents which together constitute a report to the BC Ministry of Environment on recommendations for the revision of soil standards in British Columbia. Comments will be reviewed and compiled by the SABCS, and will be much appreciated.

Please send your comments to the Science Advisory Board for contaminated Sites by email or email attachment to pwest@uvic.ca. Comments received by January 15, 2010 will be most useful in further refinement of this work. However comments at any time on SABCS work are always appreciated

Paul West, President
Science Advisory Board for Contaminated Sites in British Columbia

CSST POLICY DECISION SUMMARY

PART I: Record of CSST Policy/Decision Issues Relating to the Derivation of Matrix Standards Based on Canadian Council of Ministers of the Environment Protocol and Site-Specific Objectives Documents

PART II: Record of CSST Policy/Decision Issues Relating to the Derivation of Matrix Soil Standards Based on Novel CSST Procedures

Executive Summary

The Contaminated Sites Soil Task group (CSST) was charged with the development of "transparent and scientifically defensible" soil standards for use in the Contaminated Sites Regulation required under the British Columbia *Waste Management Act* of 1993. CSST was a multi-disciplinary group with representation from the B.C. Ministry of Environment, Lands and Parks; the B.C. Ministry of Health; the Medical Health Officers Council of British Columbia; and B.C. Environmental Health Officers. CSST carried out its work between November 1994 and November 1995.

This report reiterates the key science policy issues and decisions reached by CSST (1996) in the development of its soil standards, and provides the results of a subsequent review by the SABCS in the period 2006 to 2008. The review process of the SABCS is described in Section A1.1 of Volume I.

This report (referred to as Volume II) maintains the format of the CSST (1996) Policy Decision Summary and is presented in two parts. Part I deals with policy issues related to the development of soil quality criteria based on procedures as proposed by CCME and considered by CSST. Part II documents policy issues and decisions related to the development of soil quality standards based on "novel" procedures unique to CSST.

To assist readers with the numerous acronyms used in this document, Appendix I presents a "CSST Acronym List".

Table of Contents

PART I : Record of CSST Policy/Decision Issues Relating to the Derivation of Matrix Standards Based on Canadian Council of Ministers of the Environment Protocol and Site-Specific Objectives Documents

IA. Introduction

CSST began its task of developing transparent and scientifically defensible soil standards and related regulatory procedures for use in the Contaminated Sites Regulation by considering science policy issues and decisions inherent in two key Canadian Council of Ministers of the Environment (CCME) documents: (i) "*A Protocol for the Derivation of Ecological Effects-based and Human Health-based Soil Quality Criteria for Contaminated Sites*" - Final Draft Report, (CCME, 1994a)[1] and (ii) "*Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada*" - Final Report, (CCME, 1994b). These documents known as the "protocol" and "SSOs[2]" respectively were drafted by the Subcommittee for Environmental Quality Criteria for Contaminated Sites (SCEQCCS), an *ad hoc* subcommittee of the CCME Environmental Protection Committee - Contaminated Sites Advisory Group (EPC-CSAG) as a component of the work undertaken for the National Contaminated Sites Remediation Program (NCSRP). The SCEQCCS was charged with the task of generating a set of "common scientific tools" to guide the assessment and remediation of NCSRP sites in Canada.

CSST reviewed the two above-mentioned CCME documents in detail, and considered the possibility of outright adoption of the CCME criteria derivation procedures for use in developing soil quality standards for the Contaminated Sites Regulation. However, CSST chose not to recommend simple adoption of the CCME criteria derivation process in its entirety as discussed below, but rather decided to recommend modified soil quality standard derivation procedures for the protection of human and environmental health at contaminated sites in British Columbia. As a result, CSST has adopted, modified and/or rejected various components of the science policy recommended by CCME.

IB. CSST Record of Decision Relating to the CCME Protocol and Site-Specific Objectives Documents

The following represents a section-by-section record of CSST's decisions regarding the CCME science policy issues contained in the CCME "protocol" and "SSOs" documents. Unless otherwise indicated, each CSST record of decision relates to the identified section of the CCME protocol or site-specific objectives document.

IB1. CSST Decisions Related to CCME Protocol Part A - Framework

IB1-Section 1.3.3 - National Guidance

Issue: In order to develop "scientifically defensible" criteria SCEQCCS has elected to derive criteria based on policy decisions relating to toxicological and environmental fate/transport considerations. There is no modification of criteria in consideration of:

1. technological feasibility to achieve
2. economic costs to achieve
3. public consultation

[1] This document has since been finalized (CCME, 1995).
[2] SSOs: Site specific objectives.

SCEQCCS believes all the above issues should be addressed as part of a risk management exercise and should therefore be considered as components of selecting appropriate remedial solutions for specific sites.

Should BC Environment support criteria derivation based on toxicological and environmental fate/transport considerations?

CSST Decision: *Yes, criteria derivation should be based on toxicological and environmental fate/transport considerations. It is not possible to consider factors identified in 1-3 above in a meaningful manner when setting generic criteria. These factors are better addressed within the context of site-specific risk management.*

SABCS 2008 Review: *The SABCS agrees with the concept of criteria development as described above by SCEQCCS. This concept is consistent with documents prepared by CCME[3] and the National Academy of Science[4]. It is noted that the text of the 1996 CSST policy document hereinafter refers only to the development of "standards" and there is no further reference to "criteria". As described by the Ministry's Advisory Panel[5], there are significant legal differences between a "standard" and a "criterion". A "standard" does take into account technological feasibility, economic costs and public consultation. Many North American jurisdictions are generally very sensitive when it is implied that a criterion, guideline or screening value is used or considered as a "standard".[6] [7] [8].*

It is recognized that the BC MOE has provided for flexibility in the CSR standards, by the mechanisms of "site specific standards" and by the process of risk evaluations. The SABCS encourages that the use of these alternatives be easily facilitated. For example, an Advisory Panel report notes stakeholder comments about the administrative difficulties in using the concept of "site specific standards", to the point that the concept was used only 4 times in a period of 6 years[9].

The SABCS recognizes that the terminology of "contaminated site standards" has become established within BC. The SABCS therefore suggests that the following actions be assured in the development of all "contaminated site standards":

- *The scientific rationale for the standards must be transparent and available for review by outside parties.*
- *Comments of all parties who have reviewed draft standards should be public. Ministry response to those comments should be public.*
- *Evaluation of analytical methods and detection levels as part of the standard development process must be assured.*

---

[3] CCME, 2006: Summary of a Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines.

[4] National Academy of Sciences, and National Academy of Engineering. 1972. Water Quality Criteria. Page 3.

[5] Report of British Columbia Advisory Panel on Contaminated Sites, 2003. (Section 9)

[6] E.g. U.S. EPA Region IX. Superfund- Preliminary Remediation Goals. http://www.epa.gov/region09/superfund/prg/rsl-table.html

[7] E.g. U.S. EPA Region III. 2008. Mid Atlantic Risk Assessment- Generic Tables. http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

[8] California Environmental Protection Agency, 2005. Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil.

[9] B.C. Ministry of Water, Land and Air Protection, 2003. As quoted in report of Advisory Panel on Contaminated Sites. Page 74.

- *There should be recognition of regional background concentrations.*
- *Special efforts should be made to assure that parties who may be affected by a proposed standard should be informed (i.e., for socio-economic considerations).*

Although it is outside the scope of CSST, the SABCS recommends that there be provision for consideration of sustainability when the standards are applied, e.g., ecological impacts related to removal of soil that does not meet "standards"; limitations in technology; worker safety during remediation; and environmental impacts of disposal methods.

Additional Question

IB1-Section 1.3.3 (a) - Toxicological Derivation

Issue: Health members of CSST noted that based on "real world" experience, some of the toxicologically modeled human health soil ingestion standards might not be reflective of actual health risks. Thus, for some contaminants, CSST believes numbers based on models may not accurately reflect the actual risks posed. In consequence, as described in more detail below in Part IIC1 of this summary, CSST recommended that a "real world health experience review" be conducted to account for more practical and realistic experience, which may be available for such contaminants as lead, arsenic, cadmium, chromium and benzene. CSST believed that for these substances sufficient information may exist to allow an alternative derivation procedure to be developed which can predict likely human health outcomes from exposure to contaminant concentrations in soil.

CSST therefore proposed that empirical study results could provide a better scientific base for criteria development in some cases.

Should empirical or real world correlative data be used to adjust or correct soil standards derived from the toxicology based equations?

CSST Decision: *Yes. Such adjustment is not thought to be necessarily excluded under the section 1.3.3 of the CCME protocol. See also, Part IIC1a of this summary document.*

SABCS 2008 Review: *Supports the original CSST 1996 decision. It is further noted that, where adjustments are merited, detailed documentation is desirable for the purpose of clarity and transparency in the standards setting exercise.*

Additional Question

IB1-Section 1.3.3 (b) - Need for Documentation for "real world" matrix standards

Issue: In order to be consistent with CSST's principle of scientific "transparency" of process, CSST proposed that rationales for "real world" adjustment of standards based on models be fully documented.

Should documentation be required to support "real world" based matrix standards?

CSST Decision: *Yes.*

SABCS 2008 Review: *Supports the original CSST 1996 decision.*

IB1-Section 2.2 - Protocol issues

Issue: The protocol ignores issues relating to -

1) Toxic mixtures (i.e. possibility of toxic interactions). CCME assessment/remediation criteria are based on single contaminant analysis),

2) Depth of soil contamination on site (no advice on "how deep is safe"), and

3) Some possible defined exposure scenarios for both human health (e.g. pregnant woman, nursing mother, aged asthmatic scenarios) and ecological effects (e.g. ecological secession scenario).

Should BC Environment accept above limitations?

CSST Decision: *Yes, these issues have to be ignored in setting "generic" criteria. Generic criteria will be set using exposure assumptions that represent high exposure to receptors (e.g. children). This, along with policy decisions that specify a high "default" level of protection provide the best means of addressing these concerns in a practical manner.*

SABCS 2008 Review: *The SABCS notes that issue #2 (depth of soil contamination on a site) is addressed in Section 17(3) within the updated version of the Contaminated Sites Regulation.*

For the development of generic standards, considerations of issues such as "toxic mixtures" and the noted human health and ecological scenarios within the development of soil standards, are assumed to be accommodated by the use of conservatism, i.e. by use of high "default level of protection". The SABCS notes that the use of a high "default level of protection" is a policy decision that is reasonable in the absence of adequate scientific information to support a science-based answer to issues such as "toxic mixtures".

As per IB3-Section 5.2 of this report it is noted the SABCS recommends the concept of exposure amortization in cancer risk assessments to provide emphasis on early life stage exposure to contaminants

IB1-Section 2.3 - Ecological Guiding Principles

Issue: The stated goal of the SCEQCCS process is to develop ecological effects (EE) based criteria that would allow a "functioning soil ecosystem" to be sustained on site for current and likely future land uses.

Functional Soil Ecosystem = PLANTS, BACTERIA, FUNGI, PROTOZOAN, INVERTEBRATE and VERTEBRATE animals.

Should BC Environment support the stated goal of maintenance of a "functioning soil ecosystem" in EE criteria derivation? If yes, for which land uses?

CSST Decision: *In principle CSST supports the concept of maintenance of a 'functioning soil ecosystem" irrespective of land use.*

However, CSST also believes it is unreasonable to confer equivalent protection to all species in all circumstances. Rather, it is necessary to consider "appropriate levels of protection" to ecological receptors in the context of land use and site-specific objectives.

SABCS 2008 Re view: *The SABCS notes that the principle of maintenance of a 'functioning soil ecosystem" irrespective of land use, is a policy decision.*

.

The SABCS supports the latter CCST (1996) statement with regard to consideration of "appropriate levels of protection" in the context of land use and site-specific objectives, however the SABCS encourages efforts to review and define "appropriate levels of protection" (e.g. objectives for agricultural lands).

It is further noted that this policy has no influence on ecological considerations when a property is in use (e.g., trees and shrubs can be removed at any property at an owner's discretion and, impermeable surfaces such as asphalt pavement can be installed to cover entire open areas of industrial/commercial sites).

IB1-Section 2.3.1 - Human Health Guiding Principles

Issue: The stated goal of the SCEQCCS process is to develop human health (HH) criteria that confer "no appreciable health risk". Health Canada has stated that to achieve "no appreciable risk" one must take into account multi-media exposure to contamination such that no exceedance of the "Residual Tolerable Daily Intake" (RTDI) occurs.

i.e. RTDI = TDI - EDI

where TDI : "tolerable daily intake"
EDI : sum of five universal environmental media normal background "estimated daily intakes".

Should BC Environment support a multi-media approach to HH soil quality standard derivation and by inference support Health Canada's "no appreciable risk" concept?

CSST Decision: *CSST recommends HH soil quality standards be derived based on the simplified direct TDI apportionment equations as developed in the decision for IB3-Section 4.1.1 (Soil allocation) discussed later in this report. If an official Health Canada EDI is available for a substance, a HH "number" should also be calculated based on an equation, which incorporates the EDI (i.e. as described in the CCME SCEQCCS protocol).*

The final HH soil ingestion standard should be based on the more "reasonable" of the two preliminary numbers derived by these two equations as determined by CSST.

SABCS 2008 Review *The SABCS approves the concept of consideration of an EDI. The SABCS notes that until recently, there was a paucity of efforts by MoE and Health Canada to assess EDIs for substances commonly found at contaminated sites. Instead an apportionment equation that results in a 400% level of conservatism is applied [i.e., it is assumed each of the five media contribute equally (20%) to daily intake of a substance].*

The SABCS is aware of protocols used to develop EDIs, including those of Health Canada (for polybrominated diphenyl ethers)[10] and the World Health Organization International Chemical Assessment Documents[11].

The SABCS is aware that Health Canada, during 2008/2009, provided contracts to develop draft EDIs for 16 substances. Early review of the resulting reports is encouraged.

Databases to support assessments of EDIs for many substances are available in documents such as the U.S. FDA assessments of cumulative estimated daily intakes[12],[13], reports by B.C. municipalities of drinking water quality and MoE reports on air quality in British Columbia[14]. The ability to apply a multi-media approach that incorporates conservative background, off-site and dietary exposures will result in the calculation of scientifically supportable and realistic EDIs.
In the case that not all components have been quantified, an alternative means is discussed in IB3- Section 4.1.1.

The SABCS therefore encourages a high priority assessment of EDIs given that a default soil allocation factor of 0.2 is otherwise implied. The SABCS considers that the use of the 0.2 soil allocation factor is a matter of policy that should be replaced by a science-based effort to evaluate EDIs to the greatest extent possible.

IB1-Section 2.4 - Land Uses

IB1-Section 2.4(a) - Differential Land Uses

Issue: SCEQCCS recommended that criteria should be derived for 4 primary land uses (i.e. Agricultural, Residential/Parkland, Commercial and Industrial).

Should BC Environment support the four main land use concept?

CSST Decision: *Yes. Note that for BC Environment's regulatory purposes the Residential/Parkland group will be separated in a matrix table of standards giving 5 discrete land use categories.*

SABCS (2008) Review:
The approach of having categories is scientifically sound. The routes of exposure are scientifically different. The Ministry has recently defined three additional land uses. Therefore, the SABCS supports the seven current land use categories: Agricultural, Single Family Residential, High Density Urban Residential, Urban Parkland, Commercial, Industrial, and Wildlands land uses. The SABCS

[10] Health Canada, 2008. State of the Science Report for Polybrominated Diphenyl Ethers (PBDEs).

[11] World Health Organization International Program on Chemical Safety, 2009. http://www.who.int/ipcs/publications/cicad/cicads_alphabetical/en/index.html

[12] U.S. Food and Drug Administration, 2007. Cumulative Estimated Daily Intake/Acceptable Daily Intake Database.

[13] http://www.cfsan.fda.gov/~comm/tds-res.html

[14] e.g., Johnson, D.D., 1998. Air Toxics Monitoring in British Columbia. Ministry of Environment Report. *www.env.gov.**bc**.ca/epd/regions/skeena/**air**/pdf/**metals**.pdf*

recommends an additional land use category for land used for schools, daycare centers and community centers. In addition, the SABCS recommends two subcategories for industrial land use: rural and urban.

The land use concept is helpful in making the standards more site-specific, and as such represents a reasonable effort to allow these factors to be considered in site management decisions. Assessments of exposures at high-density urban residential sites and wildlands have been "contracted out" by the Ministry and no results of the studies were available at the time of this review.
For specific sites, the exposure routes may differ from those generally assumed for a particular land use category. The exposure routes at any given site should be verified to ensure the proper land use category is selected. It is noted, greater specificity of assessment and remediation decisions beyond the standardized land use scenarios is enabled through site-specific risk assessment.

IB1-Section 2.4(b) - Differential Protection tied to Land Use

Issue: SCEQCCS suggests t hat " contaminant sensitivity" (i.e. potential t o produce a dverse effects) increases as one moves from Industrial to Agricultural land.

i.e. Above assumption justifies:

1. Variable level of protection re: EE with changing land use, and

2. Variable receptors of concern re: HH with changing land use.

Should BC Environment support:

1. **The concept of differential levels of EE protection accorded to different land uses?**
2. **The concept of a variable level of EE protection with change in land uses?**
3. **The concept of a variable critical HH receptor of concern with change in land use?**

CSST Decision: *Yes, all three concepts should be supported.*

SABCS (2008) Review: *The SABCS supports the use of differential levels of ecological protection for the different land uses. Thus wildlands, agricultural, single family residential, urban parkland and high density urban residential are accorded a greater level of protection from contamination than commercial or industrial land uses.*
A change in land use would obviously require recognition of the intended receptors and exposure pathways.

IB1-Section 2.4.1 - Land Use Definitions

Issue: CCME provides four main land use definitions, page 14 of protocol:

1.	Agricultural	(Ag)
2.	Residential/Parkland	(R/P)
3.	Commercial	(C)
4.	Industrial	(I)

Are land use definitions appropriate to BC Environment?

CSST Decision: *Definitions in CCME protocol are appropriate.*

SABCS (2008) Review *As mentioned previously, the approach of having categories is scientifically sound. The routes of exposure are scientifically different. The SABCS supports in principle the adoption of three additional land use categories based on benefit of more site-specific applicability of numerical standards. The land use changes proposed by MoE include*

- *Separating urban parkland land use from residential land use. The MoE has provided separate land use definitions for single-family residential and urban parkland.*
- *Residential land use has been further divided into two types of residential dwellings: single-family residential and high density urban residential to accommodate for the increase in condominiums and apartment developments. A formal definition for high density urban residential has been developed by the MoE: "An area within a municipal boundary, excluding areas that are characterized predominantly by detached single-family dwellings or zoned or used for urban parks" [in Protocol 13 ("Screening Level Risk Assessment")]. The SABCS suggests the definition should also include references to condominium/apartment style multi-story dwellings located in urban areas with high densities of population.*
- *A new wildlands land use is currently under development and was created to address contamination issues in undeveloped areas and at sites that have been decommissioned and allowed to return to their nature state. MoE has released a wildlands definition.*

As noted previously, the SABCS recommends;

- *an additional category (institutional land use) to account for land used for schools, day care centers and community centers.*
- *A means to differentiate urban and rural industrial lands is required, given that vertebrate receptors would be more prevalent at rural industrial lands.*

The SABCS (2008) recommended land use definitions are described in Volume I.

IB2. CSST Decisions Related to CCME Protocol Part B - Eco Health

Part B Eco Health

IB2-Section 2.4(a) - Measurement versus Assessment Endpoints

Issue: The protocol bases Ecological Effect (EE) soil quality criteria (SQC) derivation procedures on "measurement" end points (e.g. LC_{50} and EC_X values) rather than "assessment" endpoints (i.e. Population, community, ecosystems functioning studies).

Should BC Environment support use of measurement endpoints in EE SQC derivation?

CSST Decision: *Yes - this is the only practical method in view of the lack of data relative to "ecological assessment" endpoints.*

SABCS 2008 Review: *In fact, it is invariably necessary to translate ecological assessment endpoints into one or more measurement endpoints in order to concretely assess potential ecological risks. The most important issue is whether the measurement endpoints chosen adequately and unambiguously capture the intent of the nominated assessment endpoint(s), including whether changes in the specified measurement endpoints can be directly related to changes in the assessment endpoints. Multi-species studies, while useful in detailed ecological risk assessments, have a limited potential for use in the development of generic soil quality standards, since standardized and generically applicable experimental systems (microcosms, mesocosms, etc.) have yet to be developed.*

With regard to direct soil contact exposure scenarios, use of the available measurement endpoint relies on at least three additional important assumptions for the realization of environmental protection goals using soil matrix standards:

(a) soil ecosytems are complex, and the soil supports a large number of different higher organism phyletic and functional groups, in addition to prokaryotes (e.g., fungi, protistans, small to large bodies soil infaunal invertebrates, burrowing invertebrate fauna, surface and litter dwellers, trees, shrubs, and smaller plants). In selecting ecotoxicity thresholds of soil invertebrates or plants as a basis for establishing soil protective thresholds, there is an assumption that the resulting threshold will be adequately protective of a much larger range of ecological receptors that might be directly exposed to the soil at a potentially contaminated site.

(b) Plants, as primary producers, and direct sources of food for humans and all other secondary consumers are a fundamentally important component of soil ecosystems. Various other provincial management initiatives have stressed the value of plant biodiversity (e.g., protection of rare species). In addition, loss of plant productivity as germination potential or viability, reduced yield or reproductive output may have important economic and socio-economic consequences in agronomic and other settings (e.g., backyard and community gardens) as well as direct consequences for loss of ecological productivity. Therefore, use of plant ecotoxicity data as primary measurement endpoints actually reflects an assessment endpoint that places direct value on avoidance of appreciable loss of primary productivity relative to the potential of a

site if the soils were not contaminated, as well as on plant biodiversity.

