SYNOPSIS

of

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

Submitted to the:

B.C. Ministry of Environment

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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.

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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

1 Introduction

The Ministry of Environment (MoE) and the Science Advisory Board for Contaminated Sites in British Columbia (SABCS) have recently completed a review of the BC MoE *Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites* (BC Environment, 1996). The purpose of the review was to assess related scientific knowledge that has come forward since 1996 and to recommend revisions based on those advances. This document summarizes the proposed revisions and confirmations of previous derivation protocols. Analyses and comments on the robustness of the derivations, given current scientific understanding and data availability, are also presented as appropriate.

The 1996 document was prepared by the Contaminated Sites Soils Task Group (CSST) in order to develop standard procedures for the calculation of matrix soil standards for the protection of human and ecological health to be applied at contaminated sites in British Columbia under the BC Contaminated Sites Regulation (BC CSR). The CSST protocols were used to calculate soil criteria for selected substances as noted in the B.C. CSR Schedule 5 Soil Matrix Standards. The full version of the CSST 1996 derivation procedures for soil matrix standards can be found on the MoE Land Remediation website at:
http://www.env.gov.bc.ca/epd/remediation/standards_criteria/standards/overview_of_csst.htm

The 1996 CSST procedures for the derivation of soil quality matrix standards were based on two protocol documents authored by the Canadian Council of Ministers on the Environment (CCME): *A Protocol for the Derivation of Ecological Effects-based and Human Health-based Soil Quality Criteria for Contaminated Sites* (CCME, 1994a); and, *Guidance Manual for Developing Site Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada* (CCME, 1994b)[1]. CSST considered all of the CCME derivation protocols and formulas used to calculate soil and groundwater criteria for protection of human and ecological health. In some cases, CSST accepted CCME recommendations while in other cases CSST policy recommendations differed from those of CCME. Policy decisions related to the development of the derivation protocols based on the CCME documents can be found in the *CSST Policy Decision Summary* (BC Environment, 1996) and are available on the MoE Land Remediation website at: http://www.env.gov.bc.ca/epd/remediation/standards_criteria/pdf/csst_policy_decision.pdf.

In 2005, the Ministry of Environment asked the SABCS to review the 1996 CSST protocols in order to prepare a revised CSST protocol document, if deemed necessary. To aid the SABCS, Golder Associates was provided with a contract to conduct a scientific review of post-1996 technical/scientific advances to determine whether revisions to the 1996 derivation protocols were required, and whether any previously identified gaps could now be addressed. A Task force led by Dr. Jean Cho of the SABCS assisted in the completion of this review. Golder (2005) provided recommendations to the SABCS for several changes.

In the following year with further funding, an expert panel was formed to deliberate Golder's recommendations regarding the derivation of soil quality benchmarks. The panel broadly represented a technical/scientific community that had a strong working familiarity with contaminated sites in BC.

Following completion of the panel's recommendations in 2006, UMA Engineering Ltd. (now AECOM) was contracted by the SABCS in 2007 to use the panel's work to draft recommendations to revise the 1996 CSST protocols. A SABCS task force was formed to work with UMA and the MoE. Members of the SABCS and contaminated sites experts outside the panel provided reviews of specific sections of the drafted recommendations.

The SABCS review resulted in the following reports:

[1] The CCME documents were updated in 2006.
http://www.ccme.ca/assets/pdf/sg_protocol_1332_e.pdf

- This synopsis which discusses the SABCS assessment of the soil standard setting process and which provides an overview of the Board's recommendations.
- Volume I- "SABCS Review and Recommendations for Revision of the CSST (1996) Procedures for the Derivation of Soil Quality Matrix Standards for Contaminated Sites"
- Volume II " SABCS Review and Recommendations for Revision of the CSST (1996) Policy Decision Summary", and,
- Volume III- An accessory document that includes review comments (and related responses) to draft versions of volume I and II that were prepared during 2008.

2 SABCS General Comments re: Preparation of Soil Standards for Use in British Columbia

Background

The principal goal of the British Columbia Environmental Management Act is to "ensure environmental and human health protection". With the recognition that many properties in the province became contaminated by "chemicals and other toxic materials", due to past use, the Ministry introduced a contaminated sites regulation in December 1996.

