Use of California Human Health Screening Levels (CHHSLs) in Evaluation of Contaminated Properties

January 2005

California Environmental Protection Agency

DISCLAIMER

Use of California Human Health Screening Levels in Evaluation of Contaminated Properties has been prepared by the California Environmental Protection Agency (Cal/EPA). This document is not intended to establish policy or regulation. The Human Health Screening Levels presented here are not to serve as: 1) a stand-alone decision making tool, 2) a substitute for guidance for the preparation of baseline human health risk assessments, 3) a rule to determine if a waste is hazardous under the state or federal regulations, 4) a rule to determine when the release of hazardous chemicals must be reported to the overseeing regulatory agency, 5) set of final cleanup or action levels to be applied at contaminated sites or 6) a guarantee that an oversight regulatory agency will determine that a project is adequately studied or agree with the conclusions of the site investigation and risk assessment report.

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The CHHSLs should NOT be used to determine when impacts at a site should be reported to a regulatory agency. The list of CHHSLs is also not a comprehensive list of all potential chemicals of concern that may be found at a property. All releases of hazardous substances to the environment should be reported to the appropriate regulatory agency in accordance with governing regulations. Staff overseeing work at a specific site should be contacted prior to use of the information in this document to ensure that the document is applicable to the site and that the user has the most up-to-date version available.

 However, reference to or use of the screening levels presented in this document without adequate review of the accompanying narrative could result in misinterpretation and misuse of the information.

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Overview

What are the CHHSLs?

The California Human Health Screening Levels (CHHSLs or "Chisels") are concentrations of 54 hazardous chemicals in soil or soil gas that the California Environmental Protection Agency (Cal/EPA) considers to be below thresholds of concern for risks to human health. The CHHSLs were developed by the Office of Environmental Health Hazard Assessment (OEHHA) on behalf of Cal/EPA, and are contained in their report entitled "Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil" (Appendix 1). The thresholds of concern used to develop the CHHSLs are an excess lifetime cancer risk of one-in-a-million (10^{-6}) and a hazard quotient of 1.0 for noncancer health effects. The CHHSLs were developed using standard exposure assumptions and chemical toxicity values published by the U.S. Environmental Protection Agency (USEPA) and Cal/EPA.

How can the CHHSLs help facilitate restoration of contaminated properties?

The CHHSLs can be used to screen sites for potential human health concerns where releases of hazardous chemicals to soils have occurred. Under most circumstances, and within the limitations described in this document, the presence of a chemical in soil, soil gas or indoor air at concentrations below the corresponding CHHSLs can be assumed to not pose a significant health risk to people who may live (residential CHHSLs) or work (commercial/industrial CHHSLs) at the site. As discussed below, however, evaluation of other potential environmental concerns must also be addressed.

The presence of a chemical at concentrations in excess of a CHHSL does <u>not</u> indicate that adverse impacts to human health are occurring or will occur but suggests that further evaluation of potential human health concerns is warranted. Residential CHHSLs may be used in conjunction with the human health screening evaluation described in the Department of Toxic Substances Control (DTSC) Preliminary Endangerment Assessment (PEA) Guidance Manual to assist the risk manager in deciding whether further site characterization, risk assessment, or remediation is necessary (Cal/EPA 1994b). Further evaluation may include additional sampling at the site, consideration of ambient levels in the environment, or a reassessment of the assumptions used to calculate the CHHSLs

or PEA estimates. This stepwise approach expedites judgments about the degree of effort that may be necessary to remediate contaminated properties and restore the properties to productive use.

How do the CHHSLs differ from cleanup standards?

The CHHSLs presented in the lookup tables are NOT regulatory "cleanup standards". Use of the CHHSLs and this document is voluntary on the part of those who choose to use them. At sites where cleanup of contaminated soils to levels at or below the CHHSLs would be costly, the time and effort to develop more site-specific cleanup may be desired. At sites where the extent of contaminated soil is limited or the timeframe available to carry out cleanup actions is very short, use of the CHHSLs as final soil cleanup standards may be cost-beneficial. However, this would require the concurrence of both the responsible party and the overseeing regulatory agency and can only be done after a full evaluation of site conditions and other potential environmental concerns. Regulatory agencies cannot be compelled to use the CHHSLs as final cleanup standards for a contaminated property.

If contaminant concentrations are below the CHHSLs am I finished?

As discussed above, the CHHSLs cannot be used as a stand-alone tool for final cleanup and closure decisions. In addition, using only the CHHSLs may not be protective of groundwater resources or address other potential environmental concerns. Therefore, a thorough investigation of site conditions must also be performed to ensure that: 1) all potential human exposure pathways and exposure scenarios at the site are fully accounted for; 2) groundwater resources are protected; 3) terrestrial and aquatic habitats are protected, including the erosion of contaminated soils and subsequent runoff into a nearby wetland, stream or other aquatic habitat; and 4) that nuisance (e.g., odors and staining) and gross contamination concerns are addressed. These and other issues related to environmental contamination that are identified at the site must be evaluated separately. If a formal regulatory decision or determination is desired, additional assessment or cleanup of contaminated soils to address these concerns may ultimately be required.

How should the CHHSLs be integrated into the DTSC PEA process?