(c) *Soil invertebrates are also a fundamentally important component of healthy soil ecosystems; however, it is the functions that they perform as opposed to the productivity or presence of individual taxa that are important. When moving from assessment to measurement endpoints, there is reliance on an assumption of functional redundancy across taxa, such that loss of a species is less of a concern than loss of the ability of all taxa within a functional group to modify soil structure, accelerate decomposition and transfer detrital organic carbon to higher trophic groups, and/or modify the cycling of energy, carbon, nitrogen, phosphorus, sulfur and other important substances.*

IB2-Section 2.4(b) - Preferred Measurement Endpoints

Issue: The protocol states only mortality, reproduction and growth endpoints should be used in EE based SQC derivation.

Should BC Environment support use of mortality, reproductive and growth endpoints in EE SQC derivation

CSST Decision: *Yes, the use of these endpoints is supported but will not preclude use of additional endpoints if appropriate. Enzyme induction and behavioral endpoints will not be considered.*

SABCS 2008 Review: *The CSST 1996 decision does not preclude population rather than organism endpoints. Consideration of behavioral endpoints may become warranted in the future to the extent that it is a defensible surrogate for other relevant organism-specific endpoints, not just the population level.*

However, various biochemical indicators or behaviors that have only a tenuous connection to the fitness of a species, community composition and function or ecosystem function should not be used to derive soil quality standards, even if it is clear that the response is beyond the normative range. This is because the link between such candidate measurement endpoints and the important assessment endpoints is likely to be very unclear, and likely to lead to more debate than consensus among knowledgeable practitioners. This issue notwithstanding, such biochemical indicators may in the future be very useful in a detailed ecological risk assessment for more directly evaluating bioavailability as well as mechanistic responses and causal connections associated with observed ecological impairment.

IB2-Section 2.4.2 - Short/Long-term tests

Issue: The protocol states that long-term toxicity test data is preferred for EE based SQC derivation. However, since there is not much true chronic (long-term) EE data available, it is acceptable to use short-term (acute) EE data. This short term data may be adjusted to estimate chronic dose effects for use in EE based SQC derivation, based on professional judgment; however, such decisions depend on the overall amount of data available.

Should BC Environment support application of a safety factor (SF) to NOAEL/LOAEL data to estimate "chronic toxicity" in EE SQC derivation or alternately just use acute toxicity estimates (e.g. EC_{50} and/or LD_{50} data) to derive EE based SQC (i.e. soil matrix standards)?

NB There are data limitations to use of either of these methods

CSST Decision: *No. CSST simply recommends that all relevant ecological data (i.e. short or long term) be used to derive EE SQC (soil matrix standards). In view of the inherent uncertainty associated with most ecological bioassay studies, CSST sees little need to try to adjust NOAEL/LOAEL estimates through the application of SFs.*

SABCS 2008 Review: *This issue was specifically re-visited in 2006 and 2008. SABCS recommends that the CSST 1996 decision stand.*

IB2-Section 4.1 - Ecological Receptors

Issue: The protocol has proposed critical receptors (predictive sentinel species) believed relevant to Ecological function at Agricultural, Residential/Parkland, Commercial and Industrial sites...

Should BC Environment support critical receptors identified in Table 1 of the CCME draft Protocol document as suitable predictive sentinel species to encompass the prescribed "scope" of Ecological function present at identified land use sites?

CSST Decision: *Yes, support use of critical receptors identified in Table 1 of the CCME protocol.*

SABCS 2008 Review: *SABCS notes that CCME (2006) Table 1 identifies ecological receptors and exposure pathways for four different land uses (agricultural; residential/parkland; commercial; and, industrial). CCME considers soil nutrient cycling processes, soil invertebrates, plants and wildlife as ecological receptors on all four land uses for the soil contact pathway. For the soil and food ingestion pathway CCME considers herbivores, secondary and tertiary consumers as receptors only on agricultural lands and residential/parkland land uses.*

SABCS 2008 recommends consideration of vertebrate wildlife as ecological receptors on agricultural lands, rural industrial lands and wildlands. SABCS recommends inclusion of foraging wildlife as receptors on these land uses since many herbivores, omnivores and carnivores use these lands to forage for food or prey. Therefore, contaminant exposure pathways through soil and plant ingestion are possible for vertebrate wildlife on these land uses especially for herbivores and omnivores. Particular attention must also be given to those substances that persist in the environment (i.e. DDT, PCB) and have a strong tendency to bioaccumulate and / or biomagnify up the food chain. For these substances, food chain pathways can lead to exposure of ecological receptors at higher trophic levels (i.e. secondary and tertiary consumers). Consequently, the SABCS (2008) decided to include wildlife as receptors for agricultural lands, rural industrial lands and wildlands. In "Volume I: SABCS (2008) Recommended Revisions to CSST (1996) Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites", the SABCS provides further discussion on possible means to evaluate bioaccumulation within vertebrate wildlife.

Table 1 provides a list of persistent bioaccumulative and toxic (PBT) chemicals as recognized by Environment Canada via the Stockholm Convention on Persistent Organic Pollutants and via joint Environment Canada programs with the U.S. EPA. It is noted many of the listed chemicals are no longer in-use, generated or released, and yet they persist in the environment. The U.S. EPA list of PBT chemicals is provided for comparison.

Table 1: List of Persistent Bioaccumulative and Toxic Chemicals as Recognized by Environment Canada

Category	***Chemical***	***Environment Canada***	***U.S. EPA***
Pesticides	*Aldrin*	*(1)*	*(2),(3)*
	Chlordane	*(1)*	*(2),(3)*
	DDT, DDE, DDD	*(1)*	*(2),(3)*
	Dieldrin	*(1)*	*(2),(3)*
	Endrin	*(1)*	
	Heptachlor	*(1)*	
	Hexachlorobenzene	*(1)*	*(2),(3)*
	Mirex	*(1)*	*(2),(3)*
	Toxaphene	*(1)*	*(2),(3)*
Industrial chemicals and unintended byproducts	*Benzo(a)pyrene*	*(3)*	*(2),(3)*
	Hexachlorobenzene	*(1)*	*(2),(3)*
	Octachlorostyrene	*(3)*	*(2),(3)*
	PCBs	*(1)*	*(2),(3)*
	Alkyl lead	*(3)*	*(2),(3)*
	Mercury	*(3)*	*(2),(3)*
Unintended by-products	*Dioxins and furans*	*(1)*	*(2),(3)*

(1) As per "Stockholm Convention on Persistent Organic Pollutants" (May 2001). Along with 152 nations, Canada and United States are signatories. Canada has ratified this treaty and the United States has not. The above table notes the 12 "organic persistent, bioaccumulative and toxic chemicals for control" listed within the Convention. A Stockholm Convention in May 2009 added nine more organic chemicals to its list of persistent organic pollutants: alpha and beta hexachlorocyclohexane; tetra, penta-, hexa-, and hepta-bromodiphenyl ether; chlordecone; hexabromobiphenyl; lindane; pentachlorobenzene; and, perfluorooctane sulfonic acid, its salts and perfluoroooctane sulfonyl fluoride.

(2) As per the U.S. EPA Persistent, Bioaccumulative and Toxic (PBT) Chemical Program

(3) Part of Great Lakes Binational (Environment Canada and US EPA) Toxics Strategy (Level 1 Substances)

The SABCS notes the procedures developed by CCME (2006) and by the U.S. EPA (2005) for the development of soil quality guidelines to protect terrestrial vertebrate receptors. The procedures were derived to develop soil screening levels (guidelines) that would be protective at a very conservative end of exposure and effects species distribution, i.e., the resulting screening level or guideline will indicate concentrations that <u>may</u> present an unacceptable ecological risk to terrestrial receptors. Further evaluation of the procedures should be ongoing as new information is provided.

However, the SABCS is of the opinion that additional toxicity databases and, further development and clarification of existing models is required before procedures can be recommended.

For the protection of terrestrial vertebrates, any proposed procedures will require test stages to assess factors such as data availability and verification of uptake models (in particular uptake factors into above-ground foliage) Further confirmation with field data will subsequently be required.

Therefore, the SABCS at this time, cannot recommend procedures to develop soil standards that would protect terrestrial vertebrates.

IB2-Section 4.2 - Ecological Exposure Pathways

Issue: SCEQCCS defined 3 probable ecological exposure paths:

1. Direct Soil Contact (microbes/inverts/plants) for all 4 land uses,
2. Food I ngestion (herbivores e ating c ontaminated pl ants) f or Agricultural land use only, and
3. Soil Ingestion (herbivores eating soil or fodder) for Agricultural land use only.

Should BC Environment support the above 3 exposure paths proposed in the protocol or simplify to only a single pathway (i.e. direct soil contact)?

CSST Decision: *In all cases the primary ecological matrix standard should be based on the single direct soil contact pathway only (i.e. the "soil invertebrate and plants" matrix standard). On agricultural lands, food and soil ingestion pathways may also be considered through derivation, where possible, of a livestock protection standard.*

SABCS 2008 Review: *For all land uses the direct soil contact pathway should continue to be applied to be protective of soil invertebrates and plants. SABCS 2008 also recommends derivation of separate soil invertebrate and plant standards, whenever sufficient data exists for a substance.*

The SABCS proposes an alternative procedure (to the CSST(1996) procedure) to develop standards for protection of soil invertebrates and plants. The methodology is described in Section 2.1.2 of Volume I. Within the revised methodology, soil invertebrate and plant data are NOT pooled because they represent different endpoints, modes of uptake, phylogenies, and so on. Similarly, lethal and non-lethal data are not pooled because they represent two different types of responses. Calculated thresholds for use in risk determinations should be based on sufficient data in order to meaningfully characterize any given level of risk. Therefore, rather than pooling potentially disparate data, it is more appropriate to acknowledge important data gaps and fill them. The SABCS notes the need for updated data reviews' in order to revise or derive soil standards for protection of invertebrates and plants.

Indirect soil contact pathways through ingestion of contaminated soil and fodder should continue to be applied to livestock on agricultural lands. Updated toxicity data reviews are required.

SABCS 2008 also recommends future consideration of an indirect soil pathway to be applied to vertebrate wildlife, in particular secondary and tertiary consumers that may be exposed to soil contaminants through food web trophic transfers. This pathway would only apply if bioaccumulative substances are suspected to be present on agricultural lands, rural industrial lands, or wildlands.

Although the SABCS 2008 recommends the consideration of vertebrate wildlife as receptors of concern where there is potential for exposure to contaminated soil and plants through foraging activities on agricultural lands and wildlands, the SABCS is of the opinion that additional toxicity databases and, further development and clarification of existing models is required before procedures can be recommended.

IB2-Section 5.1 - Agricultural (Ag) Scenario

Issue: Figure 5 of the protocol[15] identifies the following primary ecological activities to be protected at Agricultural sites:

- growth of crops
- raising of livestock

Therefore, require consideration of:

1. A direct soil contact procedure to protect microbial nutrient cycling essential for the health of soil invertebrates and plant growth (crops),
2. A livestock food ingestion procedure (i.e. to ensure that no indirect phytotoxicity related toxicity occurs in livestock), and
3. A. livestock soil ingestion procedure (i.e. to ensure that no direct soil ingestion related toxicity occurs in livestock).

Should BC Environment support SCEQCS Ag scenario?

CSST Decision: *Yes - CSST recommends that the growth of crops, microbial function and livestock be protected at Agricultural sites.*

SABCS 2008 Review: *The SABCS agrees with the CSST(1996) decision regarding emphasis on crops and livestock. The SABCS also recommends consideration of vertebrate wildlife foraging on agricultural lands for protection from soil/plant related toxicity. As well, secondary and tertiary consumers who hunt on agricultural lands should be protected from toxicity related to trophic transfer of contaminants where persistent bioaccumulative substances are present. As noted previously the SABCS is of the opinion that additional toxicity databases and, further development and clarification of existing models is required before procedures can be recommended.*

[15] CCME, 2006. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines http://www.ccme.ca/assets/pdf/sg_protocol_1332_e.pdf

The SABCS recommends discussion with the Ministry of Agriculture regarding levels of protection for invertebrate and plant growth on agricultural soil [e.g." what effect level (mortality or non-lethal effects) is acceptable to maintain agricultural productivity on a remediated site?"].

The SABCS agrees that microbial nutrient cycling is of significance. However, the SABCS notes there is considerable uncertainty in the bioassay data relating to microbial functions and uncertainty in interpreting the meaning of a decrease (or increase) in microbial functions. Nonetheless, the SABCS recommends consideration of the Environment Canada calculated microbial protective criteria for use as standards.

IB2-Section 5.2 - Residential/Parkland (R/P) Scenario

Issue: Figure 6 of the protocol[14] identifies the primary ecological activity to be protected at Residential/Parkland sites as:

- growth of ornamental/native flora

Therefore require consideration of a direct soil contact procedure to ensure that soil microbes, soil invertebrates and plants are protected.

Should BC Environment support Residential/Parkland scenario?

CSST Decision: *Yes - support scenario described in principle.*

SABCS 2008 Review: *The SABCS reiterates that the basic assumption for residential areas, be they single family residential or higher density urban settings is that the base case involves the potential for residents to grow ornamental plants and in the case of single family residential food substances, on site soils.*

The SABCS notes the significance of the Screening Level Risk Assessment approach for high density urban residences, given that many such residences may use imported soil for landscaping and that food substances are unlikely to be grown on such sites.

IB2-Section 5.3 - Commercial (C) Scenario

Issue: Figure 7 of the protocol[14] identifies the primary ecological activity to be protected at commercial sites as:

- managed areas for plant growth (i.e. flowerbeds and lawns)

Therefore, SCEQCCS recommends use of the same ecological receptors/scenario as that used at Residential/Parkland sites but also recommends provision of a lower level of ecological protection than that provided at either Ag or R/P sites (i.e. use soil contact procedure to protect microbes, invertebrates, and plants).

Should BC Environment support Commercial scenario?

NB It could be argued that since the primary activity to be protected relates to "managed areas", no need exists to provide soil standards capable of supporting the non-supplemented growth of microbes/invertebrates/plants at all.

CSST Decision: *Yes - support scenario described.*

SABCS 2008 Review: *The SABCS notes the following:*

- *The "standards" as developed by the CSST protocol are essentially screening levels that must be applicable to all commercial site scenarios.*
- *By policy, the Ministry requires an initial presumption that habitat for soil invertebrates and plants may be present.*

Many commercial sites will have virtually no viable habitat for soil invertebrates and plants. The SABCS notes that MoE enables a Screening Level Risk Assessment as a mechanism to rule out the potential for viable soil habitat on a site-specific basis if the site properties and land use suggest this is appropriate.

IB2-Section 5.4 - Industrial (I) Scenario

Issue: Figure 8 of the protocol[14] recommends that identical primary ecological activities be protected at industrial and commercial sites

- i.e. Maintenance of "managed areas" like flowerbeds/lawns.

Therefore SCEQCCS says at Industrial sites use the same receptors/scenario as used at commercial sites (i.e. soil contact procedure microbes/invertebrates/ plants).

NB SCEQCCS says can't "write off" industrial lands *"a priori"* - such land should at least be able to grow unsupplemented grass.

Should BC Environment support Industrial scenario

CSST Decision: *Yes - support scenario described.*

SABCS 2008 Review: *The SABCS notes the following:*

- *The "standards" as developed by the CSST protocol are essentially screening levels that must be applicable to all industrial site scenarios.*
- *By policy, the Ministry requires an initial presumption that habitat for soil invertebrates and plants may be present.*

Many industrial sites likely have little or no viable habitat for soil invertebrates and plants. SABCS notes that MoE enables a Screening Level Risk Assessment as a mechanism to rule out the potential for viable soil habitat on a site-specific basis if the site properties and land use suggest this is appropriate.

IB2-Section 7.2 - Ecological Effects Data Quality

Issue: CCME states that soil based bioassay data should meet minimum data acceptability parameters similar to those used for CCME Water Quality Guidelines.

NB These data acceptability requirements were not overly onerous based on CCME (1996) protocols; however, CCME (2006) protocols have much more stringent data screening requirements.

Should BC Environment support Data Acceptability requirements for bioassays used in EE derivation?

CSST Decision: *No - CSST recommends that all available relevant data listed in respective CCME substance assessment documents should be at least initially considered in Soil Quality Criteria Ecological Effects (SQC_{EE}) derivation*

SABCS 2008 Review: *The data in the CCME substance assessment documents would have been assessed by use of the "screening criteria" outlined in section 7 of CCME (2006). SABCS notes that in addition to use of the CCME substance assessment documents, it will be necessary to complete a more up-to-date review of the available data. The USEPA Ecotox database is available to assist with that review, as are data compilations for USEPA EcoSSLs for a limited number of substances. It is noted CCME (2006),the US EPA EcoSSL protocol and the SABCS recommended procedures for soil invertebrates and plants define criteria for data acceptance and similar guidelines should be provided for the development of BC Eco Health soil standards.*

Data accepted (and not accepted) for development of BC EcoHealth guidelines should be documented with reference to formal data evaluation criteria (i.e., the MoE should develop criteria in reference to CCME (2006) and US EPA EcoSSL protocols.)

IB2-Section 7.5.2 - SOC_{sc} Derivation

IB2-Section 7.5.2(a) - Agricultural/Residential/Parkland TEC Estimation

Issue: SCEQCCS' preferred order for Threshold Effects Concentration (TEC) estimation for Soil Quality Criteria - soil contact (SQC_{sc}) is:

1. Weight of evidence method,
2. LOEC extrapolation method, and
3. Median effects extrapolation method

Should BC Environment support preferred order for SQC_{sc} - TEC derivation?

CSST Decision: No. CSST *proposes an alternative* SQC_{sc} *derivation procedure be used (see sections 7.5.2 and 7.5.3 below). This alternative procedure is "weight of evidence" based.*

SABCS 2008 Review: *The CSST (1996) method was also revisited in 2008, and an alternate set of methods is nominated that overcomes some of the technical limitations of CCME, 1996, CSST 1996, and CCME 2006. A more detailed explanation of this method is provided in Section B2.1.2 of Volume I and Appendices B and E of Volume. I.*

IB2-Section 7.5.2(b) - Agricultural/Residential/Parkland "NPER" protection

Issue: SCEQCCS advises that the appropriate level of protection to be afforded by SQC_{sc} on Agricultural and Residential/Parkland sites lies within the "NPER" level (i.e. the "No to Potential Effects Range") for EE (see Figure 11 of protocol).

Should BC Environment support a "no to potential effects" level of protection for ecological receptors on Ag and RIP sites?

CSST Decision: *No - a more significant level of effects is acceptable.*

CSST recommends for each substance, plotting ecological data as percent response versus concentration for both lethal and non-lethal effects. Then calculate and fit "lines of best fit" and estimate concentrations corresponding to the EC50-NL and LC20.

For agricultural/residential/parkland set SQC_{sc} at the more stringent (i.e. the lesser) of the EC50-NL or the LC20 estimates.

SABCS 2008 Review: *The SABCS suggests consideration of an approach that differs from CSST 1996. The CSST(1996) method of interpolation may be significantly affected by ecotoxicity data with a very low or high effect size. As well a disproportionate amount of ecotoxicity data for one or a few species that have atypical sensitivities to a toxicant may result in development of soil concentration thresholds that may under- or over-estimate risk potential. Therefore, the SABCS has concerns related to the applicability of a linear regression approach to estimate multi-species concentration response relationships.*

To develop standards for the protection of invertebrates and plants, the SABCS recommends an approach that differs from the CSST 1996 protocol. The approach involves separating data into a Lower Effects Range (LER: EC_{15} to EC_{35}, or LC_{15} to LC_{35} data) and Median Effects Range (MER: EC_{35} to EC_{65}, or LC_{35} to LC_{65} data) set of categories for each substance. Data for non-lethal or lethal effect, and plant or invertebrate studies are analyzed separately if there are adequate data to justify this.

Using the revised approach, the SABCS recommends the following levels of protection for the different land uses:

For commercial/industrial sites

Both the plant and invertebrate $SQG_{ECO\text{-}IL/CL}$ are defined as the lower of their respective MER-NL and MER-L values, with the overall soil guideline selected as the lower of the plant and invertebrate $SQG_{ECO\text{-}IL/CL}$ values.

For residential/high density urban and urban parklands

Both the plant and invertebrate $SQG_{ECO\text{-}RL/HDU/PL}$ are defined as the lower of their respective LER-NL and LER-L values, with the overall guideline selected as the lower of the plant and invertebrate $SQG_{ECO\text{-}RL/HDU/PL}$ values.

For agricultural land and wildlands

This standard is calculated by applying the ratio of the $SQG_{ECO\text{-}RL/PL/HDU}$ / $SQG_{ECO\text{-}CL/IL}$ to the $SQG_{ECO\text{-}RL/PL/HDU}$ to derive a final value deemed protective of the Province's most sensitive land uses; i.e., the $SQG_{AL/WL}$. NOEC values are compared with the result.

As stated previously, the SABCS recommends discussion with the Ministry of Agriculture regarding the level of protection for agricultural land. The application of only the lower of the respective LER-NL and LER-L values may imply effect levels in the order of 25% on plants at a site, hence a possible yield decrease of 25% or more. The SABCS is of the opinion that such effects may not be acceptable for agricultural land.

The process of applying the SABCS approach is illustrated in Appendix E of Volume I.

IB2-Section 7.5.3 SQC_{sc} - Derivation

IB2-Section 7.5.3(a) - Commercial/Industrial (C/I) Level of Protection

Issue: The protocol states that a "lower effect" of protection is to be accorded to ecological receptors on Commercial and Industrial (C/I) lands.

This is achieved by setting SQC_{sc} equal to the Effects Concentration Low (ECL) for the "effects" distribution used to calculate the TEC for Ag, and R/P lands.

Thus, ECL equals the Effects Range Low (ERL) or 25th percentile of the EE data. (see Figure 13 of Protocol).

Should BC Environment support an "Effects range low" level of protection for ecological receptors on Commercial and Industrial lands?

CSST Decision: *No. See CSST recommendation for section 7.5.2 above.*

For commercial/industrial land establish SQC_{sc} at the less stringent (i.e. the greater) of the EC50-NL or the LC20 estimates.