Fundamental to the contaminated sites regulation, is the use of numerical standards intended to protect human health and the environment and to determine when cleanup is needed and satisfactorily completed. A MoE fact sheet (2006) states:

- *"In British Columbia, a contaminated site is defined as an area of land in which the soil or underlying groundwater or sediment contains hazardous waste or any substance in an amount or concentration that exceeds provincial environmental quality standards. A site is contaminated if it is unsuitable for specific uses of land, water and sediment".* [2]

The 1996 CSST procedures focus on procedures to derive soil standards and they have been used to develop the risk based soil standards[3] for the 19 substances in Schedule 5.

Standards for 41 other substances and chemical classes, as noted in Schedule 4, were adopted from other jurisdictions and have less site specificity. Given that the numerical values to define contaminated sites are legal standards versus being criteria or guidelines (as used in several other jurisdictions), the legal standards play a pivotal role within the site management process in British Columbia. A substance at a concentration in soil in excess of a Schedule 4 or Schedule 5 standard is considered to have the potential to harm[4] human health and/or the environment and hence is subject to further investigations, site remediation or management and/or possible liability issues. On the other hand, if the concentrations of all scheduled substances at a site are less than their individual standards, then no further actions are necessary.

The SABCS thus recognizes that:

- The standards constitute the initial framework for site assessments in B.C., i.e. with respect to characterization of a site, the standards provide an initial "yes, the site is contaminated and

[2] Within the MoE Contaminated Sites Regulation: generic groundwater standards are listed in Schedules 6 and 10: generic soil standards are listed in Schedules 4 and 10; matrix soil standards are listed in Schedule 5; and, sediment criteria are listed in Schedule 9.
[3] Also referred to as "matrix standards".
[4] A small number of the standards are not based on harm to human health or the environment but nuisance, such as taste and odours.

further actions are required" versus "no, the site is not contaminated and no further actions are required"

- A conservative approach would be used to develop standards so that based on current knowledge; there is no apparent probability of an unacceptable risk to human health and the environment.

General Comments re: Scientific Basis for Standards

The process for developing standards must be scientifically defensible to the greatest degree possible. In addition, the process must also be transparent and documented to:

- Provide parties associated with contaminant site investigations in B.C. (e.g. CSAP members, landowners, academics) with a clear understanding of the fundamentals and databases used to derive individual standards.

- Provide the initial framework for the use of additional site evaluation approaches such as development of "site specific standards" and risk assessments; and,

- Enable further upgrading of the standards as new science emerges.

During the review of the 1996 CSST protocol, the SABCS recognized there remain significant continuing limitations in the science and data available for the development of soil standards, because of factors such as:

- The chemistry of substances in the environment is very complex and is dependent on many factors such as chemical forms, pH, redox conditions, ageing, adsorption, physical forms, etc.

- The chemistry of a substance may vary among the soils of different sites. In addition, its chemistry at a specific site may differ from laboratory test media used to develop toxicological data (e.g., there may be significant variances in bioavailability).

- Biological (human, plant and animal) responses to contaminants are very complex and,

- Ecotoxicity particularly for land-based species, is a relatively new field, hence there is limited toxicology data to develop standards for ecological protection of soil invertebrates and plants, and vertebrates. There is also uncertainty about endpoints that should be used to protect ecological receptors.

Notwithstanding these difficulties, the SABCS recognizes the Ministry's need for specific soil standards given the framework of the existing legislation. In order to derive discrete numerical values as standards (as required in legislation), the best possible current databases and scientific approaches must be considered. In cases where data are limited and/or where there may be uncertainty with regard to scientific approaches, and in common with other jurisdictions, the process of standard setting must default to professional judgment of risks. Also, as common with other jurisdictions, the MoE must cope with the science limitations by applying informed conservatism.

It is the intent of this synopsis to provide an overview of the SABCS's recommended changes to the 1996 CSST document and to provide an overview of the residual scientific uncertainty in the data available to develop standards to protect various receptors. It must be emphasized that although the recommended protocols reflect to the greatest extent possible the current state of the science available for contaminants of concern, the protocols should be used judiciously.