The human health screening evaluation presented in the DTSC Preliminary Endangerment Assessment (PEA) document is intended to provide a preliminary evaluation of potential risk and hazard to human health. The PEA process uses models and exposure assumptions similar to those used to develop the residential CHHSLs but does not provide actual risk-based screening levels based on these models. The PEA screening evaluation assumes that the land use of the site will be residential, regardless of the current use and zoning for the site. Therefore, residential CHHSLs for specific chemicals may be utilized in a PEA. Chemicals that do not have CHHSLs should be evaluated using the DTSC PEA methodology for their potential to pose human health risks. Chemicals found at a site should be evaluated separately for other potential environmental concerns, using the PEA guidance and other references as appropriate. The user should consult DTSC for additional information about use of the CHHSLs in the PEA process.

How are the CHHSLs related to the USEPA Preliminary Remediation Goals (PRGs) and to the San Francisco Bay Regional Water Quality Control Board Environmental Screening Levels (ESLs)?

The soil and soil gas CHHSLs are modeled after the USEPA Region IX "Preliminary Remediation Goals (PRGs)" for these media (http://www.epa.gov/region09/waste/sfund/prg/index.htm). The primary difference between the CHHSLs and the PRGs is the use of Cal/EPA-specific "toxicity factors" (estimates of a chemical's toxicity to humans) in development of the CHHSLs, when available, rather than toxicity factors published by the USEPA. For volatile chemicals, soil gas CHHSLs were developed to evaluate the potential intrusion of subsurface vapors (soil gas) into buildings and subsequent impacts to indoor air quality.

The San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) Environmental Screening Levels (ESLs) are a compilation of screening levels for not only risk to human health but also a number of other environmental concerns. The ESLs are intended for use only at sites overseen by that agency. These ESLs may be found at the SFRWQCB web site at http://www.waterboards.ca.gov/sanfranciscobay/esl.htm. The SFBRWQCB refers to the comprehensive evaluation of all potential environmental concerns as an "Environmental Risk Assessment," as opposed to a more focused "Human Health Risk Assessment" reflected in development of the CHHSLs and this

document in general. The soil, soil gas and indoor air ESLs and CHHSLs for human health concerns were developed using similar methodology and are essentially identical. In addition, the SFBRWQCB document provides soil screening levels for leaching of contaminants into groundwater, toxicity to flora and fauna and nuisance or gross contamination concerns. These concerns are not addressed by the CHHSLs and must be evaluated separately.

Because many different sets of screening levels are now available, the overseeing regulatory agency should be consulted before using any screening levels in a human health screening evaluation. The regulatory agency may have specific recommendations with respect to which screening levels it prefers to use at sites under their jurisdiction.

If I am in the jurisdiction of the San Francisco Bay Regional Water Quality Control Board, can I continue to use that office's Environmental Screening Levels (ESLs) document?

At sites in the jurisdiction of and overseen by the SFBRWQCB, the reader should consult the SFBRWQCB regarding continued use of the ESLs versus use of the CHHSLs.

How often are the CHHSLs updated?

The CHHSLs will be updated as needed to incorporate new toxicity information of referenced chemicals as well as new information regarding the exposure or potential exposure of humans to potentially hazardous chemicals in soils. CHHSLs for additional chemicals will also be included as they become available.

Who can I contact for more information?

Refer to the CHHSL link posted on the Cal/EPA website (www.calepa.ca.gov) for further information and local contacts. The document will also be posted on the OEHHA web site (www.oehha.ca.gov), the DTSC web site (www.dtsc.ca.gov), the SWRCB web site (www.waterboards.ca.gov) and at the SFBRWQCB web site (www.waterboards.ca.gov/sanfranciscobay/), as well as other Regional Boards' web sites.

1 Introduction

1.1 Purpose and Development

The California Human Health Screening Levels (CHHSLs) were developed as a tool to assist in the evaluation of contaminated sites for potential adverse threats to human health. Residential and commercial/industrial land use screening levels for soil, soil gas and indoor air are provided in Tables 1 and 2. The screening levels in Table 1 pertain to direct exposure of humans to contaminants in soil via incidental soil ingestion, dermal contact and inhalation of vapors or dust in outdoor air. The soil gas and indoor air screening levels in Table 2 pertain to the emission of volatile chemicals from contaminated soil or groundwater and their potential intrusion into overlying buildings.

Preparation of the CHHSLs by the California Environmental Protection Agency (Cal/EPA) was required under the California Land Environmental Restoration and Reuse Act of 2001 (CLERRA 2001). CLERRA also required that a guidance document be prepared to explain how the CHHSLS may be used in California to aid in making judgments about the degree of effort (or costs) that might be necessary to remediate contaminated properties, facilitate the restoration and revitalization of contaminated properties, and assist local-level remediation programs in making more efficient and effective decisions.

Appendix 1 is the Office of Environmental Health Hazard Assessment's (OEHHA) report entitled "Human-Exposure-Based Screening Numbers Developed to Aid Estimation of Cleanup Costs for Contaminated Soil" which contains the CHHSLs, and describes the approach used to develop the human-health-risk-based screening levels, the comments received regarding the draft document and OEHHA's response to those comments. The approach reflected in OEHHA's report is based on the USEPA *Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (Part A)* (USEPA 1989) and is essentially equivalent to the approach used by USEPA Region IX in developing their *Preliminary Remediation Goals* (USEPA 2004), the San Francisco Bay Area Regional Water Quality Control Board (SFRWQCB) in developing their Environmental Screening Levels for human health (SFRWQCB 2003), and the Department of Toxic Substances Control (DTSC) in their Preliminary Endangerment Assessment (PEA) guidance (Cal/EPA 1994b).