SABCS 2008 Review: *No. This CCME procedure has been superseded after reflection and practical evaluation in the CCME (2006) derivation protocols, and earlier by CSST as noted above. Furthermore, a new set of measurement endpoints and protection thresholds is nominated as part of the update.*

IB2-Section 7.6 - SOCsi Derivation

Issue: Protocol, pages 53-60 and Appendix 7, provides for a complicated "check" procedure to accord protection to "grazing herbivores" (i.e. the Soil Quality Criteria - soil ingestion, SQC_{sl}) which might ingest contaminated soil along with fodder at Ag sites.

Should BC Environment support calculation of SQC_{sl} for use on Ag lands to protect grazing herbivores?

Initial options considered by CSST:

1. Try and calculate this and re-visit the policy question based on the experience and practicability of the process, or

2. Leave this issue either to site specific RA or address through site-specific bioassays.

CSST Decision: *No - procedure is considered too complex and too dependent on default assumptions of questionable scientific veracity.*

CSST proposed an alternative derivation procedure for a livestock protective number, which encompasses both contaminated soil and food ingestion. Estimates of chronic daily intake of contaminants via soil and food are compared to a toxicity reference value (TRV) typically derived from the veterinary literature. A soil contaminant concentration representing unity (i.e. 1.0) for the ratio of expected exposure to the TRV is set as the livestock protective soil quality standard.

SABCS 2008 Review: *As shown in Section B2.2.1 of Volume I, the SABCS agrees with the approach used by CSST (1996) and CCME (2006) for the protection of livestock. There is a need to update the information related to livestock TRVs.*

IB2-Section 7.7 - SOC_n Derivation

Issue: The protocol provides for a complicated "check" procedure to accord protection to "grazing herbivores" (i.e. Soil Quality Criteria - food ingestion, SQC_{EI}) which may consume plants in which contaminants have bioaccumulated at Ag sites. (See pages 60-65.of protocol).

Should BC Environment support calculation of SQC_{EI} for use on Ag lands to protect grazing herbivores from consuming contaminated plants?

CSST Decision: *No - Procedure is considered too complex and too dependent on default . assumptions of questionable scientific veracity. CSST recommends an alternative derivation procedure (see CSST decision for section 7.6 above).*

SABCS 2008 Review: *As noted in Section 7.6, the SABCS agrees with the CSST (1996) approach for developing standards to protect livestock. In addition, the SABCS felt that it is important to account for (i) exposures of secondary consumers (herbivores and insectivores) for all substances of concern; and (ii) exposures via further trophic transfer only for those substances that have reasonable potential to biomagnify. In Volume I, the SABCS provides by example, suggested procedures for deriving soil-screening levels (guidelines) for exposures of secondary consumers or higher trophic level vertebrates, which*

are substantially similar to CCME 2006 as well as USEPA and ORNL, published protocols for assessing vertebrate species risks.

A key challenge with the assessment of dietary exposures for terrestrial vertebrate receptors is that it relies on the accuracy of biota-soil accumulation factors (BSAFs) and bioconcentration factors (BCFs), which in turn, are invariably empirical estimates that are dependent on a range of site conditions, food web structure and foraging behavior. As a result, the SABCS is of the opinion that further development and clarification of existing models is required before procedures can be recommended.

A model for calculation of bioaccumulation within secondary and tertiary vertebrate consumers is suggested in Appendix D of Volume I.

IB2-Section 8 - Final SOC_{EE} for Various Land Uses

Issue: SCEQCCS recommends the following procedures be used in establishing SQC_{EE}:

1. At Agricultural land set SQCEE equal to the lowest of:
   - SQCsc – Ag (Soil contact), or
   - SQC_{SI} (Soil ingestion)
   - SQC_F
2. At Residential/Urban parkland land set SQCEE equal to SQCsc - R/P
3. At Commercial or Industrial land set SQCEE equal to SQCsc - C/I

Should BC Environment support final SQC_{EE} derived for the various land uses?

CSST Decision: *For Agricultural land CSST recommends SQC_{EE} be based on the lower of SQC_{sc} - Ag or SQC_F (see Part II B1c below).*

CSST supports protocol recommendations for R/P and C/I land.

SABCS 2008 Review: *As per CSST 1996 it is recommended that a soil standard for soil invertebrate and plant protection is a minimum requirement for nominating or revising a soil matrix standard. While there are obvious merits to addressing as many of the soil exposure scenarios (e.g. livestock ingesting soil and fodder; wildlife ingesting soil and plants) as is feasible, the science is currently inadequate to provide the necessary procedures for deriving standards for wildlife.*

IB2-Section 8(a) - Microbe Check

Issue: The protocol, page 42, calls for the performance of a "microbial function" check of calculated SQC_{sc} values.

Essentially the CCME microbe check calculates a microbe SQC_{sc} in an identical manner as that used to calculate the usual SQC_{sc}, except that in calculating the microbe SQC_{sc}, the invertebrate and plant data are excluded from the "effects" distribution (i.e. distribution is solely microbe based). Then the microbe SQC_{sc} is compared to normal SQC_{sc} . If the microbe SQC_{sc} is less than the originally calculated SQC_{sc} then the SQC_{sc} is set to equal the geometric mean

of both the microbe SQC_{sc} and the original SQC_{sc}. If the microbe SQC_{sc} is greater than the original SQC_{sc} then the original SQC_{sc}, stands.

Should BC Environment support the requirement for the microbe check for all land uses?

CSST Decision: *No - CSST recommends use of the microbe check only for Agricultural land use. Furthermore, CSST recommends only the simple adoption as a matrix standard, of the microbe check soil quality criteria, derived by Environment Canada under CCME methodology, when and if such criteria become publicly available).*

SABCS 2008 Review: *Notes that, while CCME 2006 and CSST 1996 indicated a desire to apply a Nutrient and Energy Cycling (microbial functioning) check value in managing contaminated soils, no single derivation of this exposure scenario/assessment endpoint has arisen in more than decade since CCME 1996 derivation protocols were introduced. There remains considerable uncertainty regarding the types of microbial studies that would be useful to establish meaningful soil protection thresholds.*

The CSST 1996 decision is retained, with reservations by SABCS. It is recommended, in light of the above-mentioned difficulties associated with this standard that MoE for now, should only consider reference to the Environment Canada calculated microbial protective criteria as guidance to determine if site-specific studies are required.

Additional Question

IB2-Section 8(b) - Additional Ecological Soil-Groundwater Protective Standards

Issue: The SSO procedure allows for use of appropriate water quality criteria in the groundwater (GW) check to ensure that soil criteria are calculated, which can adequately protect GW used for:

- aquatic life,
- livestock watering, and
- direct phytotoxicity (i.e. irrigation watering)

Should BC Environment support the above SSO procedure and use the SSO procedure to calculate environmental soil quality standards, which would be protective of groundwater, used for:

- aquatic life,
- livestock watering, and
- irrigation watering.

CSST Decision: *Yes, to develop discrete soil - groundwater protective standards. (See also Part IIB1a and IIB1b below).*

SABCS 2008 Review: *Supports the original CSST 1996 decision. Elimination of the soil to groundwater protective matrix standards would limit options for site assessment, since it would not otherwise be possible to rule out human health or ecological risks associated with contaminant exposures in potentially affected surface and groundwater bodies without reference to Schedule 6 standards.*

IB3. CSST Decisions Related to CCME Protocol Part C - Human Health

Note by the SABCS:

The CCME and CSST (1996) approaches to derive human health soil standards are classified as "deterministic approaches", where a unique value (default value) is assigned to each parameter in an equation, resulting in an output parameter which is the soil standard.

This section follows the CSST (1996) format for the derivation of soil standards to protect human health whereby basic equations for deterministic approaches are defined, and the default values for use in the equations are evaluated and determined.

As described later in this section, the SABCS reviewed the selected default values used by Health Canada, CCME, CSST (1996) and the U.S. EPA. It was noted that:

- The default values selected by the jurisdictions for use in deterministic equations to calculate contaminant limits[16] in soil ranged from "essentially no difference" to "significantly different" (i.e. by factors as much as ten). For example:
    - The default values for adult body weight are essentially the same: 70 kg by the U.S. EPA and 70.7 kg by Health Canada.
    - The daily soil ingestion rates by toddlers range from 80 mg/day (Health Canada and CSST (1996) to 200 mg/day (U.S. EPA).
    - The soil loading to exposed skin ranged from a weighted soil adherence factor of 2×10^{-7} kg/cm^2 (U.S.EPA) to 0.2×10^{-7} kg/cm^2 (Health Canada) to a value of 1×10^{-6} (CSST, 1996). It is noted the same literature sources were used by all jurisdictions.
    - The assumed exposure times at a residence range from 31 years (U.S. EPA) to a lifetime exposure of 80 years (Health Canada).
- Given the simplistic nature of the deterministic equations used to calculate soil standards to protect human health, variances in default values would have significant impacts on the resulting calculated standards.
- To select default values, an inherent bias will occur. For example, median values are selected for some default values (e.g. body weight and skin area) and 95 percentile values are selected for other default values such as soil ingestion. Another example is the selected average adult body weight of 70.7 kg, which is based on a survey of body weights of both male and female adults. In 1997 when the 70.7 kg default value was selected, the average body weight for an adult male was 78.1 kg while for a female the average body weight was 65.4 kg. Hence, for a female, a health risk would be slightly underestimated compared to a risk calculated for a male. Greater biases are observed for soil ingestion and soil dermal absorption default values. The values are highly variable despite being derived from the same literature sources.
- The literature contains many data sets for parameters such as body weight and soil ingestion in the form of distributions. However, the entire data sets are not used for the development of generic soil standards at this time. For example, information on job tenure has been studied and published, and the data indicate, as an example, that the average time a person spends on a job in Canada is 3.7 years. For the entire work force, 94% of the job lengths were less than 20 years. A 35 year job tenure is suggested by Health Canada.

[16] The "limits" are noted as "legal standards" in B.C. The limits are referred to as "criteria" by CCME and Health Canada; and as "screening levels" by the U.S. EPA.

There is a need to provide more realistic and unbiased assessments. The SABCS concurs with the U.S. EPA Science Advisory Board's (2004) encouragement that probabilistic (stochastic) methods are promoted and used for not only exposure assessments but also health effects and dose response assessments. The SABCS therefore recommends consideration of a "new beginning" for the development of soil human health standards, by the use of the stochastic approach, starting with exposure assessments.[17] As noted by the U.S. EPA, the advantages are:

- There would be reduced reliance on the use of default values
- Complete distribution data sets are used
- The resulting product would be relatively unbiased
- Results that are more realistic would occur.
- A systematic logical process is used to explore understanding and describing risk.

The SABCS recognizes that preliminary background preparation would be required to utilize the technique. The proper end-points would have to be defined. However much information is already available, and once the background information is obtained, the process is easily facilitated.

Appendix B of this document provides brief examples of preliminary stochastic determinations of soil standards for several substances.

IB3-Section 1 - Introduction/Principles

Issue: The protocol primarily bases its defined HH exposure scenario derived criterion on "direct soil ingestion" (i.e. derivation of soil ingestion Preliminary Soil Quality Criteria - Human Health, $PSQC_J$) not on other possible HH exposure routes (i.e. dermal or inhalation).

Should BC Environment support HH derivation based primarily on "direct soil ingestion"?

CSST Decision: *Yes - This is generally believed to be the quantitatively most important pathway of direct exposure to soil. Where data are available, indirect exposure to soil may also be considered.*

SABCS 2008 Review: *Sample calculations for pathway specific soil standards are provided in the SABCS (2005) report. The selected chemicals were cadmium and chromium (VI), both of which are considered potentially significant non-threshold contaminants for humans via the soil/dust inhalation pathway. The calculated standard for the soil ingestion pathway was one to three orders of magnitude more conservative than the calculated inhalation standard. The calculated dermal pathway standards were also less conservative than the derived soil ingestion pathway standards.*

As illustrated by the SABCS (2005), airborne respirable dust levels are anticipated to be generally insignificant relative to direct ingestion of soil and water, and to dermal absorption[18]. However at certain sites where dust levels may be significant (as from an unpaved road), exposure corresponding to the

[17] At this time, probability distributions for toxicity are not yet developed and single values for toxicity would be used within a stochastic effort.

[18] Health Canada, 2004. Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)

respirable dust pathway should be calculated if deemed appropriate by the assessor. With reference to IB3-Section 4.3.5(a) of this report, it may be necessary to assess the potential effects of dust levels at industrial sites to ascertain that the risk levels as calculated using MoE protocols to ascertain that the levels are in compliance with the B.C. Occupational Health and Safety Act.

Recently the MoE has established guidelines for assessment of soil vapours and also has provided"Generic Numerical Vapour Standards" in CSR Schedule 11 (effective January 1, 2009) for use at sites with volatile or semi-volatile substances in soil and/or groundwater. The approach replaces the need for soil standards that consider inhalation of vapours.

Dermal exposure to soil has been recently re-evaluated by the U.S. EPA [19]. The original version of RAGS E[20] suggested that consideration of dermal exposure may not be necessary for many chemicals, because the dermal route usually contributes far less than the ingestion route, to overall risk. The 1991 RAGS E recommended not quantifying dermal risk unless the dermal dose is at least 10% of the oral dose. However, the revised 2004 version of RAGS E suggests the need for greater attention to dermal exposure.

Based on the revised version of RAGS E, Region III of the U.S.EPA indicates that recommendations of the earlier version of RAGS E could lead to "underestimation of risk for chemicals when the dermal dose is less than 10% of the oral dose, but dermal toxicity is greater than oral toxicity." "For these reasons, EPA Region 3 will generally recommend quantifying dermal risks for all COPCs, although in specific instances, the quantitation may be eliminated." [21] PAHs as an example were noted to be of concern with regard to dermal exposure.

The SABCS recommends that for the development of the generic soil standards, soil ingestion, skin contact and particulate inhalation should be assessed separately. Although the SABCS agrees that upon human exposure to soil, "direct soil ingestion" is likely the most important human health pathway, the SABCS recommends separate concurrent assessments of dermal and particulate inhalation exposures. Methodologies for the assessments are described in IB3 Section 5.1 and IB3 Section 5.2.

The derivation of separate soil intake standards would account for differences in the mechanisms of toxicity for different exposure routes, different absorption factors and different TRVs, if available.

CSR Schedule 10 "Generic Numerical Soil and Water Standards" were included in the CSR in July 2004. The soil standards were based on US EPA Preliminary Remediation Goals adjusted to reflect BC provincial policy (e.g. for carcinogenic substances, PRG values were adjusted to reflect an incremental lifetime cancer risk (ILCR) of 1 in 100,00 (1E-05) rather than the 1 in 1,000,000 (1E-06) risk level used in the EPA derivations). Importantly, the PRG derivations, and by extension the CSR Schedule 10 soil standards, were based on the combined soil

[19] U.S. EPA, 2004. Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim

[20] U.S. EPA, 1991. Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual

[21] U.S. EPA Region III, 2003: Updated Dermal Exposure Assessment. Region III Technical Guidance Manual for Risk Assessment

ingestion, dermal absorption and particulate inhalation pathways. Therefore, there is incongruence between the CSST protocol and the process applied in developing Schedule 10 soil standards.

IB3-Section 1 (a) - Role of Checks

Issue: The protocol allows for subsequent manipulation of $PSQC_H$ via four additional "check" mechanisms designed to ensure soil criteria are not developed which might result in cross-media contamination of air and water ;

- a "ground water used as drinking water" check (GW),
- a "volatiles in indoor air" check,
- a "vegetable/milk/meat" produce check, and
- an "off-site dust" check.

Should BC Environment support subsequent application of checks on $PQSC_{HH}$?

CSST Decision: *Yes but for the GW check only. CSST believes data is insufficient at this time, to develop scientifically meaningful checks for volatiles in indoor air, vegetables/milk/meat produce or off-site dust.*

SABCS 2008 Review: *The SABCS notes that for indoor intrusion of contaminated vapour (and outdoor exposures as well), BC MoE has adopted the use of direct measurement of soil vapour concentrations, as well as Generic Numerical Vapour Standards (effective January 01,2009). Therefore, there is no need to establish a threshold soil concentration as a "volatiles in indoor air" check value.*

CCME (2006) provides means to calculate potential intake of contaminants from vegetables, milk and/or meat raised on a property. CCME acknowledges "the imprecise nature of this model, the uncertainty surrounding the underlying assumptions and the use of scientific judgment in determining input parameters". "In particular for substances that do not biomagnify, professional judgment should be applied before using the result of a generic guideline".

It is also noted within the CCME (2006) document that for residential land, the contribution of homegrown produce (i.e. from a site garden) to daily intake is less than 10% of the total fraction of produce consumed in an urban residence and there is no meat or milk production on the site. However for an agricultural site, it can be assumed 50% of all produce consumed is grown on the site, and 50% of the meat and 100% of the milk consumed is from local origin. It is recommended by the SABCS that there be "trial runs" of the CCME (2006) approach, particularly for agricultural land use to determine the relative significance of produce ingestion versus assumptions concerning soil ingestion by humans.

"Off-site dust" would be considered on a site-specific basis.
The future development process to revise and develop matrix soil standards should identify specific substances (e.g. cadmium, hexavalent chromium, nickel) which may warrant consideration of this pathway in guideline derivation.

Additional Question

IB3-Section 1(b) - Possible inclusion of "Soil-Outdoor Air" and "Soil-Indoor Air" Standards

Issue: On initial review of proposed CSST HH soil quality standards, stakeholders noted that no standards to protect against "Soil-Outdoor Air" or "Soil-Indoor Air" contaminant exposure had been proposed for common volatile petrochemical contaminants (i.e. BTXE - benzene, toluene, xylene and ethylbenzene). Several toxicological "risk-based" models were proposed by which such soil quality standards might be developed. CSST noted that these soil-air models had not yet been verified or validated by empirical studies and that the derivation of risk-based soil-air standards might be construed as establishing "acceptable" air contaminant concentrations, an activity which lies outside of CSST's terms of reference. As this issue was deemed primarily a human health issue, CSST referred it to the B.C. Ministry of Health (MOH) for advice. The advice received suggested that the issue could be more properly addressed through risk management activities performed on a site-specific basis rather than through the provision of soil-air protective standards.

Should toxicologically based "Soil-Outdoor Air" and "Soil-Indoor Air" HH protective standards be developed by CSST?

CSST Decision: *Based on the MOH's advice on this issue, CSST decided that "Soil-Outdoor Air" and "Soil-Indoor Air" standards should not be developed at this time, for any substance listed in schedule 5 of draft 3.0 of the Contaminated Sites Regulation.*

SABCS 2008 Review: *In 2007, MoE addressed contaminated vapour exposure issues, both indoor and outdoor, through development of Director's Interim Air Concentrations. Effective January 1, 2009, the CSR Schedule 11 "Generic Numerical Vapour Standards" replaced the Interim Air Concentration Criteria and directly address vapor exposure issues. This decision was because prediction of human exposure concentrations from measured soil vapour concentrations (or indoor air concentrations) is a less uncertain approach that estimation of exposures based on a soil concentration and subsequent modeling of soil-groundwater-air partitioning.*

IB3-Section 1(c) - Multimedia Approach

Issue: The protocol uses a multimedia approach to SQC_{HH} development (i.e. assumes RTDI = TDI-EDI).

where

RTDI: Residual Tolerable Daily Intake,
TDI: Tolerable Daily Intake,
EDI: Estimated Daily Intake.

Should BC Environment support use of a multimedia approach in HH soil quality standard derivation?

CSST Decision: *CSST supports the concept use of a multimedia RTDI approach in principle. However for purposes of deriving soil quality standards for use in the Contaminated Sites Regulation, CSST decided that this was best done through setting target soil intake to 20% of the TDI.*

SABCS 2008 Review: *This issue of using the 20% SAF factor is discussed in IB1- Section 2.3.1..*

There are times when the exposures from dermal absorption, soil ingestion and soil particle inhalation are more appropriately evaluated as being independent instead of additive. If a substance acts as a systemic toxicant and uptake via all three routes is predicted to incrementally increase overall exposures and risks via a common mode, then a single soil standard should be calculated accounting for all contaminated sites related exposures to the extent possible.
If, on the other hand, the exposure via one route leads to a lowest LOEC, then a draft soil quality standard should be calculated for each of the three major routes, with the most stringent value used as the applicable standard for the CSR.

IB3-Section 1(d) - RTDI Apportionment

Issue: The protocol then allows only a 20% apportionment of the RTDI to soil for purposes of SQC_{HH} derivation.

Should BC Environment support a 20% apportionment of the TDI for HH criteria derivation?

CSST Decision: *Support 20% apportionment of TDI per se, rather than 20% of the RTDI.*

SABCS 2008 Review: *This issue is discussed in IB1-Section 2.3.1. If the concept of apportionment prevails, then the apportionment applies to TDI.*

IB3-Section 1(e) - TDI Apportionment

Issue: The protocol develops soil HH criteria based on "defined exposure scenarios" tied to four land uses. One of the principles of these defined exposure scenarios is that the most highly exposed human receptor should be used (i.e. child vs. adult).

Should BC Environment support use of generic defined exposure scenarios tied to four land use categories in soil HH criteria derivation?

CSST Decision: *Yes. Again, for BC Environment's regulatory purposes, the CCME Residential/Parkland land use grouping will be separated in schedule 5 of draft 3.0 of the Contaminated Sites Regulation to give five distinct land use categories.*

SABCS 2008 Review: *The SABCS agrees with the above decision. Two additional land use categories are also to be considered: high density urban residential; and, wildlands. The human health exposure scenarios are further discussed in IB3- Sections 4.3.2 to 4.3.5.*

IB3-Section 2 - Toxicology

Issue: The protocol differentiates between non-threshold and threshold substances in conferring levels of protection and deriving criteria.

Should BC Environment support concept of differential standard derivation for threshold and non-threshold agents?