It is noted this document could not address some of the CSST protocols for soil standards, notably those to protect groundwater quality. The groundwater model is under review and revision by the MoE. The wildland and high-density urban exposure scenarios are still under development by others. However, the SABCS has provided recommendations with regard to receptors and exposures at those land uses.

As noted previously, this synopsis is followed by three documents that address the recommended revisions to the 1996 CSST documents. Volumes I and II use the format and text of the original 1996 CSST documents. The SABCS recommendations are included within the framework of those original documents to enhance the preparation of updated CSST protocols. It is understood that the MoE will use the SABCS recommendations for the development of matrix standards for Schedule 4 and Schedule 10 soil substances and to update the Schedule 5 soil standards. Consideration of all scheduled substances using common protocols will enable consistency in all soil standards.

3 Determination of soil standards to protect human health

The SABCS has reviewed advances in the assessment in risk assessment protocols for the protection of human health, which occurred following the derivation of the 1996 CSST protocol. As per a MoE request in 2006, the SABCS review includes a comparison of U.S. EPA and Health Canada exposure assumptions to determine which agency's risk assessment assumptions were most scientifically current and supportable. As well, the SABCS was requested to review the U.S. EPA and California EPA procedures for developing soil quality guidelines[5].

The SABCS review indicates that following the derivation of the 1996 CSST protocol, there have been advances in policies and science regarding risk assessment protocols for protection of human health, and regarding the development of soil quality guidelines.

A majority of the advances for risk assessment and development of soil quality guidelines have been developed by the U.S EPA. Hence, many of the recommendations the SABCS is providing to the MoE with respect to the 1996 CSST protocol documents are a result of an SABCS review of, and concurrence with specific U.S. EPA current policies and procedures. Data gaps still exist and are discussed within this document.

3.1 SABCS Comments and Recommendations re: policies for development of soil standards to protect human health

The SABCS recommends that the MoE should prepare a detailed written policy for selection of exposure scenarios and data sets to prepare soil quality standards for protection of both human health and the environment. Such a policy would ensure transparency in the procedures used to develop soil standards. At a minimum, this would include an assessment and definition of critical data (in tabular form) used to derive the standards, including receptor characteristics, duration of time at a site and target risk values clearly identified.

By example, 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:

[5] The CCME and EPA procedures are used to develop guidelines (or screening levels) versus "legal standards".

- An 1153-page U.S EPA "Exposure Factors" handbook (1997) 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 1995 U.S. EPA "Policy for Risk Characterization" [6] states in part, that each Agency risk assessment should provide the basis for the values and input parameters used for each exposure scenario. In addition, by a 1995 memorandum[7], the EPA administrator stated people both inside and outside of the Agency must better understand the basis of the Agency's decisions with the values of transparency, clarity, consistency and reasonableness. Therefore within the Superfund program[8,9] for developing soil screening levels, the Agency has evaluated databases and defined the criteria for exposure scenarios and data sets that would be used within the risk based formulae: e.g., the resulting 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. The level of conservatism is thus defined.

- There is an EPA explicit written policy for enhanced evaluation and research related to risk to children and infants from pollution in air, land and water.[10,11]

3.2 SABCS Comments and Recommendations re: procedures for development of soil standards to protect human health

Regarding specific details relating to U.S. EPA and CCME approaches for the calculation of soil guidelines, the SABCS provides the following observations and recommendations:

- Equations used by B.C. MoE, Health Canada[12] 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 considered along with the exposure period during adulthood. (The soil standards in Schedule 10 of the CSR are based on this approach.) 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

[6] U.S. EPA Science Policy Council, 1995. Guidance for Risk Characterization, Found in Appendix A in http://www.epa.gov/spc/pdfs/rchandbk.pdf
[7] Carole Browner, Administrator, U.S. EPA, 1995. Memorandum re: EPA Risk Characterization Program. http://ddoe.dc.gov/ddoe/lib/ddoe/Riggs_Remedy_100.pdf
[8] U.S EPA, 1996. Soil Screening Guidance: Technical Background Document (EPA/540/R95/128).
[9] U.S. EPA, 2002.: Supplemental Guidance for Developing Soil Screening Levels of Superfund Sites (OSWER 9355.4-24) .
[10] U.S. EPA Science Policy Council, 1995. Memorandum: Subject "New Policy for Evaluating Health Risks to children", signed by Carol Browner Administrator. http://www.epa.gov/spc/2poleval.htm
[11] U.S. EPA Science Policy Council, 1995. "Policy on Evaluating Health Risks to Children." http://www.epa.gov/spc/2poleval.htm
[12] Health Canada develops SQGs per CCME protocol

(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 a greater degree of apportionment for carcinogens that act through a mutagenic mode of action (MOA). 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 and chemicals that act with a mutagenic mode of action (MOA) for carcinogenesis in soil, the resulting standards for such 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 MOA) 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[13]. Similar reviews may be required for other substances for which standards are developed.