Soil and soil gas data collected at a site can be directly compared to CHHSLs for each chemical of concern. Under most circumstances, and within the limitations described, the presence of a chemical in soil or soil gas at concentrations below the corresponding CHHSLs can be assumed to not pose a significant health risk to people who may live or work at the site. The presence of a chemical at concentrations in excess of a CHHSL does not necessarily indicate that adverse impacts to human health are occurring but indicates that a potential for adverse risk may exist and that additional evaluation is warranted.

Residential CHHSLs are appropriate for other types of sensitive property use, including hospitals, day care centers and schools. In order to assess the maximum, future beneficial use of a property, data collected at commercial or industrial sites should be compared to both residential and commercial sets of screening levels. A formal restriction to the deed may be required for sites that meet requirements for commercial/industrial use but not residential use. Regulatory agency oversight would be needed in this circumstance.

The scope of the CHHSLs is limited to human health concerns. For this reason, the CHHSLs cannot be used as a stand-alone tool to determine the extent of remedial actions needed at sites with contaminated soils. Depending on site conditions and the chemicals present, additional cleanup of contaminated soils may be required to protect groundwater resources, prevent toxicity to flora and fauna, address uptake in edible plants, and address nuisance and aesthetic concerns posed by odors and staining. A brief summary of these concerns and a list of references for evaluating these issues are provided at the end of the text.

1.2 Tiered Approach to Environmental Risk Assessments

Human health risk assessments for regulatory purposes are usually carried out using a step-wise or "tiered" approach. Comparison of site data to residential soil or soil gas CHHSLs (e.g., in a screening health risk evaluation performed using the DTSC PEA guidance) usually represents "Tier 1". If multiple chemicals with similar health effects are present at a site then "forward mode," cumulative health risks may also need to be calculated and compared to target Tier 1 goals before an evaluation of potential human health concerns can be completed (refer to Section 2.8).

If the results of the Tier 1 assessment indicate that further evaluation of human health risks is warranted, site-specific exposure assumptions, target risks, etc., can

be substituted for default parameter values used to develop the Tier 1 CHHSLs and alternative screening levels developed under a Tier 2 assessment. This assessment can be incorporated into the guidelines presented in the DTSC PEA document. Prior to modifying the Tier 1 default assumptions, concurrence from the appropriate regulatory agency should be obtained. Site data can then be compared to the revised screening levels. This provides an intermediate but still relatively rapid and cost-effective option for preparing more site-specific screening or cleanup levels. Cumulative health risks or hazards should also be presented under a Tier 2 assessment, as described in Section 2.8.

If exposure pathways of concern and conditions at the site do not match those taken into account by the CHHSL framework or PEA methodology, a Tier 3, baseline human health and ecological risk assessment should be performed. In a baseline human health and ecological risk assessment, alternative models and site-specific assumptions are used to quantify the risk/hazard posed to human and/or ecological receptors by the impacted media in the "forward" mode. After a baseline health risk assessment is accepted by the regulatory agency, the assessment may be used in the "backward' model to develop site-specific screening or cleanup levels. An understanding of the methodologies used to develop the CHHSLs is important to ensure consistency between all tiers of assessments and to expedite their preparation and review.

1.3 Chemicals Not Listed In CHHSL Lookup Tables

The lookup tables list 54 chemicals, including many that are commonly found at sites where releases of hazardous chemicals have occurred. Cal/EPA will incorporate CHHSLs for additional chemicals in future updates of this document as needed and practical. Prior to that time, the PEA methodology should be used to evaluate those chemicals for which CHHSLs do not exist. Toxicity factors published by Cal/EPA should be utilized in the PEA when available, unless otherwise instructed by the overseeing regulatory agency.

1.4 Limitations

The CHHSLs presented in this document are NOT regulatory "cleanup standards." Use of the CHHSLs as final cleanup levels to address human health concerns should be discussed with the overseeing regulatory agency and evaluated in terms of the cost/benefit of developing more site-specific cleanup levels through a risk assessment.

The CHHSLs presented in this document are NOT adequate to evaluate ALL environmental conditions at ALL contaminated sites. Other environmental concerns posed by the presence of contamination at a site may include:

- Leaching of contaminants from soil to groundwater and subsequent impacts to groundwater quality;
- Intrusion of subsurface vapors into basements or buildings with substandard ventilation systems and subsequent impacts to indoor air;
- Uptake of contaminants in edible fruit and vegetables and subsequent intake by humans;
- Exposure of children and teachers at school sites;
- Toxicity to terrestrial flora and fauna;
- Gross contamination, including nuisance (odors, etc.) and aesthetic concerns.

A summary of potential environmental concerns that may also be relevant at a site for a particular chemical is also provided in Table 1.

The CHHSLs specifically do not address contamination in groundwater, surface water or sediment or the erosion of contaminated soils and subsequent runoff into a nearby wetland, stream or other aquatic habitat. Contamination identified in these media or that may threaten these media must be considered separately. References for evaluation of contaminants in these media are provided in Chapter 4.

The soil gas CHHSLs for the intrusion of vapors into buildings may not be adequately conservative for estimating impacts to indoor air in poorly ventilated basements or buildings with substandard ventilation systems in general. Additional guidance on this subject is provided in Section 2.5.2.