CSST Decision: *Yes*

SABCS 2008 Review: *Supports the original CSST 1996 decision.*

IB3-Section 2(a) - Risk levels

Issue: For non-threshold agents (see page 71 of the protocol). The SCEQCCS has specified that for non-threshold substances, risks should at least be remediated to levels within the range of 10^{-4} to 10^{-6}.

Should BC Environment support SCEQCCS' stated opinion regarding the "acceptable risk" range for carcinogenic substances?

CSST Decision: *CSST recommended using an acceptable risk of 1 x10^{-5} for purposes of calculating non-threshold substance soil quality standards. CSST also recommended use of 1 x10^{-5} as a default level for site-specific risk assessment. In addition, CSST was of the opinion that proponents should be able to request that the Local Medical Health Officer (LMHO) lead a community review process to recommend on a site- specific basis a level of acceptable risk. It was also felt that the final decision as to an appropriate level of acceptable human health risk for a site subjected to such a LMHO community process should lie with the BC Environment Regional Manager.*

SABCS 2008 Review: *The "acceptable risk" of 1 x10^{-5} is a policy decision. The SABCS notes a prior review of acceptable cancer risks within North American jurisdictions[22]. The maximum acceptable levels ranged from one in ten thousand to one in one million. Health Canada has adopted a 1x10^{-5} acceptable risk level. The SABCS has no issue with the above noted CSST decision.*

The SABCS notes a difference in the CCME approach in that CCME considers the 10^{-5} risk level as an incremental risk above background soil concentration.

IB3-Section 2.1.1 Classification of Carcinogenic Status

Issue: The protocol has deferred classification decisions regarding substance carcinogenicity to Health Canada.

Should BC Environment support deferring carcinogenic classification to Health Canada?

[22] Lush, J. 1994. Contaminated Sites Remediation Standards: British Columbia as Compared with North America. (Prepared for BC Environment).

CSST Decision: *CSST recommends supporting Health Canada carcinogenic classification only to the extent stated in CSST's "Hierarchy of acceptable toxicity reference value sources" paper (Fox, 1995).*

SABCS 2008 Review: *Recommends following MoE Technical Guidance Document 7 as the primary reference in determining substance carcinogenic classification for the calculation of soil quality matrix standards.*

Additional Question

IB3-Section 2.1.1(a) - Need for "Hierarchy of Toxicity Reference Values"

Issue: In order to achieve consistency in the development of toxicologically based soil quality standards to protect the health of human and non-human biota, a hierarchy of acceptable toxicity reference values was required by CSST. In consequence, a paper "Hierarchy of Preferred Sources of Toxicity Reference Values for use in Calculation of CSST Numbers for use in the Contaminated Sites Regulation" (Fox, 1995) was prepared for CSST's review and approval.

Should CSST's "Hierarchy of Acceptable Toxicity Reference Value Sources" paper be used in calculation of soil quality standards?

CSST Decision: *CSST approved the above-mentioned paper for use in calculating soil standards under the Contaminated Sites Regulation.*

SABCS 2008 Review: *Recommends following MoE Technical Guidance Document 7 as the primary reference in finding acceptable toxicity reference values for the calculation of soil quality matrix standards.*

IB3-Section 2.2 - Threshold Substances TDI/RfD Approach

Issue: The protocol uses an RfD approach for threshold substances (i.e. uses TDIs obtained from Health Canada).

i.e. $TDI = \frac{NOAEL \text{ or } LOAEL}{UF}$

where	NOAEL	No observed adverse effect level
	LOAEL	Lowest observed adverse effect level
	UF	Uncertainty factor

Should BC Environment support derivation of soil HH criteria based on TDI for non-carcinogenic substances?

CSST Decision: *Yes - This is a commonly accepted method in limit setting.*

SABCS 2008 Review: *Supports the original CSST 1996 decision.*

IB3-Section 2.2(a) - Threshold Substances TDI Sources

Issue: Page 74 of the protocol states "Health Canada has accepted responsibility for determining the TDI for each contaminant being addressed by the NCSRP".

To date, no official TDI's have be provided by Health Canada other than those published under the Canadian Environmental Protection Act (CEPA).

If Health Canada will not provide requisite TDIs, should BC Environment use RfDs from other agencies (i.e. USEPA or WHO) in deriving SQCHH standards?

CSST Decision: *Yes - As stated in CSST's "Hierarchy of Acceptable Toxicity Reference Value Sources" paper.*

SABCS 2008 Review: *Recommends following MoE Technical Guidance Document 7 as the primary reference in finding acceptable toxicity reference values for the calculation of soil quality matrix standards.*

IB3-Section 3 - Mixtures

Issue: The protocol derives criteria for individual substances only, (i.e. NOT FOR MIXTURES), or in the case where Toxicity Equivalency Factors (TEFs) are available, for chemical classes of substances (i.e. PCDD's/PCDF's and PAHs).

Should BC Environment support single substance criteria derivation and exclude consideration of toxic interactions/mixtures?

CSST Decision: *Yes - Current status of toxicological science precludes widespread generic criteria derivation based on toxic mixtures other than Dioxin - TEQs (Toxic Equivalency Quotients) or PAH BaP-TEQs.*

Issues of toxicity for interactive contaminant mixtures should be dealt with via site-specific risk assessment.

SABCS 2008 Review: *Supports original CSST 1996 decision.*

IB3-Section 3.2 - Determination of EDI

Issue: The CCME protocol recommends use of the EDI in the equation for $PSQC_{HH}$. EDIs are to be developed by Health Canada. To date, no official EDI estimates (other than those published under CEPA) have been forthcoming from Health Canada.

As few EDI's are forthcoming from Health Canada, should CSST develop its own simplified $PSQC_{HH}$ derivation formula to exclude consideration of background EDI exposure?

CSST Decision: *Yes. Note CSST has recommended an alternative $PSQC_{HH}$ derivation process (see section IB3-5.1 below). Furthermore, it is not clear that EDIs based on the average Canadian population are meaningful for use in setting soil standards.*

SABCS 2008 Review: *This issue is discussed in IB1-Section 2.3.1. The SABCS believes that meaningful EDIs for many substances can be derived for the British Columbia population. As mentioned previously, Health Canada during 2008-2009 provided contracts to prepare draft EDIs for 16 substances. The draft contractor reports, when provided by Health Canada, should be carefully reviewed.*

IB3-Section 4 - Human Health Exposure Scenarios

Issue: The CCME protocol assumes a lifetime period of exposure in HH scenarios.

Should BC Environment support HH criteria derivation based on lifetime exposure as a first principle?

CSST Decision: *Yes - Ensures no limitations on land use and will not over-estimate exposure.*

SABCS 2008 Review:

For life expectancy, the SABCS notes a Health Canada (2007 Draft) Preliminary Quantitative Risk Assessment guidance document, that suggests a life expectancy of 80 years. The SABCS also notes Health Canada's recommendation: "if cancer risks are estimated for adults only, the 56-year duration of adulthood (20 to 75 years, inclusive) should be used; if cancer risks are estimated on the basis of lifetime average daily intake, then average life expectancy of 75 years should be used[23]."

However based on an U.S. EPA[24] review of scientific studies, the SABCS does not agree with the concept of life-time exposures as used by CSST (1996) and Health Canada. The U.S. EPA[24] provided a detailed overview of three studies relating to residential and workforce activities within the U.S. population. The published results of Israeli and Nelson[26], the U.S. Bureau of Census; and, Johnson and Capel[25] provide estimates that were very similar: i.e., the 50th percentile residence time was 9 years and the 95th percentile was 30 years. The EPA confidence levels in the population mobility data (i.e., residence times) was considered medium to high.

The data by Israeli and Nelson[26] indicates a range in 95th percentiles- 8 years for renters, 41 years for homeowners and 58.4 years for farm residences. The data also indicates that the 95 percentile for residence (in all types of households) in the Western Region of the United States is 17.1 years versus 23 years for the entire country.

The exposure durations currently assumed by the U.S. EPA[27],[28] for development of residential soil guidelines are: 6 years as a child; plus an additional 24 years as an adult, for a total of 30 years exposure at a residence[29].

Similar studies of residential activities are not known to have occurred in British Columbia[30]. It is noted in IB3-4.3.4 that workplace tenures in Canada are similar

[23] Health Canada, 2004. Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)
[24] U.S. EPA, 2007. Exposure Factors Handbook
[25] Johnson, T. and J. Capel (1992): A Monte Carlo Approach to Simulating Residential Occupancy Periods and its Application to the General U.S. Population. Research Triangle Park, U.S. EPA .
[26] Israeli, M., and C.B. Nelson, 1992. "Distribution and Expected Time of Residence for U.S. Households", Risk Analysis, Vol 12 (1) pp65-72,
[27] U.S. EPA RAGS HHEM, Part B, 1991
[28] U.S. EPA, 2000. EPA/540-R-00-007 "Soil Screening Guidance for Radionuclides: User's Guide Assessment of radon exposure"
[29] These are also the exposure durations assumed in the development of Schedule 10 of the CSR.
[30] Studies of residence times in B.C. high density urban residential properties are noted to be underway.

to those of the United States and hence it is assumed residential activities in British Columbia are similar to those of the United States. The SABCS, based on the studies by Israeli and Nelson, recommends the following 95th percentiles for residential exposure durations for use in the deterministic equations to derive soil standards to protect human health:

- *41 years for urban and non-farm residences*
- *58 years for farm residences.*

IB3-Section 4.1.1 - "Soil Allocation Factor" (Apportionment)

Issue: The SCEQCCS has elected to apportion the RTDI equally among five "universal" environmental media (i.e. air, soil, water, food and consumer products).

This results in only 20% of the RTDI being available for soil HH criteria derivation.

Should BC Environment support the use of the 20% Soil Allocation Factor?

CSST Decision: *Yes - but normally only as 20% of total TDI.*

SABCS 2008 Review: *This issue is discussed in detail in IB1- Section 2.3.1. As mentioned in the Section, the SABCS encourages a high priority assessment of EDIs given that a default soil allocation factor of 0.2 is otherwise implied. The SABCS considers that the use of the 0.2 soil allocation factor is a matter of policy that should be replaced by a science-based effort to evaluate EDIs to the greatest extent possible.*

In the case that EDIs are not available, the SABCS recommends adjustment of the default 20% Soil Allocation Factor when appropriate. CSST (1996) followed CCME's assumption of five possible exposure media (soil, water, air, food and consumer products) and arbitrarily apportioned 20% of the TDI to each of these to create a Soil Allocation Factor (SAF), calculated as -

SAF = 100% / n

Where n is equal to the number of applicable exposure media.

SABCS recommends that the default SAF of 20% be adjusted if defensible contaminant-specific evidence exists demonstrating that the contaminant occurs at insignificant levels[31] in media other than soil (e.g. water, air, food, consumer products). For example, high molecular weight hydrocarbons have low solubility and volatility, therefore, exposure from air and water is likely to be insignificant and SAF would = 33% (100% divided by three applicable exposure media).

[31] Effect on calculated soil standard would be less than 10%.

IB3-Section 4.1.1 - $PSOC_{HH}$ Derivation Procedure if EDI Exceeds RTDI

Issue: The protocol states that if the EDI already exceeds the TDI (RTDI = 0) for a substance, no $PSQC_{HH}$ is to be calculated. Rather the soil HH criterion is simply established at the background (i.e. EDI) level attributable to soil.

Should BC Environment support establishment of $PSQC_{HH}$, at "background" (i.e. soil EDI) level as an appropriate SQC_{HH} soil quality standard if the EDI exceeds the TDI?

CSST Decision: *If "generic" provincial or local background can be shown to exceed the value for $PSQC_{HH}$ calculated by CSST method, then BC Environment should only require site clean-up to background level.*

SABCS 2008 Review: *SABCS supports the original CSST 1996 decision and notes that this decision is the basis of CSR Protocol 4 Determining Background Soil Quality. A review of background levels (i.e. at various regions of the province as outlined in Protocol 4.*

IB3-Section 4.1.2 - Non-threshold EDI Exceedance of RsD

Issue: The protocol (page 80) specifies that for a carcinogenic substance the SQCHH will be established at a default level of risk = $1x10^{-6}$

Should BC Environment support establishment of HH soil quality standards at a $1x10^{-6}$ level of risk?

CSST Decision: *No, CSST has decided to use $1x10^{-5}$ to calculate HH soil quality standards based on the lower limit of the acceptable risk range recently recommended by the BC Associated Boards of Health. See also, Section IB3-2 - Risk Levels, above.*

SABCS 2008 Review: *The acceptable cancer risk is solely a government policy decision. The SABCS discussed this issue in IB3-2(a). The SABCS notes a prior review by the MoE of acceptable cancer risks within North American jurisdictions[32]. The maximum acceptable levels ranged from one in ten thousand to one in one million. Health Canada has adopted an incremental $1x10^{-5}$ acceptable risk level (above soil background levels), and provides a rationale for its decision in its 2004 report entitled " Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)". Health Canada upheld this position in the 2007 PQRA Guidance, Version 2.0.*

IB3-Section 4.2 - Absorption

Issue: The protocol allows for consideration of a substance's "absorption" or bioavailability (Absorption Faction - AF) potential via ingestion, dermal or inhalation routes in SQC_{HH} derivation.

Should BC Environment support use of an Absorption Factor - Soil (AF_s) in $PSQC_{HH}$ derivation?

CSST Decision: *Yes if the AF_S for a substance is available and the source(s) are fully documented comprehensive studies.*

[32] Lush, J. 1994. Contaminated Sites Remediation Standards: British Columbia as Compared with North America. (Prepared for BC Environment).

SABCS 2008 Review: *The SABCS agrees with the CSST (1996) decision. The SABCS notes there are continuing programs by BARC[33], the US EPA[34], the UK Environment Agency[35] , and BARGE (Bioaccessibility Research Group of Europe) to assess "in vitro" methods to evaluate and to predict bioavailability of organic and inorganic substances in a soil matrix. The programs focus on developing procedures that could be used for site-specific risk assessments. The studies show that "bioaccessibility[36] (hence bioavailability) varies not only from chemical to chemical, but from site to site and between different species of a chemical"[37]. The SABCS is aware there are many chemical and physical factors in soil that would reduce bioavailability. Hence, an assumption that there is 100% bioavailability of a substance due to oral intake of soil is inherently very conservative.*

The SABCS concludes that based on current knowledge, the only option is the application of an oral bioavailability factor of 1.0 for development of generic standards. At this time, bioaccessibility can only be assessed on a site-specific basis, i.e., as part of a site-specific risk assessment.

Likewise, the inhalation respiratory absorption factor will generally default to 1 unless there is good evidence that respiratory absorption is significantly less that 100%. The UK Environment Agency states that there are no accepted methods for determining bioaccessibility as a result of inhalation of soil.

With regard to dermal absorption factors, the SABCS notes Health Canada guidance for dermal exposure. Health Canada within its 2004 document "Guidance on Human Health Preliminary Quantitative Risk Assessment " states in Section 2.5.6, that where dermal exposures are being summed with oral exposures, the RAF_{Dermal} values presented in Table 6 (of the Health Canada document) should be applied, unless more appropriate information has been identified and justified (with proper citations). For contaminants not listed in Table 6, other sources such as the Risk Assessment Information System (RAIS; http://risk.lsd.ornl.gov/rap_hp.shtml), Toxicological Profiles published by the Agency for Toxic Substances and Disease Registry (ATSDR;

---

[33] BARC (Bioaccessibility Research Council), 2007. Strategic Research Planning Workshop in Bioacessibility/bioavailability in Contaminated Site Assessment (BARC is a network that includes Health Canada, Canadian Network of Toxicology Centres, and industry scientists).

[34] US EPA, 2007. Guidance for Evaluating the Oral Bioavailability of Metals in Soil for Use in Human Health Risk Assessments, OSWER 9285.7-80

[35] UK Environment Agency, 2005. Environment Agency's Science Update on the Use of Bioavailability Testing in Risk Assessment of Land Contamination.

[36] "Bioavailability" is the fraction of a chemical than can be absorbed by the body through the gastrointestinal system, the pulmonary system and the skin. Bioavailability involves *in vivo* (live animal model) studies. 'Oral bioaccessibility" covers "*in vitro*" gastrointestinal protocols (e.g. .laboratory extraction procedures) which many be appropriate alternatives to *in vivo* (animal testing).

[37] Danish EPA, 2003. Human bioaccessibility of heavy metals and PAHs from soil. Environment Project no. 840. Reported in reference quoted in footnote 40.

http://www.atsdr.cdc.gov/toxpro2.html), or other authoritative sources should be consulted. Where alternate data sources are consulted, they must be clearly cited and fully referenced." Further discussion is noted within Tables 7 and 8 of this document.

IB3-Section 4.3.2 - Agricultural Land defined HH exposure scenario

Issue: Figure 19 of the protocol provides the SCEQCCS's defined exposure scenario for Ag land.

Should BC Environment support CCME's defined HH exposure scenario for Ag land?

CSST Decision: *Yes for assumed appropriate sensitive receptor, exposure period and direct exposure pathway to be used to calculate HH soil-ingestion standards.*

SABCS 2008 Review: *The SABCS supports the original CSST (1996) decisions as shown below, with the exception of increasing the lifetime to 80 years and decreasing the residence exposure duration to 58 years (6 Years as a child and 52 years as an adult). (See IB3-Section 4).*

Table 2: Human Health exposure scenario for Agricultural Land

.

Defined Land Use Scenario : Agricultural Lands	- a multi-functional farm with a family living on-site - children (all ages groups) are present - groundwater is used for drinking water
Sensitive Receptor	- toddler (threshold contaminants) -toddler and adult (non-threshold contaminants)
Exposure Period	Threshold: (toddler) ET = (24hr/24hr x 7d/7d x 52wk/52wk x 4.5yr/4.5yr) Non-threshold : (toddler) ET = (24hr/24hr x 7d/7d x 52wk/52wk x 6yr/80yr) (adult) ET = (24hr/24hr x 7d/7d x 52wk/52wk x 52yr/80yr)
Direct Soil Exposure Pathways	- soil ingestion - soil particle inhalation - soil dermal contact
Indirect Soil Exposure Pathways	- ingestion of groundwater as drinking water

IB3-Section 4.3.3 - Residential/Parkland defined HH exposure scenario

Issue: Figure 20 of the protocol presents SCEQCCS's defined exposure scenario for R/P lands.

Should BC Environment support CCME's defined HH exposure scenario for R/P lands?

CSST Decision: *Yes for assumed appropriate sensitive receptor, exposure period and direct exposure pathway to be used to calculate HH soil-ingestion standards.*

SABCS 2008 Review: *The SABCS supports the original CSST 1996 decisions as shown in Table 3 below, with the exception of increasing the lifetime to 80 years and decreasing the residence exposure time to 41 years. (See IB3-Section 4). As well, the SABCS recommends daily exposure times of 12 hours versus 24 hours for parkland use. Note that the 12-hour exposure time will only affect the soil particulate inhalation estimate and therefore, may be of no consequence (i.e. residential and urban park soil standards will still be the same for human pathways). It would only affect groundwater used for drinking water soil standards if a daily ingestion rate adjustment was made based on 12 hours vs. 24 hours.*

.

Table 3: Human Health exposure scenario for Residential/Parkland Land

Defined Land Use Scenario: Residential/urban parkland	- single family home with a backyard - children (all age groups) are present - groundwater may be used as drinking water
Sensitive Receptor	- toddler (threshold contaminants) - toddler and adult (non-threshold contaminants)
Exposure Period	**Residential:** Threshold: (toddler) ET = (24hr/24hr x 7d/7d x 52wk/52wk x 4.5yr/4.5yr) Non-threshold : (toddler) ET = (24hr/24hr x 7d/7d x 52wk/52wk x 6yr/80yr Non-threshold : (adult) ET = (24hr/24hr x 7d/7d x 52wk/52wk x 35yr/80yr) **Parkland** Threshold: (toddler) ET = (12hr/24hr x 7d/7d x 52wk/52wk x 4.5yr/4.5yr) Non-threshold : (toddler) ET = (12hr/24hr x 7d/7d x 52wk/52wk x 6yr/80yr Non-threshold : (adult) ET = (12hr/24hr x 7d/7d x 52wk/52wk x 35yr/80yr)

Direct Soil Exposure Pathways	- soil ingestion - soil particle inhalation - soil dermal contact
Indirect Soil Exposure Pathways	- ingestion of groundwater as drinking water

IB3-Section 4.3.4 - Commercial land defined HH exposure scenario

Issue: Figure 21 of the protocol presents SCEQCCS's defined exposure scenario for commercial land.

Should BC Environment support CCME's defined HH exposure scenario for Commercial land?

CSST Decision: *Yes for assumed appropriate sensitive receptor, exposure period and direct exposure pathway to be used to calculate HH soil-ingestion standards.*

SABCS 2008 Review: *As shown below, the SABCS supports the original CSST 1996 decisions, with the exception of:*

- *Increasing the lifetime to 80 years;*
- *Decreasing the workplace tenure to 25 years*[38] [39] [40]*.*
- *It is noted during preparation of the CSR standards in 1996, the CCME Protocol*[41] *stated that some commercial land use will include childcare centers, and hence toddlers were considered as the most critical receptors on commercial land. In Section 1 of the CSR, childcare centers are designated within the "residential lands classification".*

[38] Heisz, A. 1996. "Changes in Job Tenure and Job Stability in Canada, Report No. 95") Statistics Canada. A detailed analysis of job lengths within Canada during 1991 indicated the average job length (at a specific employer) in Canada was 3.7 years, and in Western Canada the average job length was 3.4 years. For the entire workforce, 94% of the job lengths were less than 20 years.

[39] Personal communication with A. Heisz, Statistics Canada, March 2009. Updated data to 1996, show similar average job lengths to prior data for 1991.. In British Columbia only 5.5% of the workers had job tenure of 20 years. The methodology used by Statistics Canada would not enable an exact determination of the 95th percentile job tenure. For the employment sectors (in the opinion of the SABCS to have the greatest potential for exposure to soil), the following job tenure percentiles were observed at 20 years: 98 percentile for "primary and construction"; 93 percentile for "manufacturing"; and 91 percentile for "distribution services". An 88 percentile at 20 years was observed for "public services" (i.e. 12% of public service employees remained with the same employer at 20 years tenure.). However it is not expected this sector would have a significant potential for exposure to soils.