- 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:
    - Exposure durations at workplaces
        - The default commercial/industrial workplace exposure time in the U.S. is 25 years, vs. the 35 years assumed in Canada.
        - 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 Volume II).
    - 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.

[13] Jin, A. and K. Teschke, 1995. "The Relationship between Exposure to Soil Contaminants and Biomarkers or Health Effects in Humans: Lead, Arsenic, Cadmium, Chromium and Benzene- A Literature Review for the Province of British Columbia, Ministry of Health and Ministry of Environment, Lands and Parks

- 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.
    - Based 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 additional review of recent data prior to consideration of modifying the Canadian value of 20 mg/day.

- Soil contact
    - For the purpose of risk assessment, skin surface areas for individual body parts are similar 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[14]. The values used by U.S. EPA appear more indicative of finding reported in the literature. In addition, there are significant differences in skin absorption factors for several substances as noted in Table 8 of Volume II. 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 evaluation of the EPA findings and the identification of the classes of substances that may constitute significant intake via skin exposure. In the development of each individual soil standard, there should be detailed documentation that includes consideration of skin exposure.

In addition to the above noted recommendations that are based on a review of U.S. EPA procedures and the literature, the SABCS also provides the following recommendations relating to the development of soil standards to protect human health:

- The "toddler" should not be the most sensitive receptor at commercial sites. In the 1995 CCME document, daycare centers were included within commercial sites; hence, the toddler was designated as the most sensitive receptor. The 2006 CCME document maintains that all age groups generally have full access to commercial properties and some commercial properties will include daycare facilities.

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

- Currently the CSR places daycare centers within "residential" land uses. Health Canada differentiates commercial sites between those with daycare centres and those without. Commercial sites with day-care facilities are to address risks to infants, toddlers and children who attend those facilities. The CSST (2006) exposure assumptions for "residential" land uses are overly conservative for schools, daycare centers and community centers. An additional land use category is recommended to address lands used solely for schools, day care centers and community centers.

- As discussed in Volume II, 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 on a chemical-specific basis.

- The text in the CSST (1996) version of Section D2 "Soil Odour Quality Standards" should be removed. Soil odours are a soil vapour issue, which should be addressed through the "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

- Based on a SABCS review of the currently available science regarding soil vapour, it was found that analysis for volatiles in a soil sample would not provide a meaningful assessment of potential soil vapour intrusion.[15] Therefore, this document does not suggest the use of soil standards for protection of air quality at a site. As noted above, vapours would be addressed by direct measurement of soil vapour and/or above ground air as per the Director's "Generic Numerical Vapour Standards" and the Interim Guidance for "Site Vapour Assessment".

- Sample calculations prepared for the SABCS indicate that soil ingestion is likely the major route of exposure of contaminated soil when compared to exposures via dermal absorption and particulate inhalation. However, the emerging science indicates dermal exposure may indeed be significant for various chemicals.

- The SABCS suggests the development of soil standards for industrial land uses using the protocols outlined in Volume I. A review of provincial legislation suggests that the derivation of the industrial standards will require assessment of particulate inhalation, given that an industrial site must also comply with the exposure limits outlined in the B.C. Occupation health and Safety regulation. All numerical exposure limits in the regulation are based on air monitoring.

- Background adjustments during derivation of soil matrix standards are not required. Volumes I and II recommend that there be reference to Protocol 4, which contains a set of procedures for consideration of regional and local background soil concentrations.

- The MoE should assure harmonization of procedures used to develop all standards provided within the CSR (i.e. standards within Schedules 4, 5, 6 and 10 and, the subsequent development of Upper Cap Concentrations in Protocol 11).