The CHHSLs for direct-exposure to soils concerns are calculated assuming that specific exposure pathways are complete for the human receptor: incidental soil ingestion, dermal absorption of chemicals in soil, and inhalation of vapors or particulate matter in ambient (outdoor) air. For volatile chemicals, the soil gas CHHSLs are calculated assuming that the exposure pathway of inhalation of

indoor air contaminated with vapors intruding from the subsurface is complete. If these pathways are not congruent with site conditions, the CHHSLs should not be used. The PEA guidance should then be followed.

The CHHSLS for inorganic chemicals (metals) are based on human health risks. However, metals are naturally occurring in the soil. Therefore, metals concentrations should be compared to local background levels as discussed in Section 2.7.

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2 CHHSL Lookup Tables

2.1 Organization of Lookup Tables

CHHSLS for soil, soil gas and indoor air are presented in Tables 1 and 2. Soil CHHSLs address the potential direct exposure of residents and workers to contaminants in soil. Indoor air and soil gas screening levels address the potential intrusion of subsurface vapors into buildings and subsequent impacts to indoor air quality (and resulting potential exposure of residents and workers in those buildings).

Separate CHHSLs are presented for residential and commercial/industrial land uses. A summary of models and exposure assumptions used for each land use is in Appendix 1. The category "Residential Land Use" applies to sites where unrestricted land use is desired. This includes use for residences, hospitals, day-care centers and other sensitive purposes (Cal/EPA 2002). Residential CHHSLs incorporate conservative assumptions regarding the long-term, frequent exposure of children and adults to contaminated soils in a residential setting. In contrast, "Commercial/Industrial Use Only" assumes that only working age adults will be present at the site on a regular basis. Exposure assumptions incorporated into these CHHSLs are less conservative than assumptions used in the residential land-use scenario.

In a DTSC PEA, the land use of the site under a Tier 1 assessment is assumed to be residential, regardless of the current use and zoning for the site. Other regulatory agencies may evaluate land use with respect to the current and foreseeable future use of the site in question. Reference to adopted General Plan zoning maps and local redevelopment plans is an integral part of this evaluation.

If chemicals at a site exceed residential CHHSLs but are below CHHSLs for commercial/industrial land-use, restrictions on the use of affected property will likely be necessary (refer to Section 2.10). The need for such restrictions should be weighed against the cost-benefit of remediating the property to meet the CHHSLs for unrestricted land use.

Although schools may also be a sensitive land use, proposed school sites must be evaluated using the OEHHA Guidance for Assessing Exposures and Health Risks at Existing and Proposed School Sites (Cal/EPA 2004a) rather than the CHHSLs. Refer to Section 2.9 for a discussion of school-specific risk evaluations. Use of

the lookup tables for sites with other land uses (e.g., agriculture, parkland, etc.) should be discussed with and approved by the overseeing regulatory agency.

2.2 Developing a Conceptual Site Model

The primary condition for use of CHHSLs is that exposure pathways of concern and conditions at the site match those taken into account in the development of the CHHSLs. Thus, it is always necessary to develop a conceptual site model (CSM) to identify likely contaminant source areas, exposure pathways, and potential receptors to determine the applicability of CHHSLs at the site and the need for additional information. The conceptual site model summarizes information about site conditions in a schematic presentation in terms of: 1) primary sources (e.g., leaking tanks); 2) secondary sources (e.g., contaminated soil); 3) contaminant transport mechanisms (e.g., volatilization and intrusion into buildings); 4) contaminated exposure media (e.g., indoor air); and 5) potentially complete exposure pathways.

The CSM can be used to provide a rationale for additional site investigation, as a basis for a more detailed CSM, and/or to select screening levels or cleanup levels for specific environmental concerns. An example model is shown in Figure 2-1. The example model represents a hypothetical release of petroleum-based fuels and pesticides to soil and groundwater at a large housing redevelopment project with open spaces accessible to residents (direct exposure), enclosed buildings (vapor intrusion), wetlands (ecotoxicity) and communal garden areas where fruits and vegetables are grown (uptake in edible plants). Potential environmental concerns at the hypothetical site are identified by a check mark in the appropriate column. In addition, xylene and other compounds in petroleum often cause odor and aesthetic concerns (nuisances). Cleanup to address these and other gross contamination concerns may be required even after all other potential concerns have been adequately addressed.

If completed exposure pathways at a site match those pathways considered in the development of the CHHSLs, the appropriate soil and soil gas data can be directly compared to the CHHSLs to determine if the magnitude of exposure may pose a potential threat to human health. If the exposure pathways at a site do not match those pathways used in the development of the CHHSLs, these screening levels may not be used, and a site-specific human health risk evaluation should be performed.

Other potential environmental concerns must be evaluated separately, either through use of a comparable set of screening levels or through a more detailed, site-specific environmental risk assessment. Additional information regarding the preparation of conceptual site models is provided in the DTSC *Preliminary Endangerment Assessment Manual* (Cal/EPA 1994b), the USEPA Region IX *Preliminary Remediation Goals* document (USEPA 2004), the USEPA *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final Document (USEPA 1988) and the Region 2 Environmental Screening Levels document (SFBRWQCB 2003).

2.3 Using the Lookup Tables

A step-by-step approach for using the CHHSLs is summarized below.

Step 1 – Check for CHHSL Updates and Applicability

Check with the overseeing regulatory agency to determine if the CHHSLs can be applied to the subject site. Ensure that the most up-to-date CHHSLs are being used.