[40] A very detailed analysis of the U.S. labour force was conducted by Burmaster (Risk Analysis, 2000. Vol. 20, No.2). A survey of residents in 50,000 households in more than 2000 geographic areas in the U.S. indicated the arithmetic means of total industrial job tenures range from 1.41 years for workers in lumber and wood products to 7.48 years for "professional and photographic equipment". The highest 95 percentile for projected tenure was males in the agricultural industry (39 years). For non-agriculture occupations, the 95 percentile ranged from 5.9 years for "handlers, equipment cleaners, helpers and labourers" to 37 years for workers in "primary metals industries". Overall, the 95th percentile values for job tenure for men and women in the manufacturing sector are 25 and 19 years respectively. The U.S. EPA Exposure Manual adopted the 25-year default value to protect workers across a wide spectrum of industrial and commercial sectors.

[41] CCME, 1996. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. Report CCME EPC-101E, March 1996.

Therefore the SABCS suggests removal of "toddlers" as sensitive receptors at commercial land uses. Given the definition of commercial lands within the CSR, it is highly unlikely a toddler would be exposed to contaminated soil 12 hours per day, 5 days a week for 48 weeks of a year at a commercial land such as a shopping center. No child exposure is expected at commercial distribution centers, or sites such as automobile repair facilities. Health Canada[42] indicates that a "child" is a critical receptor at a commercial land use with a daycare, and a 'teen" is designated as the critical receptor at a commercial site "without daycare" (the exposure pathway is "vapour inhalation").

- *The SABCS suggests a separate land use category ("institutional") for daycare centers, schools and community centers.*

Table 4: Human Health Exposure Scenario for Commercial Land

Defined Land Use Scenario: Commercial	- urban commercial property -groundwater may be used as drinking water
Sensitive Receptor	-adult (non-threshold contaminants)
Exposure Period	Threshold: (Adult) ET = (12hr/24hr x 5d/7d x 48wk/52wk x 25yr/25yr) Non-threshold : (Adult) ET = (12hr/24hr x 5d/7d x 48wk/52wk x 25yr/80yr)
Direct Soil Exposure Pathways	- soil ingestion - soil particle inhalation - soil dermal contact
Indirect Soil Exposure Pathways	- ingestion of groundwater as drinking water

[42] Health Canada, 2004. Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)

IB3-Section 4.3.5 - Industrial Land defined HH exposure scenario

Issue: Figure 22 of the protocol presents SCEQCCS's defined exposure scenario for industrial land.

Should BC Environment support CCME's defined HH exposure scenario for Industrial land?

CSST Decision: *No. CSST has recommended that issues relating to the derivation of soil quality standards to protect HH at industrial sites should be referred to the Workers Compensation Board (see decision relating to additional question below).*

SABCS 2008 Review: *SABCS recommends derivation of soil quality matrix standards for "intake of contaminated soils" for industrial lands. The recommended exposure scenarios are noted below.*

Table 5: Human Health Exposure Scenario for Industrial Land

Defined Land Use Scenario: Industrial	- property zoned as industrial -adults have access to property -groundwater may be used as drinking water
Sensitive Receptor	- adult (threshold contaminants) -adult (non-threshold contaminants)
Exposure Period	Threshold: (adult) ET = (12hr/24hr x 5d/7d x 48wk/52wk x 25yr/25yr) Non-threshold : (adult) ET = (12hr/24hr x 5d/7d x 48wk/52wk x 25yr/80yr)
Direct Soil Exposure Pathways	- soil ingestion - soil particle inhalation - soil dermal contact
Indirect Soil Exposure Pathways	- ingestion of groundwater as drinking water

Additional Question

IB3-Section 4.3.5(a) - Role of Worker's Compensation Board in Industrial Site Management

Issue: The Worker's Compensation Board (WCB) is mandated to protect worker's health and safety from exposure to industrial chemicals. Thus if soil quality standards for the protection of human health from contaminants at industrial sites were to be derived by BC Environment using CSST derivation procedures, such standards might conflict with WCB standards.

Should BC Environment specify human health protective soil-ingestion standards for industrial sites or leave the issue of the development of such standards at these sites to the WCB?

CSST Decision: *Based on WCB statutory primacy in this area, CSST recommends that human health soil-ingestion standards not be specified for the industrial land use category in the Contaminated Sites Regulation. Rather the issue of worker safety as it relates to the possible ingestion of contaminants in soil should be regarded as the sole responsibility of the WCB.*

Consequently, in regard to protection of human health, only soil quality standards protective of groundwater used for drinking water, will be derived for industrial lands.

SABCS 2008 Review: *The SABCS recommends derivation of soil quality matrix standards for "intake of contaminated soils" for industrial lands. Industrial properties comprise a significance portion of properties that are assessed under the CSR. The lack of standards for industrial lands provides uncertainty within the CSR process.*

Worker safety in British Columbia is regulated by the B.C. Occupational Health and Safety (OHS) Regulation. The regulation provides a Table of Exposure Limits for "Chemical Agents and Biological Agents". The following observations are made:

- *The workplace limits focus to chemicals in use at a facility.*
- *Worker exposure is primarily assessed on the basis of air concentrations (i.e., as aerosols, dusts, fumes or mists). The exposure levels are compared to ceiling limits, short-term exposure limits, or 8-hour time-weighted-averages (TWA) that are listed in the Table of Exposure Limits.*
- *Substances that contribute significantly to the overall exposure by the skin route are noted. The intent is to alert the reader (of the published limits) that air sampling alone is insufficient to quantity exposure accurately and that measures to prevent significant skin absorption should be considered.*
- *There is no reference to ingestion of substances in WCB guidance.*
- *Substances designated as carcinogens, reproductive toxins and sensitizers are listed. If any such substance is present in the workplace, the employer must replace it, if practical, with a material, which reduces the risk to workers. If it is not practicable to substitute a material which reduces the risk to workers, the employer must implement an exposure control plan to maintain workers' exposure as low as reasonably achievable below the listed exposure limits (Section 5.57 of the OHS Regulation)..*
- *The employer must ensure that no worker is exposed to a substance that exceeds the ceiling limit, short-term-exposure limit, or 8-hour TWA limit.*

The SABCS recommends discussion with the Ministry of Labour, and Citizen Services. However, for now, the SABCS recommends:

- *Soil standards should be derived for industrial sites based on derivation formulae described in this report and using exposure scenarios described in IB3 Section 4.3.5 of this report as there may be elevated levels of chemicals in soil and groundwater that are not currently in use yt the operating facility and would not be captured by the workplace limits. At a minimum, the COPCs from the environmental site investigation should be documented.*

- *The derived standards should be based on separate assessments of ingestion, skin exposure and dust exposure. The dust exposure would be based on 10 milligram/m$^{3.}$ This level is the "Particles Not Otherwise Classified Limit" in the OHS Table of Exposure Limits.*
- *The acceptable inhalation risk concentration calculated by use of the CSR procedures should be compared with the risk associated with inhalation of substances at the levels indicated in the Table of Exposure Limits. If the CSR standards are more stringent, then there should be no conflict with the OHS guidelines.*
- *Further clarification of the derivation of OHS limits using the ACGIH procedures is necessary, particularly for carcinogens. There is a need to clarify the responsibility of a site investigator to a site manager, re: compliance with Section 5.57 of the OHS Regulation where in the presence of carcinogens, the employer may be required to have an exposure control plan to maintain workers' exposure as low as reasonably achievable.*

IB3-Section 5.1 - $PSQC_{HH}$ derivation formula for threshold substances

Issue: Page 89 of the protocol uses the following formula for $PSQC_{HH}$.

$$PSQC_{HH} = \frac{(TDI - EDI) \cdot SAF \cdot BW}{[(AF_I \cdot IR) + (AF_D \cdot DR) + (AF_S \cdot SR)] \cdot ET} + BSC$$

NB The above "CCME protocol" $PSQC_{HH}$ formula effectively uses the RTDI, where RTDI = (TDI - EDI)

Should BC Environment support the "CCME protocol" $PSQC_{HH}$ formula proposed by SCEQCCS for non-carcinogenic substances?

CSST Decision: *See sections 1d and 2.3.1 above - CSST recommends that the "CCME protocol" $PSQC_{HH}$ formula for non-carcinogenic substances should be used, where published data for EDI and BSC (Background Soil Concentration) are available, to calculate a new $PSQC_{HH(EDI)}$ value. This new $PSQC_{HH(EDI)}$ value should then be compared to the value calculated for $PSQC_{HH}$ using CSST's preferred simplified "TDI apportionment based" formula (see below). CSST recommends adoption as the appropriate soil quality standard, of the "more reasonable" of the CCME protocol-based $PSQC_{HH(EDI)}$ or the TDI apportionment-based $PSQC_{HH}$.*

SABCS 2008 Review: *Notes that the use of an EDI (and RTDI) and a soil allocation factor might represent 'double counting' of background exposures. For example, dietary ingestion might figure into both the SAF and EDI.*

SABCS (2008) recommends the following approach:

1. *If a scientifically defensible EDI can be determined which takes into account the contribution from all potentially contaminated environmental media, then no further correction via the SAF is required.*

2. *Alternatively, if insufficient data are available to determine an EDI with confidence, then no correction for EDI would be applied, but an SAF would be used, and would have the value 1/n, where n is the number of*

environmental media in which the contaminant in question could be expected to be present in potentially significant concentrations.

In addition, the correction for background soil concentration should be removed as part of the SABCS (2008) recommended revisions to the CSST protocol (human soil ingestion calculation). It is our position that in general, if the calculations determine that there is a certain threshold safe concentration in soil, then it makes no sense to allow a higher concentration (and correspondingly higher exposure) for province-wide use just because the background concentration of that chemical in a particular region happens to be high. Derivations for which the soil quality guideline is close to or below background levels can be examined on a case-by-case basis.

As per CSST(1996), the SABCS recommends the continued calculation of the human health soil standard ($PSQS_{HH}$) using either equation A or B below, depending on whether an estimated daily intake (EDI) can be confidently developed toward deriving a residual tolerable daily intake (RTDI).

Equation A. Use when a credible Estimated Daily Intake (EDI) value is not available -

$$PSQS_{HH} = \frac{TDI \cdot SAF \cdot BW}{\left(AF_G \cdot IR \cdot D_1 \cdot D_2\right) + \left(AF_S \cdot SA_H \cdot SL_H \cdot D_1 \cdot D_2\right) + \left(AF_L \cdot IR_A \cdot P_{air} \cdot D_1 \cdot D_2 \cdot D_3\right)}$$

Equation B. Use when a credible Estimated Daily Intake (EDI) value is available -

$$PSQS_{HH} = \frac{RTDI \cdot BW}{\left(AF_G \cdot IR \cdot D_1 \cdot D_2\right) + \left[AF_S \cdot \left(SA_H \cdot SL_H + SA_O \cdot SL_O\right) \cdot D_1 \cdot D_2\right] + \left(AF_L \cdot IR_A \cdot P_{air} \cdot D_1 \cdot D_2 \cdot D_3\right)}$$

where:

$PSQS_{HH}$	Preliminary human health-based soil quality standard (mg/kg)
TDI	Tolerable daily intake (mg/kg bw-day)
SAF	Soil allocation factor (unitless)
BW	Body weight (kg)
AF_G	Relative absorption factor for gut (unitless; typically assumed to be 1.0)
AF_S	Relative absorption factor for skin (unitless; chemical dependent)
AF_L	Relative absorption factor for lung (unitless; typically assumed to be 1.0)
IR	Soil ingestion rate (kg/day; age group specific)
SA_H	Skin surface area (hands) exposed (cm^2)
SL_H	Soil loading to exposed hand skin assuming one event/day (kg/cm^2-day)
SA_O	Skin surface area (other than hands) exposed (cm^2)
SL_O	Soil loading to exposed skin (other than hands) assuming one event/day (kg/cm^2-day)
IR_A	Receptor air intake (inhalation) rate (m^3/day)
P_{air}	Particulate concentration in air (kg/m^3)
D_1	Exposure term: days per week exposed/7days
D_2	Exposure term: weeks per year exposed/52 weeks
D_3	Hours per day exposed (h/24 hrs)
RTDI	Residual tolerable daily intake (mg/kg bw-day) = TDI – EDI

The SABCS notes there is no stated policy within the 1996 CSST document regarding the use of risk assessment protocols to develop soil standards for protection of human health. (e.g., are the standards to be based on average, or high-end exposures?). The current MoE policy appears to be as follows:

- A sensitive receptor for a particular land use is selected, e.g. infant/toddler/child/teen or adult.
- Exposure to an "average sensitive receptor" is assumed (i.e. with respect to body weight, skin area, air intake, life-time)
- The 95% upper confidence limit on the arithmetic mean is chosen for parameters directly related to exposures to contaminated soil [i.e., soil ingestion rates, soil loading to skin and time of potential exposure to contaminants (job tenure, and residence tenure)].
- The 95% upper confidence limit would be based on typical human behavior and activities. For example, pica behavior would not be considered for soil ingestion default values. A central tendency soil contact activity should be considered and a high-end - weighted (95% UCL) would be assessed within that activity. A high-end soil contact activity should not be used with a high-end weighted parameter (e.g. a 95% soil loading factor should not be based on a "children in mud" scenario). Instead, a 95th percentile soil-loading factor for daycare children playing indoors and outdoors would be a more reasonable maximum exposure scenario.)
- MoE policy assumes that an individual at a residence or job will exposed continually to the contaminated soil (i.e., 24 hours/day, 7 days/week, 52 weeks/year for a resident, and 12 hours/day, 5 days a week for 48 weeks/year for a commercial/industrial worker). (The SABCS does consider this to be overly conservative,)
- Where data are not available, default values will be based on worst possible scenarios, e.g. absorption rates for ingestion and inhalation could be assumed to be 100%.
- Toxicity reference values (TRVs) are selected as per MoE Technical Guidance 7.

It is recommended that the MoE should have a written transparent policy with respect to development of matrix human health soil standards, to define the desired levels of conservatism. (The policy should also refer to the development of ecological soil standards.)

Are the CSST (1996) procedures for derivation of human health standards different from those of the U.S. EPA?

This section is an addition to previous CSST (1996) report format. As noted in the introduction to this document, the MoE requested the SABCS to assess the U.S. EPA and Health Canada exposure assumptions to determine which agency's assumptions were most scientifically current and supportable. The SABCS provides its assessment in the following text and in Tables 6-8. Table 7 provides the SABCS recommended default values for use in the derivation of soil standards to protect human health. .

- *Equations used by B.C. MoE, Health Canada and CCME to develop soil screening values for non-carcinogenic substances are similar to those used by the U.S. EPA and California EPA.,*

- *Equations used by B.C. MoE, Health Canada and CCME to develop soil-screening values for carcinogenic substances differ from those used by the U.S. EPA. For land uses where childhood exposure may occur, the U.S. EPA apportions the exposure period so that 6 years of childhood exposure is included with the exposure period experienced during adulthood. It is noted this approach is used to develop the soil standards in Schedule 10 of the CSR. As discussed in Volumes I and II, the SABCS recommends the use of this U. S. EPA approach to develop soil standards for carcinogenic substances where residential, urban park, high density urban (HDU) and wildlife land use occurs. Adoption of the approach would better reflect current science and emerging policies.*

- *It is noted that for the development of soil screening levels, the U.S. EPA uses an increased level of apportionment for carcinogens that act through a mutagenic mode of action. The SABCS advises the MoE that Health Canada is currently reviewing this approach, and internationally it appears the approach is at the "moving front of science". If adopted, this approach will affect the current standards, and the SABCS recommends collaboration with Health Canada in this regard.*

- *If the revised CSST document adopts the U.S. EPA procedures for developing guidelines (or standards) to protect children from carcinogens in soil, the resulting standards for carcinogenic substances will be lower than standards derived by use of the CSST (1996) procedures. As shown by example in Appendix G of Volume I, the standard for benzo(a)pyrene (as a carcinogen that acts through a mutagenic mode of action) in residential soil will decrease from 5 to 0.8 mg/kg.*

  During 1996, CSST conducted a review of empirical studies to provide "real world" adjusted standards for arsenic, cadmium and lead. Similar reviews may be required for other substances, following derivation of new standard.

- *Default values are similar (or near similar) in Canada and United States for:*
  - *Average body weights*
  - *Skin areas*
  - *Average life times.*

- *Default values are dissimilar for:*
  - *Life-time exposure to carcinogens*
    - *The default commercial/industrial workplace exposure time in the U.S. is 25 years, vs. the 56 or 60 years assumed by CSST (1996). Health Canada now assumes a 35 year exposure time.*
    - *Following a review of the literature and discussion with Statistics Canada, the SABCS recommends that 25 years be used as an exposure time in commercial and industrial workplaces. (See discussions in IB3-Section 4.3.4.)*
  - *Exposure durations at a residence*
    - *The default residential exposure duration in the U.S. is 31 years, versus an assumed lifetime exposure (e.g. 80 years) as used by MoE, Health Canada and CCME.*

- *Following a review of the literature, the SABCS as per discussion in Volume II, makes the recommendation for the following exposure durations at residences:*
    - *41 years in an urban/non-farm residence*
    - *58 years at a residence on agricultural land.*

- *Soil ingestion*
    - *The default values used by U.S. EPA for soil ingestion are 200 mg/day for children and 100 mg/day for adults, versus the Canadian values of 80 mg/day for children and 20 mg/day for adults.*
    - *Base on a review of the literature as outlined in Volume II, a soil ingestion value of 100 mg/day for children reflects most recent literature reported findings. An opinion rendered by a key researcher in this area, suggests 50 mg/day may be more appropriate for adults. However, the confidence level in data of adult soil ingestion rates remains low, and the SABCS recommends addition review of recent data prior to consideration of modifying the Canadian value of 20 mg/day. . A recent review of ingestion data conducted for Health Canada also suggests the 20 mg/day intake by adults. [43] It is noted the review suggests retention of the 80 mg/day soil ingestion rate for children.*

- *Soil contact*
    - *Skin surface areas for individual body parts are similar in both countries. For the purpose of risk assessment, similar skin areas of toddlers are used in both countries to evaluate dermal uptake of contaminants. However, for adult exposures in residential scenarios, the U.S. EPA uses skin areas that are greater than those suggest by CCME. The U.S. EPA default values include residents who may frequently wear shorts (i.e. in the Southern U.S., hence leg exposure) versus no leg exposure considered for Canada. The SABC suggests retaining the CCME recommended values for skin areas.*
    - *There are large differences in the values for "skin loading to exposed skin". As discussed in Volume II, the values recommended by CCME and Health Canada are much lower than those adopted by U.S. EPA, and levels suggested in the literature[44]. The values used by U.S. EPA appear more indicative of finding reported in the literature. Likewise, there are significant differences in skin absorption factors for several substances as noted in Table 8 of this report. The SABCS recommends a detailed review to resolve these issues.*
    - *Recent U.S. EPA assessment has suggested that for some substances, dermal exposure may be very significant. The SABCS recommends identification of the classes of substances that may constitute significant*

[43] Wilson Scientific and Meridian Environmental, 2006. Critical Review of Soil Ingestion Rates for Use at Contaminated Site Human Health Risk Assessment in Canada. Prepared for Health Canada Contaminated Sites Division.

[44] It is noted the CSST(1996) "skin loading factor " default value is higher than the U.S. EPA default value. .

intake via skin exposure, and that the soil standards for such substances include consideration of skin exposure.

With regard to policies, it is note U.S. EPA policies relating to risk characterization are distinct and include:

- *The requirement by the chief administrator, for transparency, clarity, consistency and reasonableness with the subsequent designation of an Implementation Team to assure the requirements are addressed. The policy is reflected in the following examples:*
    - *An 1153 page U.S EPA "Exposure Factors" handbook has been prepared to provide the bases for selection of default exposure factors to be used in risk assessments. All relevant literature is described in detail; the rationale for each recommended default value is provided; and, an assessment of confidence levels is provided.*
    - *The policy for providing soil-screening guidelines includes the criteria for exposure scenarios and data sets that would be used within the risk based formulae: e.g., the guidelines specify the use of the median values for body weight, skin area and respiration rates; 95 percentiles for exposure times, soil ingestion and skin loading; and, 100% absorption factors for ingestion and respiration.*
    - *There is an explicit EPA written policy for enhanced evaluation and research related to risk to children and infants from pollution in air, land and water.*

Table 6: Review of Default Values for Soil Standard Calculations

Receptor Characteristic	Toddler	Adult
Age	0.7 mo- 4 yr	>20 yr
Body Weight (kg)	16.5 (Health Canada)[45] 15 (U.S. EPA) (1-5 years)[46]	70.7 (Health Canada)[45] 70 (U.S. EPA)[46]
Soil Ingestion Rate (kg/day)	80×10^{-6} (Health Canada)[45] 200×10^{-6} (U.S. EPA)[47] 100×10^{-6} (Calabrese)[48] 106×10^{-6} (Stanek and Calbrese),[49] 100×10^{-6} (MDEP)[50]	20×10^{-6} (Health Canada)[45] 100×10^{-6} (U.S. EPA for residential and agricultural)[46] 50×10^{-6} (U.S. EPA for industrial setting)[46] 50×10^{-6} (Calabrese)[48]

[45] Health Canada, 2004. Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)
[46] U.S. EPA, 1997. Exposure Factors Handbook
[47] (conservative mean estimate) U.S. EPA (1997). Exposure Factors Handbook.. (U.S. EPA confidence in value for children is rated "medium". The confidence in the value for adults is rated "low".)
[48] (recommended upper bound), Calabrese, E.J., 2003. Letter to Kevin Holtzclaw, General Electric. Re: Housatonic River Risk Assessment
(recommended central tendency: 20 mg/day for children: 10 mg/day for adults)
[49] (95 percentile over one year exposure) . Stanek, E.J., and E.J. Calabrese, 2000. Daily Soil Ingestion Estimates for Children at a Superfund Site, In: Risk Analysis 20(5), pp 627-635.