- The MoE should complete its review of the current groundwater transport model, as soon as possible so that the updated soil standards for all substances will include protection of the groundwater pathway for drinking water, down gradient vapour intrusion and protection of the environment.

[15] The SABCS is aware of continuing research in this area that may in the future provide the scientific understanding to permit such a correlation for certain substances.

3.3 Summary of SABCS assessment of current scientific certainty in procedures and data availability to derive soil standards to protect human health

To a large degree, common databases and approaches to prepare soil standards for protection of human health are used and accepted by the international scientific community. Scientific knowledge about the toxicity of substances to human health continues to emerge. For many substances, including those newly introduced to commerce, data availability is limited. As a result, the databases and approaches to prepare soil standards require frequent review to reflect new scientific knowledge.

With regard to the procedures and databases to derive soil standards to protect human health, the following comments are provided:

- Many exposure factors (such as ingestion rates, skin exposure, body weights, and respiration) are based on actual field studies. Toxicological reference values are obtained from animal testing studies, human epidemiology studies and/or occupational exposure data. Canadian and international health experts have reviewed such data for the purposes of human health risk assessment evaluations. Notwithstanding the complexity of the inherent chemical and biological processes that may occur, the scientific confidence in the data bases for the above noted exposure factors and the existing toxicity data bases, are currently considered by the SABCS to be "acceptable".
- Interpretations of exposure factor databases have been variable among regulatory agencies. For example, Health Canada and the U.S. EPA have adopted significantly different default values for soil ingestion and skin contact, even with the use of the same published databases. A better means is required to provide consistency for interpretations and use of exposure databases.

  Probability distribution functions have been developed for many exposure factors. Use of an entire probability distribution function rather than the use of one selected default value from that distribution function would result in more realistic and "unbiased" soil standards and provide a systematic logical process to the understanding of risk.

  A stochastic (probabilistic) approach enables the use of probability distribution functions. The Science Advisory Board of the U.S. EPA in its 2004 report has recommended the greater use of stochastic methods for assessment of risk to human health. The SABCS agrees with the recommendation and encourages the MoE to consider the use of stochastic methods to develop soil standards.
- There are data gaps in knowledge regarding bioavailability of substances; the relative significance of soil ingestion vs. intake via water, air, food and consumer products (hence a soil allocation factor, SAF, of 0.2); and, exposure factors. The absence of relevant data has resulted in a policy to apply a high degree of conservatism, as described below:
    - Bioavailability: As a result of data gaps relating to the bioavailability of substances ingested by humans, it is MOE policy that bioavailability factors are assumed to be 100 percent. For the derivation of generic standards there appears to be no current option other than to use the prudently conservative factor of 100% assimilation. The option of using bioavailability factors less than 100% can be used in site-specific assessments. The Volume I document provides for assessment and use of published bioavailability factors when available in published literature.

      The issue of bioavailability is very complex, because the derivation process for soil guidelines and standards includes the assumption that a contaminant might be taken up into the body from soil to the same extent as from the medium of exposure in the study used to derive the oral TRV. The SABCS notes that the bioavailability of substances from B.C. soils is highly variable, given that sources of contamination may vary from vitrified mining wastes where bioavailability is

likely very low, to soils recently contaminated by chemical spills, where bioavailability is likely very high. Generic standards obviously cannot consider such variable conditions; however there should be an approved bioaccessibility test (e.g. laboratory extraction procedures) for site-specific risk assessments, based on current knowledge. The SABCS recommends a review of findings by Bioaccessibility Research Canada (BARC), the U.S. EPA and the UK Government Environment Agency with regard to bioaccessiblity and bioavailability studies related to contaminants in soil.