Step 2 - Prepare a Conceptual Site Model

The purpose of the conceptual site model is to present information about site conditions and potential impacts to receptors. All potential environmental concerns at the site (e.g., contaminant sources, pathways, exposure routes and receptors) should be clearly identified in a conceptual site model (Section 2.2 and Chapter 4). Identification of these concerns helps to provide the rationale for the type and location for site sampling. The level of detail required in a conceptual site model will vary from site to site. The presentation and scope of the model should be discussed with the overseeing regulatory agency. The conceptual site model should be continually updated as additional data for the site is obtained.

Step 3 – Collect Data

An environmental risk assessment is based on the results of a thorough site investigation, where all chemicals of potential concern have been identified. The scope and type of site investigation will vary depending on the site specific history and the nature of the actual or suspected chemical release. Sampling objectives should be defined in advance of field activities. For example, the objective may be to document whether a release has occurred; to identify hot spots that may require an expedited removal action; to provide sufficient data to determine whether site remediation is necessary; or to evaluate whether site conditions would be consistent with proposed or potential land uses.

Steps 4 - Determine the Desired Land Use

Screening levels for residential land use are generally appropriate for other sensitive uses of the property (e.g., day-care centers, hospitals, etc.). If preparing a DTSC PEA, residential land use CHHSLs should be used. **For evaluation of commercial/industrial properties, it is highly recommended that site data be compared to CHHSLs for both unrestricted/residential and commercial/industrial land use.** Commercial/industrial CHHSLs should be used only under the oversight of a regulatory agency, as that agency will likely require a land use covenant that restricts use of the property to these purposes.

Steps 5 - Select CHHSLs

Based on the actual or proposed land use, select the appropriate soil and/or soil gas CHHSLs. Replace CHHSLs with naturally occurring, background concentrations of chemicals of concern (e.g., arsenic) or laboratory method reporting levels if appropriate (see Sections 2.6 and 2.7).

Step 6 - Compare Site Data To CHHSLs; calculate cumulative risks as necessary

Compare site data to CHHSLs to identify areas where concentrations of contaminants pose potential human health concerns. For sites where sample data are limited and/or if preparing a DTSC PEA, compare the maximum-detected concentrations of chemicals of concern to the CHHSLs.

For sites where an adequate number of data points are available, statistical methods can be used to estimate site-specific exposure point concentrations. The exposure point concentration is the lesser of the maximum-detected concentration and the 95% upper confidence limit (UCL) of the arithmetic mean of sample data (Cal/EPA 1996a). The USEPA guidance document *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* recommends evaluating the distribution of the data and choosing the best UCL estimate for the data set (USEPA 2002). Guidance for the estimation of exposure point concentrations, use of "non-detect" data, and other issues is also provided in the Cal/EPA documents *Preliminary Endangerment Assessment Guidance Manual* (Cal/EPA 1994b), *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (Cal/EPA 1996a), among other sources. As discussed in these documents, sample data collected outside of impacted areas should generally not be included in estimation of exposure point concentrations.

For residential land use scenarios, soil sample data should be averaged over no more than a 1,000 ft^2 area (assumed area of a typical, urban area back yard and footprint area of typical residence). For commercial/industrial properties, soil sample data can be averaged within affected areas of open spaces.

Use the maximum soil gas concentration over an area of the footprint of existing or assumed future buildings to compensate for potentially isolated rooms within a building and the uncertainties in soil gas collection.

If multiple chemicals with similar heath effects are present at a site, the cumulative excess cancer risk and/or noncancer hazard index should be calculated before final consideration of the site for closure. This will be of particular concern at sites where residual concentrations of chemicals with similar noncancer health effects may approach CHHSLs following the proposed, final cleanup of contaminated soil. Calculation of cumulative risks and hazard indices is discussed in Section 2.8. The need to include calculation of cumulative health risks in final closure reports should be discussed with the overseeing regulatory agency.

Steps 7 - Evaluate the Need for Additional Investigation or Actions to Address Human Health Concerns

Based on a comparison of available site data to the CHHSLs, the objectives identified in Step 3 should be evaluated. For example, comparison to CHHSLs may show that a site does not pose an unacceptable health risk to residential users, or it may show that additional investigation is warranted. Summarize the results of this evaluation in the Tier 1 Human Health Risk Assessment report (or preliminary endangerment assessment), and include recommendations for additional investigations or remediation as needed. Decisions for or against additional actions should always be made in coordination with the overseeing regulatory agency.

Step 8 - Evaluate Other Potential Environmental Concerns

The soil CHHSLs presented in Table 1 are limited to human health concerns associated with direct exposure to contaminated soil. In many instances, the presence of a potential hazardous chemical in soil may pose other environmental concerns that outweigh the risk to human health through direct exposure (see Sections 1.4 and 2.2, Chapter 4 and Table 1). The purpose of the Conceptual Site Model (Step 2) is to assist the user in identifying these concerns early in the process. For example, many metals and pesticides are significantly more toxic to flora and fauna than they are to humans (e.g., copper and nickel). Chemicals that easily leach from soils (e.g., MTBE) may pose a threat to shallow groundwater

resources even though direct exposure to the soils does not pose a significant health risk. Since the CHHSLs do not address impacts to groundwater, surface water or sediment, these and other potential environmental concerns should be addressed as part of a comprehensive environmental risk assessment.