		50 x 10^{-6} (MDEP)[50]
Inhalation Rate (m^3/d)[51]	9.3 (Health Canada) [45] 6.8-8.3 (U.S. EPA)[46]	15.8 (Health Canada) [45] 15.2- males (U.S. EPA) [46] 11.3 females (U.S. EPA) [46]
Skin Surface Area(m^2)	Hands: 0.043[52] (CCME) Other (arms and legs): 0.258 (CCME) [52] Face, forearms, hands, lower legs, feet: 0.28 [53](U.S. EPA)	Hands: 0.089 (CCME) [52] Other (arms): 0.25 (CCME) [52] Face, forearms, hands and lower legs: 0.57 (U.S. EPA-residential)[53] Face, hands and forearms: 0.33 (U.S. EPA-commercial/industrial)[53]
Soil Loading to Exposed Skin (kg/cm^2/event)	Hands: 1 x 10^{-7} (Health Canada)[45] Surfaces other than hands: 1 x 10^{-8} (Health Canada)[45] Child: 2 x 10^{-7} (body part weighted) (U.S. EPA)[46]	Hands: 1 x 10^{-7} (Health Canada)[45] Surfaces other than hands: 1 x 10^{-8}) [45] Adult: 0.7 x 10^{-7} (body part weighted-residential) (U.S. EPA)[46] Adult: 2 x 10^{-7} (body part weighted-commercial/industrial [46]

Table 7: Recommendations re: default values

Receptor Characteristic	SABCS Assessment	SAB Recommendations
Age (Group)	U.S. and Canada categories are similar.	No changes required.
Body Weight (kg)	Similar body weights are assumed in U.S. and Canada.	No changes required. 16.5 kg (Toddler) 70.7 kg (Adult)
Soil Ingestion Rate (IR) (kg/day)	For children, the more recent data indicates the IR used by Health Canada/CSST is a bit low.	A change from 80 x 10^{-6} kg/day to 100 x 10^{-6} kg/day is recommended as a child IR[54].

[50] (Enhanced ingestion rate) Massachusetts Department of Environmental Protection, 2002. Technical Update, Calculation of an Enhanced Soil Ingestion Rate

[51] No significant differences are noted between U.S. EPA and Health Canada; hence the SABCS suggests retaining the inhalation rates as recommended by Health Canada.

[52] CCME, 1996. A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. Report CCME EPC-101E, March 1996.

[53] U.S. EPA, 2004. Risk Assessment Guidance for Superfund (RAGS), Part E. Supplemental Guidance for Dermal Risk Assessment (Interim)

[54] The studies of child soil ingestion rates by Stanek and Calabrese (2000) reflect current science. The studies were well designed and there was a large sample size. As well as assessing the adequacy of each of eight trace elements

	For adults, the Health Canada/CSST SIR is significantly less than IR used by U.S. EPA and as recently suggested by investigators. (i.e., a level of 50 x 10^{-6} kg/day versus 20 x 10^{-6} kg/day as used in Canada)	No change in the adult SIR is recommended at this time, i.e., retain 20 x 10^{-6}. The confidence in existing data for adult soil-ingestion is low relative to the confidence in data for children. The SABCS notes Health Canada is undertaking further study in this area. The IR for adults should be reviewed upon completion of the Health Canada studies. [55]
Inhalation Rate (m^3/d)[56]	U.S. and Canada default values for inhalation rates are similar.	No changes required. (Children) 9.9 (Adults) 15.8
Skin Surface Area(m^2)	U..S. and Canada default values for total skin surface areas in children are similar. Canadian protocols separate hand skin area from "other skin" areas. In Canada skin areas assumed for exposure in adults in residential areas are about 50% of U.S. assumptions. U.S. EPA considers frequent use of shorts for outdoor activities by residents in many areas of the U.S., hence leg exposure is also considered. Total skin areas for commercial/industrial workers are similar in the U.S. and Canada. U.S. protocols consider all body parts separately.	The U.S. EPA considers residential skin exposure to include face and legs (i.e. wearing of shorts), in addition to hands and arms. CCME and Health Canada only consider hand and arm exposure. CCME rationale for selecting only arm and hand exposure is not provided. The SABCS defers this as a policy issue. Given the low frequency of days in a year, shorts could be worn in Canada; the SABCS suggests that the current Health Canada assumption for skin exposure remains.
Soil Loading to Exposed Skin (kg/cm^2/event)	Different approaches occur whereby Health Canada[39] has two different soil loading factors: one for hands and	There is a need to improve the transparency of the recommendations provided by Health Canada. For

for evaluating soil ingestion, the study assessed variance components such as soil ingestion between subjects, between days on a subject, and uncertainty on a subject day. 95th percentiles of soil ingestion were predicted over 7 days, 30 days, 90 days and 365 days.

[55] The confidence in data for adult soil-ingestion is low relative to the confidence in data for children. The published studies for adult intake have so far focused on a small number of adult(s), e.g. ten versus the 64 children used in the study by Stanek and Calabrese. Wide variances in data were observed among the small adult study groups. It is noted Health Canada in its draft work plan for 2008-2009 (Safe Environments Programme) proposes to further assess soil ingestion rates using cesium as a marker.

[56] No significant differences are noted between U.S. EPA and Health Canada, hence the SABCS suggests retaining the inhalation rates as recommended by Health Canada.

	the other for surfaces other than hands. The U.S. EPA body part weighted soil loading factors are different for children and adults. As well different soil loading factors are provided for adult (residential) and for adult (industrial/commercial).[50] Overall it is noted the soil loading factors used by the U.S. EPA are greater than those used by Health Canada. For example, for a child, the U.S EPA weighted soil adherence factor is $2x10^{-7}$ kg/cm^2. Health Canada indicates a soil-loading factor of 1 x 10^{-7} kg/cm^2 for hands and 1x 10^{-8} kg/cm^2 for other surfaces. The weighted soil adherence factor using the Health Canada recommendations would be $0.2x10^{-7}$ kg/cm^2	instance the U.S. EPA Supplemental Guidance for Dermal Risk Assessment details the rationale for selection of the recommended skin exposure areas and soil loading factors. There are obviously disparities between Health Canada and U.S. EPA approaches for dermal contact, even with the use of the same scientific literature as reference. The SABCS recommends a detailed review to further assess the differences between Canadian and U.S. default values used for dermal risk assessment. Until the review is completed, the SABCS can only recommend continuation of use of current default values for dermal contact as shown in Table 6.

Table 8: Comparison of U.S. EPA AF_{dermal} with Health Canada AF_{dermal} (Skin absorption factors)

Chemical	Health Canada AF_{dermal}	U.S. EPA AF_{dermal}[57]
Benzo(a)pyrene	0.1	0.13
Cadmium	0.14	0.001
Chlordane	0.05	0.04
DDT	0.2	0.03
Di-nitrotoluene, 2,4	0.13	10.2
Lindane		0.04
Pentachlorophenol	0.11	0.25
PCBs 1254/1242		0.14
Semivolatile organic compounds	0.1	0.1
TCDD and other dioxins		0.03 0.001 (if soil organic content is >10%)

[57] U.S. EPA, 2004. Risk Assessment Guidance for Superfund (RAGs), Volumes I: Human health Evaluation Manual (Part E, Supplemental Guidance of Dermal Risk Assessment) Interim

IB3-Section 5.1 - $PSQC_{HH}$ derivation formula for threshold substances

Issue: CSST has recommended that a preferred simplified "TDI apportionment-based" $PSQC_{HH}$ value based on a 20% apportionment of the TDI, always be calculated.

See CSST decisions relating to: IB1 - Section 2.3.1. , and
IB3 - Section 1(c) and Section 4.1.1.

In view of CSST's decisions, the following "TDI apportionment-based" $PSQC_{HH}$ derivation formula was proposed:

$$PSQC_{HH} = \frac{[SAF \times TDI] \times BW}{[(AF_I \times IR) + (AF_D \times DR) + (AF_S \times SR)] \times ET}$$

where SAF = 0.2

Should BC Environment support CSST's above simplified "TDI apportionment based" $PSQC_{HH}$ derivation formula?

CSST Decision: *Yes for threshold substances. Use SAF = 0.2 as standard default apportionment factor for TDI.*

SABCS 2008 Review: *See IB1-Section 2.3.1 and IB3 Section 4.1.1.*

IB3-Section 5.2 - $PSQC_{HH}$ derivation formula for non-threshold substances

Issue: For non-threshold substances, page 90 of the protocol uses the following formula to derive a CCME recommended $PSQC_{HH}$ value:

$$PSQC_{HH} = \frac{RsDxBW}{[(AF_I \times IR) + (AF_D + DR) + (AF_S \times SR)] \times ET}$$

NB The formula assumes adult is critical receptor

Should BCE support CCME's above recommended $PSQC_{HH}$ derivation formula for carcinogenic substances?

CSST Decision: *Yes, use formula but RsD should be based on 1 x 10^{-5} acceptable risk.*
Note that ET (Exposure Time) should be based on a 70 year lifetime for agricultural, residential, urban park and commercial land use scenarios.

SABCS 2008 Review:

- *The CCME derivation formula for carcinogenic compounds is appropriate for evaluating risk to adults. For greater transparency, the SABCS recommends replacement of the term "RsD" with the equivalent "Target risk(TR) divided by the accepted cancer slope factor (CSF)".*
- *Based on discussions in IB3 (Section 1), the generic CSR soil standards to protect human health from exposure to carcinogens should be based*

on ingestion and dermal contact, given that there are now CSR measurement guidelines and generic numerical vapour standards.

- *For generic soil standards based on exposure to dust, airborne respirable dust levels are anticipated to be generally insignificant relative to direct ingestion of soil and water, and to dermal absorption[58]. However, at certain sites, exposure corresponding to the respirable dust pathway should be calculated for site-specific conditions if deemed appropriate by the assessor. As noted previously, assessment of dust intake at industrial sites may be required.*
- *The SABCS notes that various agencies and organizations are assessing the concept of exposure amortization in cancer risk assessments to provide emphasis on early life stage exposure to contaminants. For example, the U.S. Executive Order 13045 requires that "each Federal Agency shall make it a high priority to identify and assess environmental health and safety risks that may disproportionately affect children…" Depending on available data, the US EPA recommends characterization of risk separately for susceptible populations and life stage (i.e. children).[59] Further efforts in this area are encouraged by the U.S. EPA Science Advisory Board[60]. The SABCS recommends the acceptance of similar policies for British Columbia.*
- *The SABCS therefore recommends that the methodology used by the U.S. EPA[61] to develop residential soil "screening levels" should be used to develop the CSR soil standards for carcinogenic substances at properties where childhood exposure may occur. The methodology as described in this section places greater emphases on the potential impact of childhood exposure to carcinogenic chemicals. The same methodology is used by California EPA.[62]*
- *Periodic review of ongoing related research is recommended to ascertain that the derived "standards" reflect adequate protection for children.*
- *Default values for the development of the CSR soil standards should be consistent with 2004 Health Canada recommendations with the exception of:*
    - *Adoption of a life expectancy of 80 years. This is consistent with (i) recent census data for increased average longevity in BC populations, and (ii) proposed changes by Health Canada. While not an upper percentile estimate of longevity, an assumed lifespan substantially greater than this would not appreciably affect exposure calculations.*
    - *For workers it is suggested that the carcinogenic risk be based on an exposure term of 25 years as discussed in Section IB3-4.3.4.*

---

[58] Health Canada, 2004. Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)

[59] U.S. EPA, 2005. Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum Technical Panel.

[60] U.S. EPA Science Advisory Board, 2007. Letter to the U.S. EPA Administrator re: Consultation on Enhancing Rick Assessment Practices and Updating EPA's Exposure Guidelines.

[61] E.g. U.S. EPA Region IX. Superfund- Preliminary Remediation Goals. http://www.epa.gov/region09/superfund/prg/rsl-table.html

[62] California Environmental Protection Agency, 2005. Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil.

- *The soil ingestion rate for a toddler should be 100 mg/day.*
- *As discussed in Section 1B3-4 of this report the SABCS recommends the following "years of exposure" to residential and agricultural sites:*
  - *41 years for urban and non-farm residences (6 years as a child and 35 years as an adult).*
  - *58 years for farm residences (6 years as a child and 52 years as an adult).*
- *As suggested in C3.1.29(c) of Volume I, the U.S.EPA approach for assessing mutagens carcinogens that act through a mutagenic mode of action (MOA) must be considered in the future. It is noted Health Canada is reviewing the concept. The soil guideline derivation formula and a sample calculation are provided in Appendix G of Volume I. The example, using benzo(a)pyrene as the test substrate, shows that the calculated guideline becomes more stringent. .*

The SABCS recommends the following formulas be used to develop soil standards for carcinogenic substances.

$PSQC_{HH}$ derivation formula- Ingestion (Commercial, industrial workers)

The following formula should be used to derive soil standards for protection of adults (e.g. commercial and industrial scenarios) from exposure to carcinogenic compounds (via ingestion):

$$PSQC_{HH-Ing} = \frac{TR \cdot BW \cdot LE}{(AF_G \cdot IR_S) \cdot D1 \cdot D2 \cdot D3 \cdot CSF}$$

Where

Equation Term		*DEFAULT VALUE*	*UNITS*
$PSQS_{HH}$	*Preliminary human health based soil standard*		*mg/kg*
TR	*Target Risk*	10^{-5}	*unitless*
BW	*Body weight*	*70*	*kg*
LE	*Life expectancy*	*80*	*yrs*
CSF	*Cancer slope factor*	*Chemical specific*	$(mg\backslash kg\text{-}day)^{-1}$
AF_G	*Relative absorption factor for gut.*	*Assumed to be 1.0*	*unitless*
IR	*Soil ingestion rate (kg/day; adult)*[63]	20×10^{-6}	*kg/day*

[63] As per Health Canada (2004), soil ingestion exposures are considered to be independent of the time spent outdoors. "Although it is unlikely that ingested soil would be delivered as a single bolus dose, it is equally unlikely

D_1	*Days per week exposed/7 days*	*5/7*	*days/days*
D_2	*Weeks per year exposed/52 weeks*	*48/52*	*weeks-weeks*
D_3	*Total years exposed to site*	*25*	*years*

<u>PSQC$_{HH}$ derivation formula- Ingestion (where childhood exposure may occur- residential and parkland)</u>

The following formula should be used to derive soil standards for human health protection where part of the lifespan includes childhood exposure (e.g. residential and parkland scenarios) to carcinogenic compounds (via ingestion of soil):

$$PSQC_{HH-Ing} = \frac{TR \cdot LE}{CSF \cdot D_1 \cdot D_2 \cdot IF_{soil/adj}}$$

Where:

Equation Term		*DEFAULT VALUE*	*UNITS*
$PSQS_{HH}$	*Preliminary human health based soil standard*		*mg/kg*
TR	*Target Risk*	10^{-5}	
LE	*Life expectancy*	*80*	*years*
CSF	*Cancer slope factor*	*Chemical specific*	*(mg\kg-day)* $^{-1}$
D_1	*Days per week exposed/7 days*	*7/7*	*days/days*
D_2	*Weeks per year exposed/52 weeks*	*52/52*	*weeks-weeks*
$IF_{soil/adj}$	*Age-adjusted soil ingestion factor*	*Calculated below*	*(mg-yr/kg-day)*

And:

$$IF_{Soil/adj} = \frac{IR_{soil/age1-6} \bullet ED_{age1-6}}{BW_{age1-6}} + \frac{IR_{soil/age6-41} \bullet ED_{age6-41}}{BW_{age6-41}}$$

Where:

Equation Term		DEFAULT VALUE	UNITS
$IF_{soil/adj\ (urban/non-farm)}$	*Age-adjusted soil ingestion factor) (urban/non-farm residences)*	*42 x* 10^{-6}	*(kg-yr/kg-d*

that intake would be distributed uniformly throughout the day." "Therefore for purposes of conservatism, 100% of the daily unintentional intake of contaminated soil should be assumed."

$IF_{soil/adj\ (farm)}$	*Age-adjusted soil ingestion factor (farm residences)*	54×10^{-6}	*(kg-yr/kg-d)*
$IR_{soil/age\ 1-6}$	*Ingestion rate of soil age 1-6*	100×10^{-6}	*kg/day*
$IR_{soil/age\ 6-41}$	*Ingestion rate of soil*	20×10^{-6}	*kg/day*
ED_{age1-6}	*Exposure duration during ages 1-6 (yr)*	*6*	*years*
$ED_{age6-41}$	*Exposure duration during ages 6-41 (yr) (urban/ non-farm residences)*	*35*	*years*
$ED_{age6-58}$	*Exposure duration during ages 6-58 (yr) (farm residences)*	*52*	*years*
BW_{age1-6}	*Average body weight from ages 1-6*	*16.5*	*kg*
$BW_{age7-41}$	*Average body weight from ages 7-41 and ages 7-58*	*70*	*kg*

<u>$PSQC_{HH}$ derivation formula- Dermal (Commercial, industrial workers)</u>

The following formula should be used to derive soil standards for protection of adults (e.g. commercial and industrial scenarios) from exposure to carcinogenic compounds (via skin contact):

$$PSQS_{HH-dermal} = \frac{TR \cdot BW \cdot LE}{CSF \cdot \left[SA_H \cdot SL_H + SA_O \cdot SL_O\right] AFs \cdot EF \cdot D_{1\cdot} \cdot D_2 \cdot D_3}$$

Where:

Equation Term		*DEFAULT VALUE*	*UNITS*
$PSQS_{H-dermal}$	*Preliminary human health based soil standard*		*mg/kg*
TR	*Target Risk*	10^{-5}	
BW	*Body weight*	*70*	*kg*
LE	*Life expectancy*	*80*	*Years*
CSF	*Cancer slope factor*	*Chemical specific*	*(mg\kg-day)* $^{-1}$
AF_S	*Dermal absorption factor (unitless)*	*Chemical specific*	
SA_H	*Skin surface area exposed (hands)*	*890*	cm^2
SL_H	*Soil loading to exposed skin (hands)*	1×10^{-7}	*(kg/*cm^2*-event)*
SA_O	*Skin surface area exposed (other than hands)*	*2500*	cm^2
SL_O	*Soil loading to exposed skin (other than hands)*	1×10^{-8}	*(kg/*cm^2*-event)*

EF	*Exposure frequency*	*1*	*(events/d)*
D_1	*Days per week exposed/7 days*	*5/7*	*Days/days*
D_2	*Weeks per year exposed/52 weeks*	*48/52*	*Weeks/week*
D_3	*Total years exposed to site*	*25*	*Years*

$PSQC_{HH}$ derivation formula- Dermal (where childhood exposure may occur- agricultural, residential and parkland)

The following formula should be used to derive soil standards for human health protection where part of the lifespan includes childhood exposure (e.g. agricultural, residential and parkland scenarios) to carcinogenic compounds (via skin contact):

$$PSQS_{HH-dermal} = \frac{TR \cdot LE}{CSF \cdot AF_{skin} \cdot EF \cdot DFS_{adj} \cdot D_{1} \cdot D_{2} \cdot}$$

***W**here:*

Equation Term		*DEFAULT VALUE*	*UNITS*
$PSQS_{HH-dermal}$	*Preliminary human health based soil standard*		*mg/kg*
TR	*Target Risk*	*10^{-5}*	
LE	*Life expectancy*	*80*	*Years*
CSF	*Cancer slope factor*	*Chemical specific*	*(mg\kg-day) $^{-1}$*
AF_S	*Dermal absorption factor (unitless)*	*Chemical specific*	
EF	*Exposure frequency*	*1*	*(events/d)*
DFS_{ADJ}	*Age adjusted soil dermal contact factor*	*Calculated below*	*Kg-year/kg-day*
D_1	*Days per week exposed/7 days*	*7/7*	*Days/days*
D_2	*Weeks per year exposed/52 weeks*	*52/52*	*Weeks/week*

Where:

$$DFS_{adj} = \frac{D_{3C} \cdot (SA_{C-H} \cdot SL_H + SA_{C-O} \cdot SL_O)}{BW_C} + \frac{D_{3A} \cdot (SA_{A-H} \cdot SL_H + SA_{A-O} \cdot SL_O)}{BW_A}$$

Where:

Equation Term		*DEFAULT VALUE*	*UNITS*
D_{3C}	*Exposure time at site (child)*	*6*	*Years*
$D_{3A\ (urban/non-farm)}$	*Exposure time at site (adult) (urban/non-farm)*	*35*	*Years*
$D_{3A\ (farm)}$	*Exposure time at site (adult) (farm)*	*52*	*Years*
SA_{C-H}	*Skin surface area exposed-child (Hands)*	*430*	cm^2
SA_{A-H}	*Skin surface area exposed-adult (Hands)*	*890*	cm^2
SA_{C-O}	*Skin surface area exposed Child (other than hands)*	*2580*	cm^2
SA_{A-O}	*Skin surface area exposed Adult (other than hands)*	*2500*	cm^2
SL_H	*Soil loading to exposed hands*	1×10^{-7}	$(kg/cm^2\text{-event})$
SL_O	*Soil loading to exposed skin other than hands*	1×10^{-8}	$(kg/cm^2\text{-event})$
BW_C	*Body weight*	*15*	*kg*
BW_A	*Body weight*	*70*	*kg*

PSQC$_{HH}$ derivation formula

As per discussion in IB3-Section 1, the generic soil standards for carcinogenic compounds would be:

$$PSQS_{HH} = \frac{1}{\frac{1}{PSQS_{HH-dermal}} + \frac{1}{PSQS_{HH-ingestion}} + \frac{1}{PSQS_{HH-inhalation}}}$$

As noted previously, PSQS $_{HH\text{-}inhalation}$ may have to be calculated for dust exposure at industrial land-use sites or for properties located adjacent to contaminated sites that have no soil cover. For other land-use sites, the risk due to inhalation of dust particles would be insignificant.