- Estimated daily intakes (EDI)/soil allocation factors (SAF): In the absence of scientific data to the contrary, it was CSST(1996) policy that the soil ingestion pathway is assigned an SAF (soil allocation factor) of 0.2.[16] (This is consistent with the CCME 2006 protocol for derivation of soil quality guidelines.) Given the significant degree of conservatism within this policy, the SABCS supports the adjustment for background exposures for threshold acting toxicants in cases where supporting data are available, i.e., if published EDI's are available, the soil matrix standard would be calculated without the five-fold correction for SAF and background soil concentration. This is consistent with the approach taken in the Canada Wide Standard (CWS) for petroleum hydrocarbons (PHCs).
    - The SABCS notes that since 1996, more databases have been developed to better enable determinations of EDI's for many substances. The impact of the 0.2 SAF on soil standards is very significant, and the SABCS encourages the development of B.C.-specific EDI's. It is noted Health Canada has an ongoing program to assess EDI's and it is recommended that there be ongoing communications with Health Canada regarding the development of the B.C-specific EDI's. It is also recommended that the efforts of Health Canada EDI program be continued at a "high priority" level.
    - A database for bioavailability factors and SAFs for substances of concern should be maintained by the CSAP risk assessment group to assure consistency among risk assessors in B.C. and to aid in future developments of the standards
    - If this approach is to be fully utilized, there should be a collaborative component or a reporting mechanism that becomes a part of the public record.
- Exposure times. The MoE assumes exposure times such as 24 hours/day, 7 days/week, and 52 weeks/year for residences and parkland. (In Volume I, the SABCS recommends reduction of exposure in parkland to 12 hours.) The SABCS notes these exposure assumptions are unlikely in real life. The SABCS recommends a review of post-1996 findings with regard to exposure times (i.e., the recent studies by Copes and Lencar[17], 2009). An element of conservatism would still be provided by the use of 95 percentile data for exposure times.

Based on current knowledge, the SABCS considers the scientific confidence in the data and procedures to develop soil standards to protect human health, to be "moderate" The uncertainty can be reduced through frequent monitoring of the results of basic toxicological research and, better understanding of population activity patterns, estimated daily intakes (EDIs) and bioavailability.

Given the inherent conservatism in the development of the human health standards under the CSST protocols, and given the existing knowledge of toxicology, a very high level of human health protection will

[16] It is assumed an individual could be exposed to a substance via 5 pathways: soil, water, air, food and consumer products. The 1996 CSST assumes that exposure via all pathways will occur; hence soil exposure should not constitute more than 1/5 of the assumed total sources.

[17] http://www.env.gov.bc.ca/epd/remediation/presentations/feb16-17-09/risk-assess-multi.pdf

likely be provided by standards developed by use of the CSST protocol and the recommended SABCS revisions.

4 Determination of soil standards for ecological protection

SABCS reviewed the many complexities associated with the derivation of soil protection standards for flora and fauna. Subsequently the following comments and recommendations were developed with regard to the standards for protection of the land-based ecological receptors-plants, invertebrates and vertebrates.[18]

4.1 SABCS Comments and Recommendations re: procedures for development of soil standards to protect plants and invertebrates

- It is Ministry policy, by the application of the soil invertebrate and plants standards, to ensure some level of ecological health protection at a given site where natural soils and/or vegetation are exposed (i.e., via direct soil contact). As noted in the CSST policy report, " the invertebrate/plant ecological protection goals are not established to be protective of all individual species per se, rather, the intent is to protect a sufficiently robust subset of the potentially present flora and fauna to facilitate maintenance of some minimum level of soil ecological and ecosystem function, with the level of protection varying across land use type".
- The levels of protection at residential, commercial and industrial land uses are primarily a reflection of policy. However, for agricultural lands (and wildlands) the protection levels must be based on a good scientific understanding of factors such as microbial nutrient cycling to maintain the sustainability of the land. Liaison with the Ministry of Agriculture and Lands is encouraged to ascertain that there would be a consensus about the levels of protection proposed for agricultural lands and wildlands.
- The SABCS recommendation document describes an alternative procedure [to the procedure used in CSST (1996)] to provide, when possible, separate soil quality standards for protection of soil invertebrates and plants. The alternative procedure is outlined in Section B2.1.2 of the Volume I document. The SABCS believes this procedure to be an improvement over the method described in the CSST (1996) document. Working examples of the alternative procedure are provided in Appendix E of Volume I. It is noted the procedure can provide possible values for protection of plants and invertebrates, using a limited database. However those values should be viewed as provision or preliminary until the toxicity data gaps are filled.

  Future development of soil standards to protect plants and invertebrates will require an updated toxicity database by reference to CCME, EPA Eco-SSL and recent literature. Application of data quality screening criteria as provided in Volume I, will be required.