2.4 Screening For Soil Direct-Exposure Concerns

The soil screening levels presented in Table 1 address potential exposure of humans to contaminants in soil through incidental soil ingestion, dermal absorption and inhalation of dust or vapors in outdoor air. These soil screening levels are given in milligrams (mg) of chemical per kilogram (kg) of dry soil. Therefore, the analytical laboratory must be instructed to report their results accordingly. Models and assumptions used to develop the soil CHHSLs are summarized in Appendix 1. The CHHSLs represent a combination of standard assumptions regarding exposure of residents and workers to contaminants in soil and outdoor air and toxicity factors for each of the specific chemicals listed. CHHSLs for chemicals that are known or suspected carcinogens were calculated using a target excess lifetime cancer risk of one-in-one-million (10^{-6}). A target hazard quotient of 1.0 was used to calculate CHHSLS for noncancer health effects.

The presence of a chemical in soil at concentrations below its corresponding CHHSL can be assumed to not pose a significant health risk to people who may live or work at the site. Since sites usually have multiple contaminants, the cumulative, or total risk and hazards posed by all the hazardous chemicals a site should also be estimated using the approach described in Section 2.8.

Residential and commercial/industrial soil CHHSLs are applicable to soils that are at the ground surface or could be brought to the ground surface at some time in the future, with subsequent potential exposure by human receptors. A depth of more than three meters (approximately 10 feet) is generally used to delineate "deep" soils that are likely to remain isolated in the subsurface versus "shallow" soils that may be exposed during future redevelopment activities (Cal/EPA 1996a). Exposure of workers to deeper soils could still occur during periodic construction and utility maintenance work. Even if deep soil contamination does not present a human health risk, the overseeing regulatory agency may require preparation of a formal land-use covenant in order to allow such contamination to remain on site.

2.4.1 Evaluating Lead

In Table 1, the Commercial/Industrial Soil CHHSL for lead is listed as 3,500 mg/kg. This number was calculated using the methods described in Appendix 1. It should be noted, however, that this screening number is above the Total Threshold Limit Concentration for lead (1,000 mg/kg) as defined in Title 22 of the California Code of Regulations. It is also above the USEPA Region IX Preliminary Remediation Goal (PRG) of 800 mg/kg for commercial land use.

OEHHA is evaluating the method it used to derive its health-based screening number for a commercial/industrial scenario. Until this evaluation is complete, the commercial/industrial Soil CHHSL for lead in Table 1 should be considered an interim value, and the overseeing regulatory agency should be consulted on the appropriate screening number to be used at a site under investigation.

2.5 Screening of Volatile Organic Chemicals

2.5.1 Soil Screening Levels for Direct Exposure Concerns

Screening levels for direct exposure to volatile organic compounds (VOCs) in soil were not developed by OEHHA and are not included in this edition of the CHHSLs document. Direct-exposure models such as those used by USEPA Region IX do not take into account the total amount (mass) of a volatile chemical that might be present at a site (refer to Appendix 2). This is important, since the direct-exposure models assume a continuous off-gassing of vapors throughout a 30-year exposure period. In addition, the models assume exposure both via inhalation of vapors emitted to outdoor air and via incidental ingestion of volatile chemicals in soil. These assumptions may be overly conservative for highly volatile chemicals that are not expected to remain at significant concentrations in the soil over time following off-gassing to the outdoor air.

Bulk soil screening levels (i.e. concentrations measured in soil) for volatile chemicals are not presented in this document. The restricted size of soil samples limits the ability to use soil data to evaluate vapor intrusion concerns except at sites with very minor releases. At sites where significant releases of volatile chemicals have occurred, the collection of soil gas data in conjunction with bulk soil data is strongly recommended. For sites characterized by only minor releases of volatile chemicals and limited impacts to soil (e.g., minor spills around the fill ports of underground storage tanks), cleanup of soils to meet direct-exposure

concerns should generally be adequate to address vapor intrusion concerns (see also Table 1).

2.5.2 Soil Gas Screening Levels for Vapor Intrusion Concerns

The indoor air and soil gas screening levels presented in Table 2 address the potential emission of volatile chemicals from contaminated soil or groundwater and subsequent intrusion into the indoor air of overlying buildings. A full discussion of the development of the soil gas screening levels, and the models and assumptions used, is discussed in Appendix 1.

The soil gas CHHSLs for the intrusion of vapors into buildings were developed assuming that buildings have a "slab on grade" construction. The screening levels are also considered to be adequately conservative for buildings with crawl space or underground parking construction. These reflect the most common type of building designs in California. The soil gas screening levels may not be adequately conservative for estimating impacts to indoor air in structures with basements, however, or buildings with substandard ventilation systems in general. Field data suggest that attenuation of vapors in such scenarios may be an order of magnitude below that expected in rooms or buildings with normal ventilation systems. Therefore, at sites where significant vapor intrusion concerns may exist, the collection and evaluation of samples from both basement areas and overlying living spaces may be warranted.

Additional information on subsurface vapor intrusion into buildings is provided the USEPA document *User's Guide for the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings* (USEPA 2003) and in the following section.