In the case that data are not available to assess PSQS$_{HH\text{-}dermal,}$ then the generic soil standard at all land use sites (except industrial) would be based solely on ingestion.

IB3-Section 5.3.2 - Need for Groundwater Check

Issue: The protocol presents a GW leachate model which can calculate for non ionic organic contaminants only, a soil concentration which will not result in GW exceeding the Drinking Water (DW) guideline

Should BCE support the need to protect GW used as DW from soil contaminants?

CSST Decision: *Yes. See also IIB1a below.*

SABCS 2008 Review: *Supports the original CSST 1996 decision.*

IB3-Section 5.3.2(a) - GW Check Preferred Model

Issue: CSST noted that SCEQCCS recommended a relatively unsophisticated model be used to calculate soil-groundwater protective standards.

Should BCE support the specific leachate model presented in the protocol to back calculate soil contaminant concentrations which would not result in GW contamination in excess of appropriate DW guidelines?

CSST Decision: *No. CSST has recommended use of alternative soil to GW contaminant fate and transport models, which are believed to offer a level of protection, which is more consistent with CSST principles. See also IIB1b below.*

SABCS 2008 Review: *SABCS notes that MoE is conducting a 2008 review of the 1996 CSST groundwater model and therefore, it would be premature to recommend changes in procedures and/or policy at this time. It is noted the SABCS has previously provided comments on contaminant transport in groundwater, with the intent to aid the Ministry in its review process*[64, 65, 66, 67].

IB3-Section 5.3.2(b) - GW Check Mandatory Use

Issue: The protocol views the GW check as a mandatory actionable check (i.e. if the GW check produces a soil criterion more stringent than the CCME recommended $PSQC_{aH}$, then the GW based criterion must be used in place of the $PSQC_{HH}$).

Should BCE support use of the GW check as a mandatory actionable check mechanism for $PSQC_{HH}$?

[64] SABCS, 2005. Report on Screening Level Risk Assessment SLRA Level 1 and SLRA Level 2 (Groundwater Module)
[65] Golder Associates, 2005. Report to SABCS- "Approaches and Methods for Evaluation Vertical Transport in Groundwater-Hydrogeological Assessment Tools Project.
[66] SABCS, 2006. Report on Hydrogeological Assessment Tools for Modeling Transport of Metals in Groundwater.
[67] SABCS, 2006. Report on Hydrogeological Assessment Tools to Determine the Rate of Biodegradation for Organic Contaminants in Groundwater.

CSST Decision: CSST *recommends that the GW as DW "check" should be incorporated as a specific discrete soil quality standard for all land uses. See IIB1a below.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision. However, the SABCS urges expediency in completion of the MoE review of the CSST groundwater model to ascertain that the best current science is considered.*

IB3-Section 5.3.3 - Produce/Milk/Meat (Vegetable check)

Issue: The protocol presents a complex and elaborate check procedure to ensure that the derived $PSQC_{HH}$ do not inadvertently result in unacceptable contributions to the total daily intake of contaminants via home-grown produce, meat and milk. This procedure not only estimates the contaminant transfer to produce/milk/ meat based on questionable bio-concentration factor (BCF) values, but it also estimates the type and amounts of foods grown on-site and the amounts of such foods actually consumed on-site.

The protocol proposes that this "vegetable" check be a mandatory actionable check mechanism on Agricultural lands and "recommends" that it also be so used on residential sites for backyard garden produce.

Should BCE support the produce/meat/milk check as a mandatory actionable check mechanism for $PSQC_{HH}$ on Ag, and R/P lands?

CSST Decision: No see Section 4.3.2 above.

SABCS 2008 Review: *See discussion IB3-Section 1(a). The SABCS suggests an evaluation of the procedure described in the CCME (2006) report, particularly for agricultural land use.*

IB3-Section 5.3.4 - Indoor Air Volatilization Check

Issue: The protocol presents in Appendix 9, a check mechanism designed to ensure that volatile organic contaminants do not migrate into the basements of buildings and thus pose a potential HH indoor air contamination risk.

The SCEQCCS recommends that this check be considered a mandatory actionable check to be applied to the CCME recommended $PSQC_{HH}$ for all four land categories.

The CCME model is based on a residential home (parameter value estimates were subjected to stochastic analysis). There is some question then as to how relevant the modeled conditions (i.e. residential building parameters) might be if applied to a generic industrial site (i.e. large factory building parameters).

The CCME model calculates $PSQC_{HH}$ soil criteria for volatile substances, which result in indoor air concentrations, which would not be expected to exceed 20% of the inhalation reference dose for non-carcinogenic substances or a carcinogenic risk level in excess of $1 \times 10^{-6.}$

Should BCE support use of the indoor air volatilization check as a mandatory actionable check mechanism for $PSQC_{HH}$ across all land uses?

CSST Decision: *No. CSST believes the "state of science" regarding air infiltration modeling is not sufficiently developed at this time, to allow meaningful generic indoor air volatilization checks to be calculated.*

However, CSST has also encouraged BC Environment to initiate Indoor Air Infiltration model validation studies and has recommended that the above decision should be revisited in light of the results of such studies in the future. See also CSST decision relating to section 1 above.

SABCS 2008 Review: SABCS notes that concerns related to exposures to contaminating vapours at contaminated sites has since been addressed in the short term by the MoE "Generic Numerical Vapour Standards" which came into effect January 1, 2009 and address volatile and semi-volatile substances directly. The SABCS also approves of the Director's use of generic soil vapour standards (rather than soil matrix standards) to provide indoor air volatilization checks.

IB3-Section 5.3.5 - Off-site Dust Check

Issue: Appendix 6 of the protocol recommends that an "off-site dust" check incorporating an erosion model be applied to the CCME recommended $PSQC_{HH}$ value calculated for industrial land. The purpose of this check is to ensure that the transfer of eroded soil contaminants from industrial sites remediated in compliance with the CCME recommended $PSQC_{HH}$ value will not result in soil contamination on neighboring R/P properties in excess of the $PSQC_{HH}$ - R/P.

The CCME model first estimates, wind erosive transfer of soil from industrial lands to neighboring R/P properties. The model then estimates the degree of mixing of eroded and native soil on the R/P site. Finally the model back-calculates a contaminant concentration in the soil of the industrial site which would not be expected to result in contamination of the neighboring R/P site in excess of the R/P criterion.

The protocol states in Appendix 6, that "if the $PSQC_{HH}$ for the industrial site exceeds Ci (i.e. the concentration in eroded soil), then the SQC_{HH} should be set to equal Ci." A further recommendation is made to "cap" all P SQC_{HH} calculated for Industrial lands at 15x the SQC_{HH} for residential sites to protect against possible off-site contamination.

Should BC Environment support the use of the off-site dust check as a mandatory actionable check for $PSQC_{HH}$ on industrial lands?

CSST Decision: *No. CSST believes such potential off-site pollution of neighboring properties can be better controlled through the application of existing BC Environment legislative and regulatory controls.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision. Additional comments regarding dust inhalation are provided in IB3-Section 1.*

IB3-Section 6 - Derivation of Final SQC_m for Various Land Uses

Issue: The protocol establishes the following final SQC_{HH} for various land uses:

Agricultural lands

Final SQC_{HH} = most stringent of -
1. Agricultural PSQC
2. GW Check
3. Volatile Indoor Air Check
4. Vegetable produce check

Residential/Parkland

Final SQC_{HH} = most stringent of -
1. Residential / Parkland $PSQC_{HH}$
2. GW Check
3. Volatile Indoor Air Check

It is also recommended that;
1. Vegetable produce check be viewed as an additional Major Adjustment Factor (MAF) to be considered in determining final $SQC_{HH.}$

Commercial Lands

Final SQC_{HH} = most stringent of -
1. Commercial $PSQC_{HH}$
2. GW Check
3. Volatile Indoor Air Check

Industrial Lands

Final SQC_{HH} = most stringent of -
1. Industrial $PSQC_{HH}$
2. GW Check
3. Volatile Indoor Air Check

It is also recommended that:
1. Off-site dust check be viewed as an additional Major Adjustment Factor (MAF) to be considered in determining final $SQC_{HH.}$

Should BC Environment support use of the above CCME procedures in derivation of final SQC_{HH} for various land uses?

CSST Decision: *CSST supports only the use of the following procedures to calculate SQC_{HH} values for use as HH matrix standards, for the various land uses:*

1. Agricultural Lands

Calculate discrete SQC_{HH} values for;
1. Agricultural $PSQC_{HH}$
2. GW Check

2. Residential/Urban Parkland

Calculate discrete SQC_{HH} values for;
1. Residential/Urban Parkland $PSQC_{HH}$
2. GW Check

3. <u>Commercial Lands</u>

Calculate discrete SQC_{HH} values for; *1. Commercial $PSQC_{HH}$*
2. GW Check

4. <u>Industrial Lands</u>

Calculate discrete SQC_{HI}, values for; *1.GW Check*

SABCS 2008 Review: *SABCS recommends the following requirements be added:*

4. <u>Industrial Lands</u>

Also calculate discrete SQC_{HH} values for Industrial $PSQC_{HH}$

5. High Density Urban

Calculate discrete SQC_{HH} values as per exposures in Table 3.

6. Wildlands

Calculate discrete SQC_{HH} values as per exposures in Table 3

IB4. CSST Decisions Related to CCME Protocol Part D - Final SQC Part D. Derivation of Final SQC

IB4-Section 1.1 - Final criteria derivation

Issue: The protocol sets a single final soil quality criterion (SQC_F) for each substance for each land use category, as the most stringent of the final SQC_{EE} and the final SQC_{HH}.

Should BCE support final derivation of a single final SQC?

CSST Decision: *No, CSST recommends calculation of discrete $SQCE_E$ and SQC_{HH} values for use in establishing discrete site-specific factor associated soil quality standards. See also additional question below.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision to ensure CSR Schedule 5 standards remain in "matrix" form. . This allows, for example, use of discrete pathway receptor standards as COPC screening values when applying risk-based standards where at least one mandatory numerical standard for a substance is exceeded and a risk assessment is being conducted.*

Additional Question

IB4-Section 1.1(a) - Need to Identify "Mandatory" Soil Quality Standards

Issue: The standards of the Contaminated Sites Regulation act both to qualify a site as a contaminated site, and may also be used to determine when a contaminated site has been satisfactorily remediated, under the Contaminated Sites Regulation. As a result, one or more of the soil quality matrix standards listed in schedule 5 of draft 3.0 of the Contaminated Sites Regulation must act as a "mandatory" standard against which the determination as a contaminated site under the regulation can be made. CSST agreed with CCME policy that equal weight should be accorded to the protection of human and non-human biota from toxic insult at remediated contaminated sites, and extended this policy to include the consideration of the aesthetic concerns detailed in the "other protection" section of schedule 5 matrices.

Should CSST recommend "mandatory" matrix standards for use in the Contaminated Sites Regulation?

CSST Decision: *In view of the above, CSST decided that for purposes of defining a site as a contaminated site under the Contaminated Site Regulation the following three soil quality matrix standards should be viewed as mandatory applicable standards;*

- *"Soil ingestion" standard (Human Health protection) at Agricultural, Residential, Urban Park and Commercial sites,*
- *"Soil Invertebrate and plants" standard (Environmental protection), at all sites, and the*
- *"Odour" standard (Other protection) at all sites.*

SABCS 2008 Review: *SABCS supports retention of the first two bullets of the CSST 1996 decision but also recommends that the third bullet dealing with "odour" standards be deleted since the MoE's recent Director's Interim Air Concentration Criteria and proposed CSR Schedule 11 Vapour Standards supercede the need for such standards in CSR Schedule 5.* CSR Protocol 16 "Determining the Presence and Mobility of Nonaqueous Phase Liquids and Odorous Substances" has been issued in draft. The current draft (Version 1, Draft 4, July 2009) states "Under Section 11(1) of the Regulation a site is contaminated with respect to odorous substances if a substance is present at the site whose concentrations exceed any of environmental quality standards in Schedule 11 for the applicable land use."

Additional Question

IB4-Section 1.1(c) - Need for new "Other Protection" matrix standards

Issue: CSST recognized that soil contaminants can present "hazards" beyond those directly related to ecological and human health. These include physical/chemical hazards (explosivity, flammability, corrosivity, reactivity, radioactivity, etc.) and issues of aesthetic quality (organoleptic considerations). The CCME protocol does not address any of these non-toxicological hazards.

Should BC Environment derive soil quality numbers to address possible physical/chemical hazards and/or aesthetic issues?

CSST Decision: *Yes, but only for organoleptic and aesthetic concerns. No soil quality numbers should be derived to deal with explosivity, reactivity, corrosivity, flammability or other such physical/chemical hazards which soil contamination may present. According to BC Environment members of CSST, such hazards are adequately addressed by provisions in the Special Waste Regulation. A CSST soil quality standard to address odour considerations will be presented as a discrete matrix standard.*

See also IID1 below.

SABCS 2008 Review: *SABCS suggests that with the promulgation of CSR Schedule 11 vapour standards there longer remains a need for discrete matrix aesthetic standards to address odour.*

IB4-Section 1.2 - Nutritional Requirement and Background Concentration Verification Section 1.2(a) - Nutritional Requirement

Issue: The protocol allows further adjustment of the SQC_F to ensure: Plant nutritional requirements are met by both Agricultural and Residential/Parkland SQC_F

Specifically, the protocol states " If SQC_F concentration can be shown to be less than that concentration required to meet essential nutrient demands of plants then the final SQC_{EE} becomes the plant nutritional requirement concentration."

Should BCE support the CCME plant nutritional verification procedure?

CSST Decision: *No,* CSST *believes agricultural sites are "managed" sites and therefore the assurance of plant nutritional requirements at such sites is a primary responsibility/decision of site owner.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision.*

IB4-Section 1.2(b) - Background Concentration Verification

Issue: The protocol allows further adjustment of the SQC_F to ensure:

> Background soil contaminant concentrations are considered by both Agricultural and Residential/Parkland SQC_F.
>
> Specifically, the protocol states "If SQC_F is below the acceptable background concentration then SQC_F is replaced by the background concentration as the operative criterion".

Should BCE support Background verification procedure?

CSST Decision: *In principle, CSST agrees with the concept that SQC values should not be established at levels below normal background levels. This belief is reflected in existing BC Environment policy and in draft 3.0 of the Contaminated Sites Regulation which precludes the classification as a contaminated site, and thus the consequent requirement to remediate, any site with contaminant concentrations at or below local natural background concentrations of any substance*

SABCS 2008 Review: *The SABCS notes that the above CSST decision reflects the intent of the MoE protocol 4 "Determining Background Soil Quality". As part of the SABCS (2008) recommended revisions to the CSST protocol (human soil ingestion calculation, it is recommended that the correction for background soil concentration be removed. It is our position that in general, if the calculations determine that there is a certain threshold safe concentration in soil, that is more stringent than background concentrations, then the derivations for must be examined on a case-by-case basis as has previously happened (See Section IIC1a)*

END OF PART I

PART II : Record of CSST Decisions on Policy/Decision Issues Relating to the Derivation of Matrix Soil Standards Based on Novel CSST Procedures

IIA. Introduction

In addition to considering CCME guidance relating to soil quality standards for contaminated sites, CSST also developed a number of additional new procedures by which to derive numerical matrix soil standards for use in the Contaminated Sites Regulation. As detailed below, these new derivation procedures also required CSST to make decisions relating to science policy and address unique issues and assumptions inherent in these "novel" matrix standards.

IIB. New "Environmental Protection" Matrix Standards

IIB1a. Need for additional soil groundwater protective matrix standards

Issue: CSST noted that as suggested in the CCME SSOs procedures, additional new soil groundwater protective standards to protect the current and future use of groundwater at remediated contaminated sites for use by non-human receptors (i.e. aquatic life, livestock and irrigation) could be developed and added to matrices if desired.

Should new additional soil groundwater protective matrix standard derivation procedures be developed?

CSST Decision: *CSST decided that to the greatest extent possible, additional new soil groundwater standards to protect groundwater used for irrigation, livestock watering and for use by aquatic life should be incorporated into matrices.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision.*

IIB1b. Models to be used for derivation of additional soil to groundwater protective matrix standards

Issue: The model and equations recommended by CCME to derive soil to groundwater criteria to protect groundwater used as drinking water from non-polar organic soil contaminants are inadequate to derive soil groundwater protective standards for either polar organics or heavy metals. Nor is the CCME model believed to be sufficiently sophisticated to allow the derivation of practical soil standards for use at remediated contaminated sites to protect groundwater for current and future use by the non-human receptors.

However, BCE hydro-geologists through the use of progressively more sophisticated models were able to provide for CSST's approval, procedures which would allow the derivation of both the new soil groundwater standards called for under CSST's decision IIB1a above and for the future protection of groundwater used as drinking water. Details of these new soil-groundwater standard derivation procedures and models appear in the document "Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites" (CSST, 1996).

Should the new soil-groundwater fate and transport models proposed by BC Environment hydro-geologists be used by CSST to derive additional new soil to groundwater matrix standards?

CSST decision: *The new soil to groundwater models proposed by BCE hydro-geologists were reviewed and ultimately approved for use by CSST.*

Consequently, where appropriate, new soil groundwater matrix standards were calculated and added to the environmental protection section (to ensure protection of groundwater used for aquatic life, livestock and irrigation) and to the human health protection section (to ensure protection of groundwater used for drinking water) in schedule 5 of the draft Contaminated Sites Regulation.

SABCS 2008 Review: *SABCS notes that MoE is conducting review of the 1996 CSST groundwater model and therefore, it would be premature to recommend changes in procedures and/or policy at this time.*

IIB1c. Livestock Matrix Standards

Issue: CSST rejected the "herbivore check" proposed by CCME for agricultural and residential land uses. CSST's had several reasons for this decision. For example, CSST believed it was more reasonable to assume that livestock were not raised at (i.e. absent from) most residential sites within the Province, and that the CCME model for the herbivore check employed assumptions which were not scientifically defensible. Consequently, CSST originally proposed that the issue of livestock protection at remediated agricultural sites might be adequately addressed by reference to the "Toxicity to soil invertebrates and plants" matrix standard.

However, when this assumption was tested based on the veterinary literature, it was found that for many substances, the "Toxicity to soil invertebrate and plants" matrix standard was in fact not sufficiently protective of livestock. BCE toxicologists through the use of a more sophisticated model were able to provide for CSST's approval, procedures for selected heavy metals, which would allow the derivation of a new "Livestock ingesting soil and fodder" matrix standard for use at agricultural sites. Details of the new livestock standard derivation procedure and model appear in "Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites" (CSST, 1996).

Should the new livestock soil and fodder ingestion model proposed by BC Environment toxicologists be used by CSST to derive new "Livestock ingesting soil and fodder" matrix standards?

CSST Decision: *The new "Livestock ingesting soil and fodder" standard derivation models proposed by BCE toxicologists were reviewed and ultimately approved for use by CSST.*

Consequently, where appropriate, calculated new livestock protective matrix standards were added to the environmental protection section of schedule 5 of the draft Contaminated Sites Regulation.

SABCS 2008 Review: *The need for a soil matrix standard for livestock protection on agricultural lands based on soil and fodder ingestion is supported by SABCS. SABCS, however, felt that the toxicity reference values selected and general procedure for estimating soil ingestion and plant ingestion exposures should be consistent with CCME (2006) rather than CSST (1996). In turn, it is recognized that a major*

uncertainty in the calculated soil standard is the relationship between soil and plant concentrations. The use of standardized regression approaches for predicting plant concentrations from soil concentrations of contaminants of potential concern has become a routine part of environmental risk assessments in North America.

IIB1d. Use of Interim CCME Criteria as "Toxicity to soil invertebrate and plant" Matrix Standards in Schedule 5.

Issue: For several substances proposed for inclusion in schedule 5, the available soil invertebrate and plant toxicity data was either insufficient or inadequate to generate appropriate "Toxicity to soil invertebrate and plant" protective standards for use in the environmental protection section of CSST matrices. For these substances however, data was available to allow the derivation of CSST "Intake of contaminated soil" protective standards for use in the human health protection section of matrices.

It was also noted that in circumstances where data was inadequate to generate both human health and environmental protection matrix standards, CSST had decided that no matrix would be constructed for use in schedule 5 of the Contaminated Sites Regulation. Rather, for such substances, CSST had decided that the CCME interim criteria would continue to be used as the appropriate soil standard in schedule 4 of the regulation.

Should CCME Interim soil quality criteria be used as appropriate "Toxicity to soil invertebrate and plants" matrix standards for substances for which human health matrix standards can be calculated but for which no soil invertebrate and plants standard can be calculated?

CSST Decision: *Rather than "lose" the ability to use legitimately derived matrix standards to protect human health for substances for which environmentally protective matrix standards could not be derived due to data limitations, which would effectively result if no matrices were developed for such substances, CSST decided that since the interim CCME criteria were deemed to be "equally protective of the health of both human and nonhuman biota", the interim CCME criteria could be used as "Toxicity to soil invertebrate and plants" standards in matrices for substances for environmental protective matrix standards by normal CSST procedures.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision.*

IIC. New "Human Health Protection" Matrix Standards

IIC1a. Adjustment of toxicologically derived soil ingestion standards to incorporate "real world" experience in arsenic, cadmium and lead matrices.

Issue: Health members of CSST noted that based on "real world" experience, some of the toxicologically modeled matrix soil ingestion standards might not be reflective of actual health risks. As a result, a contract was arranged with the UBC Department of Health Care and Epidemiology to review empirical studies which correlated health outcomes with exposure to arsenic, cadmium, chromium, lead and benzene in soil. As a result of this review, MOH members were able to provide empirically derived soil ingestion standards for arsenic, cadmium and lead. These "real world" adjusted standards were provided to CSST for approval.

Should toxicological derived "soil intake" matrix standards for arsenic, cadmium, chromium, lead and benzene be adjusted based on the results of the "real world" clinical experience review conducted for these substances?