- The MoE has provided for two new land uses: wildlands and high density urban. Land use scenarios, receptor characteristics and assumptions for these two new land uses remain under development pending completion of research work by other groups. The SABCS in its

[18] 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. The SABCS anticipates that the SLRA process will be widely used and accepted by all Parties (land owners, consultants and regulatory agencies).

reports Volume I and Volume II, suggests consideration of soil invertebrates and plants within the wildland scenario. For high-density urban land-use, soil invertebrates and plants should also be considered, with the understanding that the SLRA process may have a significant role for site-specific assessment at high-density urban land use sites to evaluate whether viable soil habitat is present.

- For the purpose of deriving generic standards, there should be consideration of three levels of protection for plants and invertebrates: wildlands/agricultural (most protective); residential/high density urban/urban parks (less protective than wildlands/agricultural but more protective than commercial/industrial); and, commercial/industrial (least protective, but still minimally protective). Discussion with the Ministry of Agriculture and Lands is recommended to verify the appropriateness of the suggested protection levels for biota on wildlands and agricultural lands.

4.2 SABCS Comments and Recommendations re: procedures for development of soil standards to protect microbial functions

The SABCS agrees that microbial nutrient cycling is of significance. However, the SABCS notes there is considerable uncertainty in bioassay data relating to microbial functions and uncertainty in interpreting the meaning of incremental decrease (or increases) in microbial functions. The SABCS recommends reference to the Environment Canada criteria for guidance to determine if site-specific studies are required.

The SABCS also encourages future evaluation of Procedure 2 (as defined for soil invertebrates and plants) to develop soil standards to protect microbial functions. Similar data quality evaluations would be required. However determination of land use- specific endpoints will be required.

4.3 SABCS Comments and Recommendations re: procedures for development of soil standards to protect vertebrates

- The SABCS recommends consideration of vertebrate wildlife foraging on agricultural lands, rural industrial lands and wildlands as potential receptors of concern.
- Volume I provides an example of procedures that could be used to identify protection levels for vertebrates, including a possible means to calculate soil guidelines to protect secondary and tertiary consumers in soils that are contaminated with persistent bioaccumulative pollutants. *However, the SABCS is of the opinion that additional toxicity databases and, further development and clarification of existing models are required before procedures to develop screening values can be recommended.*
- For the protection of terrestrial vertebrates, any proposed procedures will require a trial program (using selected contaminants) 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.

4.4 SABCS Comments and Recommendations re: procedures for development of soil standards to protect aquatic biota

There is a need to complete the ongoing review of the groundwater transport model by the Ministry. The absence of this review has precluded the ability of SABCS to review the protocols for development of soil standards to protect aquatic life, as well as other receptors impacted directly or indirectly by ground water (e.g. drinking water).

4.5 Summary of SABCS assessment of current scientific certainty in procedures and data availability for development of soil standards to protect the environment (ecological components)

The complexities and limitations in the development of soil standards for protection of flora and fauna are noted in Volumes I and II. In general, it is noted:

- The chemistry of substances in soil is very complex, and it is difficult to evaluate bioavailability. Conservative approaches (i.e. worst-case scenarios) are used to develop the CSR generic matrix soil standards to protect terrestrial species (e.g., 100% bioavailability is assumed). Options such as laboratory bioaccessibility studies should be considered to enable standards based on leachate quality versus bulk analysis.
- There is a lack of field data (at contaminated sites) to test the applicability of the existing approaches used to derive the ecological standards, and to evaluate potential measurement and assessment endpoints. The SABCS considers the current state of the available science, particularly field data to underpin the procedures to develop standards to protect terrestrial plants, invertebrates and vertebrates to be still in need of significant enhancement.
- The SABCS notes the program of field survey method development in the Detailed Ecological Risk assessment guidance project that could prove useful in that regard.

RE: Plants and invertebrates :

- The amount of toxicity data varies considerably. For some substances, particularly metals, there are adequate data to develop protection levels for soil-dependent plants and invertebrates. For many contaminants, in particular organic substances, the databases are not adequate. Appendix E of Volume I provides examples of data gaps. Appendix E also indicates that numerical limits for protection of plants and invertebrates can be provided even when databases are not adequate. However, the derived limits should be viewed as provisional or preliminary until the data gaps are filled.