2.5.3 Evaluating Vapor Intrusion Concerns

If the concentration of a volatile chemical in soil gas at a site exceeds its CHHSL, the exposure pathway of soil vapor intrusion into indoor air should be further evaluated using the Cal/EPA *Guidance for the Evaluation and Mitigation of Subsurface Vapor Intrusion to Indoor Air* (Cal/EPA 2004b). The investigation of this pathway can be complex. The identification of sources of indoor air contaminants is often complicated by the presence of the same or similar chemicals products found and used in many households and industrial buildings (e.g., aerosol sprays, dry-cleaned clothing, cleaners, and tobacco smoke). Elevated levels of the same chemicals in ambient, outdoor air also pose a

problem. Plumes of groundwater contaminated with volatile chemicals can also serve as the source of volatile chemicals found in soil gas and extend over significant areas. If there is strong evidence that the intrusion of vapors into buildings may exceed levels of potential concern, the collection and analysis of indoor air samples may be necessary. The inevitable effect of indoor air studies on the personal lives of residents and building workers will further require that risk issues be carefully communicated.

Guidance on the collection of soil gas and indoor air samples is provided in the following documents, among other sources:

- *Soil Gas Advisory* (January 2003): Department of Toxic Substances Control and Los Angeles Regional Water Quality Control Board; http://www.dtsc.ca.gov/policyAndProcedures/SiteCleanup/SMBR_ADV_activesoilgasinvst.pdf.

- *Indoor Air Sampling And Evaluation Guide* (2002): Massachusetts Department of Environmental Protection, Office of Research and Standards, WSC Policy #02-430; http://www.state.ma.us/dep/bwsc/finalpol.htm.

Properly collected indoor air sample data may be compared to the indoor air screening levels. Averaging of indoor air data within a single building may not be appropriate beyond the specific room being tested. Screening levels for indoor air (Table 2) are based on standard exposure models for long-term inhalation of contaminants in air at a target excess cancer risk of 10^{-6} and a target hazard quotient of 1.0. The indoor air CHHSLs do not account for potential cumulative effects posed by the presence of multiple contaminants in air (see Section 2.8).

2.6 Substitution of Laboratory Reporting Limits for CHHSLs

The overseeing regulatory agency should review and agree to the analytical methods used to quantify chemicals in soil samples to make sure that the methods are sensitive enough to detect low concentrations of chemicals of potential concern. The attainment of detection limits that are at or below the screening levels should be part of the Data Quality Objectives. If all agreed-upon methods have been used, the overseeing regulatory agency may allow the use of the method reporting limit in place of the screening level in cases where a CHHSL for a specific chemical is less than its laboratory method reporting limit. Potential

examples include the soil direct-exposure CHHSL for dioxin (e.g., 0.0000046 mg/kg for residential exposure).

2.7 Substitution of Naturally Occurring Concentrations for CHHSLs

Naturally occurring background concentrations of arsenic, beryllium, cadmium, chromium and other metals in soils may exceed their respective soil CHHSLs. Cal/EPA generally does not require cleanup of soil to below background levels. This issue is frequently encountered with arsenic. Natural background concentrations of arsenic in California are often well above the health-based, direct-exposure goals in soil of 0.07 mg/kg for residential land use and 0.24 mg/kg for commercial/industrial land use (e.g., Bradford et. al, 1996; LBNL 2002). Background concentration of arsenic or other metals of potential concern at a site should be determined from analysis of site-specific samples in uncontaminated areas using guidance published by Cal/EPA and/or reference to published data for nearby sites (Cal/EPA 1997). However, background data for nearby sites may only be used as a surrogate for uncontaminated site data if those data are obtained from soil of the same lithology as that found on-site.

2.8 Cumulative Risks at Sites with Multiple Contaminants

Risks posed by exposure to multiple chemicals with similar health affects are considered to be additive or "cumulative." For example, the total excess lifetime risk of cancer posed by the presence of several carcinogenic chemicals in all exposure media is the sum of the risk posed by each individual chemical. The same is true for chemicals that cause noncarcingenic health effects.

A stepwise approach for screening of sites with multiple contaminants is suggested (after USEPA 2004):

Step 1: Identify potential chemicals of concern.

Step 2: Record CHHSLs for each chemical separated by media type (soil, soil gas and/or indoor air). Include CHHSLs for both cancer and noncancer effects, if available (refer to Appendix 1). If CHHSLs are not available for specific chemicals, evaluate those chemicals using the approaches discussed in Appendix 1 and in the PEA manual.

Step 3: Calculate cumulative cancer risk estimates by taking the assumed exposure point concentration for each chemical (maximum or approved 95% UCL) and divide by the respective CHHSL concentration designated for cancer evaluation. Multiply the ratio by 10^{-6} (the target risk used to develop the CHHSLs) to calculate the estimated cancer risk for that specific chemical for a reasonable maximum exposure (RME).

$$Risk = [\left(\frac{conc_x}{CHHSL_x}\right) + \left(\frac{conc_y}{CHHSL_y}\right) + \left(\frac{conc_z}{CHHSL_z}\right)] \times 10E-06$$

For multiple chemicals, simply add the risks for individual chemicals or sum individual ratios and multiply the total by a factor of 10^{-6}:

Step 4: Calculate cumulative noncancer hazard estimates by taking the assumed exposure point concentration for each chemical (maximum or approved 95% UCL) and divide by the respective CHHSL concentration designated for noncancer effects. This generates an individual Hazard Quotient for that chemical. Calculate a cumulative Hazard Index by adding the individual Hazard Quotients. A Hazard Index of one or less is generally considered "safe". A ratio that is greater than one suggests that further evaluation is necessary. (Note that carcinogens may have CHHSLs for both cancer effects as well as noncancer effects. Refer to Appendix 1).