CSST decision: *CSST approved "real world" adjustment of soil ingestion matrix standards for arsenic, cadmium and lead. CSST also approved the use of "real world" standards for arsenic, cadmium and lead as soil ingestion matrix standards in schedule 5 of the Contaminated Sites Regulation.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision and anticipates that additional "real world" adjustments may be required by the development of new standards..*

IID. New "Other Protection" Matrix Standards

IID1a. Physical/Chemical Hazard Protective Matrix Standards

Issue: CSST noted that in addition to protection of the health of human and non-human biota from toxic risk and/or hazard, it would be desirable to also ensure that soil contamination concerns relating to physical/chemical hazards (i.e. explosivity, flammability, reactivity, radioactivity, etc.) and objectionable odour were adequately addressed in the matrices.

Should new matrix standard derivation procedures be developed to ensure protection against "other" non-toxicological (i.e. physical/chemical) hazards associated with soil contamination?

CSST Decision: *CSST decided that an additional section of Site-specific Factors (i.e. "Other Protection") would be added to matrices to deal with non-Matrix standards to protect against objectionable soil odours arising from on-site volatile contaminants would be derived using the "Simplified Odour Model" approved by CSST.*

SABCS 2008 Review: *SABCS recommends deletion of the above section related to "odours" standards since the CSR Schedule 11 "Generic Vapour Standards" came into effect in January 1, 2009..*

CSST Decision: *BC Environment members of CSST were of the opinion that physical/chemical hazards possibly associated with soil contaminants could be adequately controlled under the existing provisions of the Special Waste Regulation. Consequently, CSST decided that no additional matrix standards to protect against physical/chemical hazards or risks of on-site soil contaminants were in fact necessary.*

SABCS 2008 Review: *SABCS supports original CSST 1996 decision.*

END OF PART II

References Cited

CCME, 1994a. "A Protocol for the Derivation of Ecological Effects-based and Human Health-based Soil Quality Criteria for Contaminated Sites" Final Draft Report. CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites. The National Contaminated Sites Remediation Program. July, 1994.

"Guidance Manual for Developing Site-Specific Soil Remediation Objectives for Contaminated Sites". Draft 2. Version 1. The National Contaminated Sites Remediation Program. June 6, 1994.

"A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines". Report CCME-EPC-101E. The National Contaminated Sites Remediation Program. August, 1995.

"Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites". BC Environment. January, 1996.

"Hierarchy of Preferred Sources of Toxicity Reference Values for Use in Calculation of CSST Numbers for Use in the Contaminated Sites Regulation". BC Environment. Feb. 27, 1995

BARC (Bioaccessibility Research Council), 2007. Strategic Research Planning Workshop in Bioacessibility/bioavailability in Contaminated Site Assessment

BC Advisory Panel on Contaminated Sites. (2003). Report to the Minister of Environment. (Section 9)

BC Ministry of Environment, Lands and Parks. (1996). CSST Policy Decision Summary. Part 1: Record of CSST Policy/Decision Issues Relating to the Derivation of Matrix Standards Based on Canadian Council of Ministers of the Environment Protocol and Site-specific Objectives Documents and Part II: Record of CSST Policy/Decision Issues Relating to the Derivation of Matrix Soil Standards Based on Novel CSST Procedures. BC Environment, Environmental Protection, Risk Assessment Unit. Victoria, British Columbia.
http://www.env.gov.bc.ca/epd/remediation/standards_criteria/pdf/csst_policy_decision.pdf

BC Environment. (1996). Overview of CSST Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites. BC Environment, Environmental Protection Department, Risk Assessment Unit. Victoria, BC.
http://www.env.gov.bc.ca/epd/remediation/standards_criteria/standards/overview_of_csst.htm

Burmaster, D.E., (2000). Distributions of Total Job Tenure for Men and Women in Selected Industries and Occupations in the United States, February 2006. In: Risk Analysis, Vol. 20(2), 2000.

Canadian Council of Ministers of the Environment. (CCME). (1994a). A Protocol for the Derivation of Ecological Effects-based and Human Health-based Soil Quality Criteria for Contaminated Sites. Final Draft Report. CCME Subcommittee on Environmental Quality for Contaminated Sites. National Contaminated Sites Remediation Program.

CCME (Canadian Council of Ministers of the Environment). 1994b. Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada. Final Report. National Contaminated Sites Remediation Program.

CCME (2006) A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines. Winnipeg, Manitoba. Accessed at http://www.ccme.ca/assets/pdf/sg_protocol_1332_e.pdf

Danish EPA (2003). Human bioaccessibiity of heavy metals and PAHs from soil. Environment Project No 840.

Fox (1995). Hierarchy of Preferred Sources of Toxicity Reference Values for Use in Calculation of CSST Numbers for Use in the Contaminated Sites Regulation. BC Environment. Victoria, BC.

Golder Associates (2005) Scientific Review of British Columbia CSST Soil Standards Derivation Protocol. Science Advisory Board for Contaminated Sites in British Columbia. University of Victoria. Victoria BC, Canada.

Golder Associates (2005). Report to SABCS- "Approaches and Methods for Evaluation Vertical Transport in Groundwater-Hydrogeological Assessment Tools Project.

Health Canada, 2004. Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA)

Health Canada (2008). State of the Science Report for Polybrominated Diphenyl Ethers (PBDEs).

Heisz, A. (1996). Changes in Job Tenure and Job Stability in Canada. Report No. 95. (Statistics Canada)

Heisz, A. (2009). Personal communication with D. Konasewich re updates of 1996 report.

Israeli, M., and C.B. Nelson (1992). "Distribution and Expected Time of Residence for U.S. Households", In: Risk Analysis, Vol 12 (1) pp65-72,

Johnson, D.D. (1998?). Air Toxics Monitoring in British Columbia. Ministry of Environment Report. www.env.gov.**bc**.ca/epd/regions/skeena/**air**/pdf/**metals**.pdf

Johnson, T. and J. Capel (1992): A Monte Carlo Approach to Simulating Residential Occupancy Periods and its Application to the General U.S. Population. Research Triangle Park, U.S. EPA .

Lush, J. (1994). Contaminated Sites Remediation Standards: British Columbia as Compared with North America (prepared for B.C. Environment).

Ministry of Environment (MoE). (2005). Environmental Management Act, Contaminated Sites Regulation BC Reg. 375/96.
http://www.qp.gov.bc.ca/statreg/reg/E/EnvMgmt/EnvMgmt375_96/375_96_00.htm

MoE. (2005). Contaminated Sites Regulation, Schedule 5 Matrix Numerical Soil Standards. Victoria, BC. http://www.qp.gov.bc.ca/statreg/reg/E/EnvMgmt/EnvMgmt375_96/375_96_06.htm#Schedule5

National Academy of Sciences and National Academy of Engineering (1972). Water Quality Criteria. (page 3)

Science Advisory Board for Contaminated Sites in B C. (2006). Contaminated Sites Soils Taskgroup (CSST). Protocols for the Derivation of Soil Matrix Standards (Schedule 5) 2006 Update.

SABCS (2005). Report on Screening Level Risk Assessment SLRA Level 1 and SLRA Level 2 (Groundwater Module)

SABCS (2006). Report on Hydrogeological Assessment Tools for Modeling Transport of Metals in Groundwater.

SABCS(2006). Report on Hydrogeological Assessment Tools to Determine the Rate of Biodegradation for Organic Contaminants in Groundwater.

UK Environment Agency, 2005. Environment Agency's Science Update on the Use of Bioavailability Testing in Risk Assessment of Land Contamination.

U.S. EPA (1991. Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual

U.S. EPA (2000). EPA/540-R-00-007 "Soil Screening Guidance for Radionuclides: User's Guide Assessment of radon exposure"

U.S. EPA (2004). Risk Assessment Guidance for Superfund (RAGS), Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment) Interim

U.S. EPA, (2005). Supplemental Guidance for Assessing Cancer Susceptibility from Early-Life Exposure to Carcinogens. Risk Assessment Forum Technical Panel.

U.S. EPA (2007). Exposure Factors Handbook.

US EPA (2007). Guidance for Evaluating the Oral Bioavailability of Metals in Soil for Use in Human Health Risk Assessments, OSWER 9285.7-80

U.S. EPA Region III (2003). Updated Dermal Exposure Assessment. Region III Technical Guidance Manual for Risk Assessment

U.S. EPA Region III (2008). Mid Atlantic Risk Assessment- Generic Tables.
http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/usersguide.htm

U.S. EPA Region IX. Superfund- Preliminary Remediation Goals.
http://www.epa.gov/region09/superfund/prg/rsl-table.html

U.S. EPA Science Advisory Board (2007). Letter to the U.S. EPA Administrator re: Consultation on Enhancing Rick Assessment Practices and Updating EPA's Exposure Guidelines.

U.S. Food and Drug Administration (2007). Cumulative Estimated Daily Intake/Acceptable Daily Intake Database.

U.S. Food and Drug Administration
http://www.cfsan.fda.gov/~comm/tds-res.html

World Health Organization International Program on Chemical Safety, 2009.
http://www.who.int/ipcs/publications/cicad/cicads_alphabetical/en/index.html

APPENDIX A

GLOSSARY

Acronym	Definition
AF	Absorption Factor
AF_D	Absorption Factor - Dermal
AF_I	Absorption Factor - Gut (ingestion)
Ag	Agricultural Land Use
AUF	Area Use Factor
BCE	BC Environment
BCF	BioConcentration Factor
BSC	Background Soil Concentration
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
BV	Biological uptake – soil to vegetation
BW	Body Weight (kg)
CCME	Canadian Council of Ministers of the Environment
C	Commercial Land Use
C/I	Commercial/Industrial Land Use
CEPA	Canadian Environmental Protection Act
CSAG	Contaminated Sites Advisory Group
CSST	Contaminated Sites Soil Taskgroup
DMIR	Dry Matter Intake Rate
DTED	Daily Effects Threshold Dose
DW	Drinking Water
EC50-NL	Median Effective Concentration - Nonlethal distribution (mg/kg)
ECL	Effects Concentration Low (mg/kg)
EDI	Estimated Daily Intake (mg/d)
EE	Environmental Effects, Ecological Effects
EHO	Environmental Health Officer
EPC	Environmental Protection Committee
EE SQC	Environmental Effects - Soil Quality Criteria
ERA	Environmental Risk Assessment
ERL	Effects Range Low (ecological)
ET	Exposure Term (hr/d/wk/yr)
FIR	Food Ingestion Rate
GW	Groundwater
HH	Human Health
HH SQC	Human Health Soil Quality Criteria Human
HRA	Health Risk Assessment
IR_S	Soil Ingestion Rate (mg/d)
IR_f	Food Ingestion Rate (kg/d)
LC_{20}	Lethal Concentration - 20%
LC_{50}	Median Lethal Concentration
LD_{50}	Median Lethal Dose
LER	Lower Effect Range
LMHO	Local Medical Health Officer

Acronym	Definition
LOAEL	Lowest Observed Adverse Effect Level
LOEL	Lowest Observed Effect Level
MAF	Major Adjustment Factor
MER	Mid-Effects Range
MoE	BC Ministry of Environment
MOH	BC Ministry of Health
NCSRP	National Contaminated Sites Remediation Program
NOAEL	No Observed Adverse Effect Level
NOEL	No Observed Effect Level
NPER	No to Potential Effects Range
PA	Particulate Concentration in Air
PAH	Polynuclear Aromatic Hydrocarbon,
PAH BaP-TEQ	Polycyclic Aromatic Hydrocarbon PAH Benzo[a]pyrene Toxicity Equivalency Quotient
PCDD	Polychlorinated Dibenzo-p-dioxin
$PSQC_{HH}$	Preliminary Soil Quality Criteria - Human Health (TDI based)
$PSQC_{HH}$(EDI)	Preliminary Soil Quality Criteria - Human Health (EDI based)
R	Residential Land Use
RA	Risk Assessment
RfC	Reference Dose - Inhalation (mg/m^3)
RfD	Reference Dose - Oral (mg/kg)
RsD	Risk Specific Dose (mg/kg)
RTDI	Residual Tolerable Daily Intake (mg/d)
SABCS	Science Advisory Board for Contaminated Sites in British Columbia
SCEQCCS	Subcommittee for Environmental Quality Criteria - Contaminated Sites
SAF	Soil Apportionment Factor (20%)
SF	Safety Factor
SMC 1	Soil Quality Criteria - Microbe Check Group 1
SMC 2	Soil Quality Criteria - Microbe Check Group 2
SQC	Soil Quality Criteria
SQS	Soil Quality Standard
SQC EE,	Soil Quality Criteria - Environmental Effects
SQC_F	Soil Quality Criteria - Final
SQC FI,	Soil Quality Criteria - Food Ingestion
SQC_H SQC HH,	Soil Q uality Criteria - Human Health Soil
SQC ia	Quality Criteria - Indoor Air
SQC meat	Soil Quality Criteria - Meat
SQC milk	Soil Quality Criteria - Milk
SQC SC, SQC_{SC}	Soil Quality Criteria - Soil Contact
SQC SC1, SQC_{SC1}	Soil Quality Criteria - Soil Contact Group 1
SQC SC2, SQC_{SC2}	Soil Quality Criteria - Soil Contact Group 2

Acronym

Definition

	Definition
SQC_{SI},	Soil Quality Criteria - Soil Ingestion
SQC_{SI+F}	Soil Quality Criteria - Soil Ingestion + Food
SQC_{veg}	Soil Quality Criteria - Vegetables
SR	Soil Dermal Contact Rate
SS-ERA	Site Specific - Environmental Risk Assessment
SS-HRA	Site Specific - Human Health Risk Assessment
SSO	Site Specific Objective
SSS	Site Specific Standard
TDI	Tolerable Daily Intake (mg/d)
TEC	Threshold Effects Concentration - ecological
TEC	Toxicity Equivalency Factor
TEQ	Toxicity Equivalency Quotient
TRV	Threshold Reference Value
UF	Uncertainty Factor
USEPA	United States Environmental Protection Agency
WCB	Workers Compensation Board of British Columbia
WHO	United Nations World Health Organization
Ya-aq	Groundwater Coefficient - Aquatic Life
Ya-dw	Groundwater Coefficient - Drinking Water
Ya-ir	Groundwater Coefficient - Irrigation Watering
Ya-lw	Groundwater Coefficient - Livestock Watering

Appendix B: Comparison of methodologies to derive soil standards (Using only the formula for soil ingestion)

The purpose of this appendix is to illustrate the results using four different approaches for deriving human health soil quality objectives (using only the formula for soil ingestion):

1. Using the CSST (1996) formula and current Health Canada recommended default values
2. Using the CSST (1996) formula and adjusting the soil ingestion rate from 80 mg/kg to 100 mg/kg as suggested by the SABCS
3. Using the amortization approach for carcinogens (e.g. PCP) as per IB3-Section 5.1
4. Using a stochastic approach with a soil allocation factor of 0.2.
5. Using a stochastic approach with an EDI probability distribution function as determined by a Health Canada contractor.
6. Using a stochastic amortization approach

The results of the stochastic approach illustrate the results of a "one-time" only trial. Additional adjustments to the distributions should be assessed.

The results are shown in the following table:

Method of determination	mg/kg – Cr(VI)	mg/kg- Hg	mg/kg- PCP
Current MOE Standard	100	15	100
CSST using default formula[68]	112	11	292
SABCS using default formula[69]	90	9	
Age amortization approach as per IB3-Section 5.1			126 (using Health Canada default values)
Stochastic (using SAF=0.2)[70]	Mean: 79 Std Dev: 48	Mean: 7.6 Std Dev: 12.6	
Stochastic (using Health Canada EDI)[71]	Mean: 165		
Stochastic using 50 percentile age amortization value			90

[68] $PSQS_{HH-oral} = \dfrac{SAF \cdot TDI \cdot BW \cdot AT}{(AF_G \cdot SIR) \cdot D_1 \cdot D_2 \cdot D_4}$

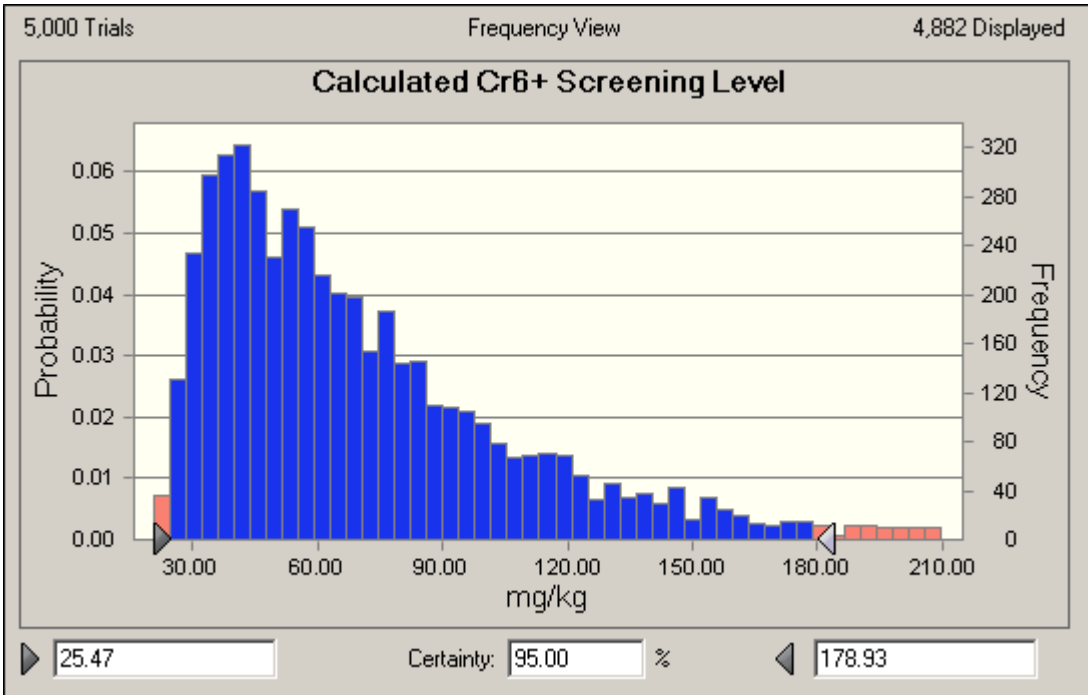
SAF=Soil allocation factor: 0.2	AF_G =absorption through gut: 1.0
TDI= Tolerable daily intake:3 x 10^{-3} mg/kg-d for Cr(VI) and 3 x 10^{-4} mg/kd-day for Hg	SIR = soil ingestion rate: 8 x 10^{-5} kg/day
BW= Body weight: 15 kg	D1 = Days exposed per seven days: 7/7
AT=D_4 (years/years)	D2 = Weeks exposed per 52 years; 52/52

[69] Same as above except SIR = 1 x 10^{-4} kg/day

[70] Same formula as footnote 1 except BW and SIR distribution functions used during stochastic analysis:
BW: Lognormal Distribution- Mean: 16.5 kg; Std Deviation 4.5 kg (as per Health Canada contractor)
SIR: Triangular Distribution- Min: 2 x 10-5; Mode: 1 x 10^{-4} ; Max: 4 x 10^{-4} (as per Health Canada contractor)..

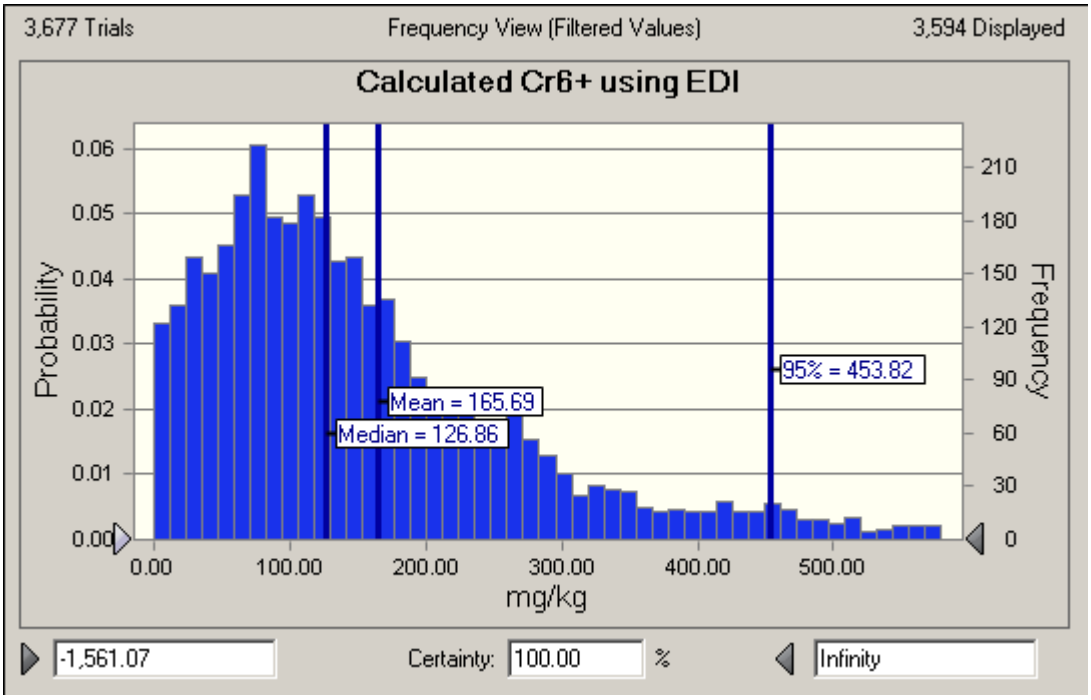
[71] Same as footnote 74, except SAF is substituted by (TDI-EDI) where EDI is probability distribution function as determined by Health Canada contractor for Cr(VI), Lognormal distribution: 5%: 7.9 x 10-4; 95% is 5.45 x 10-3

Example of Monte Carlo stochastic determination of human health soil standard for chromium VI



Mean: 79 mg/kg
Standard deviation: 48 mg/kg

Example of Monte Carlo stochastic determination of human health soil standard for chromium VI using EDI determined by Health Canada contractor



EDI Distribution for Cr(VI) as determined by Health Canada contractor