  It is noted standardized test procedures to generate new toxicity data for a broader range of soil-dependent organisms have been recently developed by Environment Canada.
- As discussed in Volume II, IB1-Sections 2.4(a) and (b), there is scientific uncertainty about the endpoints that should be used for the preparation of soil standards to protect invertebrates and plants (e.g. mortality, reproduction, enzyme induction, behavior, significance of loss of a particular species, etc.). It is the opinion of the SABCS that the MoE, at this time, has little choice but to maintain the CSST policy decision [Section 2.4(b) of Volume II] to continue the use of mortality, reproductive and growth endpoints to derive ecological soil guidelines.
- As per Section 1.1(a) of the policy document, there are three "mandatory" matrix standards: soil ingestion standard for human health protection; soil invertebrates and plants standard; and, the odour standard.[19] The complexities associated with the science to develop protocols for protection of soil invertebrates and plants are unfortunate given that many of the most stringent standards currently outlined in Schedule 5 are related to the protection of soil invertebrates and plants. It is noted that of the 19 substances in Schedule 5, only one direct soil exposure standard for human health (mercury) is more stringent than the standards for

[19] As noted previously, CSST 2008 recommends the use of soil vapour measurements rather than reference to the odour standards

any of the ecological receptors.[20] Hence, the most restrictive mandatory numerical standards for many substances are, and are likely in the future, to be based on databases and procedures with the high uncertainties with respect to factors such as toxicity testing, bioavailability and the selection of test species that would protect a significant segment of an assemblage.

- At a minimum, there is obviously a need to provide additional toxicity data for many substances to enhance the development of standards to protect soil invertebrates and plants.

RE: terrestrial vertebrates

- Considerably less toxicity information is available for terrestrial wildlife and livestock species for soil-based exposures and most toxicity studies are performed using oral dosages in food. The bulk of available mammalian toxicology data for environmental contaminants is generated using laboratory animals, particularly rodents. Few toxicity studies have been conducted on avian wildlife and most have been performed on poultry and game birds.
- Standardized methods for conducting toxicity tests for wildlife and livestock species are generally lacking. There are few vertebrate toxicity tests where bulk concentrations of a substrate (i.e., in soil) are used.
- There is a large degree of uncertainty associated with the estimation of actual uptake of substances that can bioaccumulate via secondary and tertiary consumers. Where possible, field data should have preference over theoretical approaches or laboratory data.

4.6 Summary of SABCS conclusions re: development of soil standards to protect the environment (ecological components)

In suggesting the need for additional research and field data acquisition programs for determining soil concentrations that would provide ecological protection, the SABCS recognizes that this is a challenge being experienced in many jurisdictions. Nonetheless jurisdictions have, on the basis of the current science, attempted to develop "screening values" (US EPA Eco-SSL) and guidelines (Environment Canada) for soils to provide ecological protection.

*Re: Standards for protection of terrestrial vertebrates*The SABCS is of the opinion that further development and clarification of existing models is required before protocols can be recommended for the development of soil concentrations that would protect terrestrial vertebrates,

As per CCME and US EPA Eco-SSL, the resulting soil concentrations, when developed, should be considered as "screening levels" or "guidelines", that would indicate the need for site-specific risk assessment that will use professional judgment and knowledge in the field application of such standards.

Re: Standards for protection of terrestrial plants and invertebrates

For the development of soil standards to protect soil invertebrates and plants, the SABCS provides a procedure that is based on an approach suggested by CCME (2006). The CCME and SABCS procedures used to assess toxicity data, are similar to procedures used by EPA Eco-SSL. While the desired endpoints used by the EPA are different from those CCME and the SABCS, overall it could be stated that the scientific approaches of all parties are relatively similar.

[20] It is noted soil standards for protection of drinking water for 6 substances are the more stringent standards)

- With the provision that additional toxicology data are obtained (by use of updated literature searches and reference to information in EPA Eco-SLL) and with the use of the SABCS modified protocol procedure, the SABCS would consider the resulting soil limits derived for several substances (with adequate databases), to be representative of current science. The resulting soil protection values could be assumed to provide a level of protection to terrestrial plants and invertebrates, as per the MoE policy described in Section 4.1 of this synopsis.

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