For more information, refer to the USEPA Preliminary Remediation Goals

$$Hazard\,Index = [\left(\frac{conc_x}{CHHSL_x}\right) + \left(\frac{conc_y}{CHHSL_y}\right) + \left(\frac{conc_z}{CHHSL_z}\right)]$$

document (USEPA 2002). OEHHA has also developed a spread sheet tool for calculating cumulative risk. This spread sheet is available on Cal/EPA's, DTSC's, the State Board's and OEHHA's web pages.

2.9 Evaluation of School Sites

DTSC's Schools Property Evaluation and Cleanup Division is the lead agency for the environmental assessment of potential contamination at new, expanding, or existing schools. Since January 2000, school districts have been required to conduct an environmental assessment under the oversight and approval of DTSC prior to the construction of new schools. By law, DTSC uses specific guidance and protocols for school projects. Because of this, the CHHSLs may not be applicable for these sites. Contact DTSC for further information and direction for

the evaluation of potential contamination on school properties and the application of the CHHSLs.

2.10 Use of CHHSLs as Cleanup Levels and Land Use Restrictions

As stated earlier in this guidance, these CHHSLs are not stand-alone decision making tools, a set of final cleanup or action levels to be applied at contaminated sites or a guarantee that an oversight regulatory agency will determine that a project is adequately studied or agree with the conclusions of the site investigation and risk assessment report. Cleanup decisions are at the discretion of the overseeing regulatory agency and can only be made after a full evaluation of site conditions and potential human health and environmental concerns.

While regulatory agencies cannot be compelled to use the CHHSLs as final cleanup standards for a contaminated property, there may be circumstances where the residential CHHSLS would be sufficiently protective and considered as appropriate cleanup levels with the following caveats.

- The overseeing regulatory agency has determined that the site has been adequately characterized and agrees that the use of CHHSLs is appropriate.

- The potentially complete exposure pathways at the site match the exposure pathways used to develop the CHHSLs and no additional completed exposure pathways or receptors were identified.

- All other environmental concerns have been addressed to the satisfaction of the overseeing regulatory agency (refer to Section 1.4 and Table 1).

In a similar manner, there may be circumstances where the Commercial/Industrial CHHSLS would be sufficiently protective and considered as appropriate cleanup goals under regulatory agency oversight. Their use at a site in this context must also be coupled with the understanding that such a use of these CHHSLs may be subject to existing regulations and land-use covenants. In addition, the following should also be considered:

- **Concentrations of chemicals in soils left in place at a commercial/industrial site should always be compared to both commercial/industrial AND residential CHHSLs.** If the soils meet

CHHSLs for residential land use after cleanup then this should be clearly stated in the site closure report. This point may prove important should the site unexpectedly become desirable for other uses in the future (e.g., residential, day care, health care, etc.).

- Sites cleaned up to commercial CHHSLs only are not suitable for unrestricted land use without further evaluation. The appropriate regulatory agency should be consulted to determine actions necessary to remove land-use restrictions.

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3 Conditions Warranting Site Specific Human Health Risk Assessments

3.1 Site Considerations

Use of the CHHSLs is optional and a standard human health risk assessment may be undertaken for any site. Site conditions may prevent the full use of the CHHSLs and require preparation of a more site-specific, health risk evaluation or baseline risk assessment (refer to Section 1.2). Examples of site conditions that may warrant site-specific or detailed human health risk assessment include:

- Sites that have a high public profile and need a detailed, fully documented human health risk assessment for public review;
- Sites where multiple contaminants with similar health effects are present and cumulative health risks (or hazards) must be calculated;
- Sites with contaminants for which CHHSLs have not been developed.
- Sites where alternative target risk levels or chemical-specific toxicity factors may be acceptable to the regulatory agency (Appendix 1);
- Sites where direct-exposure concerns for residents and workers may not need to be considered (Section 2.4);
- Sites where site conditions may be engineered to eliminate or reduce specific exposure pathways;
- Sites where field observations or site conditions indicate that the CHHSLs may not be adequately protective or may be excessively conservative.

Additional considerations should be evaluated on a site-by-site basis and discussed with the overseeing regulatory agency.

3.2 Tier 2 Human Health Risk Assessments

3.2.1 Purpose

The Tier 1 CHHSLs were developed with default or generic assumptions that are not specific to any particular site condition. If site soil concentrations exceed CHHSLs, site-specific exposure assumptions may be used in the standard risk models described in Appendix 1 or the PEA guidance to estimate risk and/or develop site-specific CHHSLs. Using alternative exposure assumptions in these standard risk models could reduce the time and cost incurred by both the regulated business and the overseeing responsible party in finalizing the risk assessment. Modifications to the default assumptions must be described and justified in the text of the report, presented with the revised set of screening or cleanup levels, and agreed to beforehand with the regulatory agency.

3.2.2 Examples of Site-Specific Adjustments

Potential site-specific modifications include:

- Use of alternative target risk levels, and/or alternative exposure assumptions;
- Elimination of direct-exposure concerns through imposition of institutional controls;
- Inclusion of potential exposure of construction and trench workers to contaminated soil not likely to be exposed at the ground surface in the future (e.g., capped soils or soils isolated at depth);
- Consideration of method reporting limits or natural background or ambient concentrations of a chemical in place of the CHHSL.

After incorporating site-specific parameter values into the Tier 1 direct-exposure models, alternative human-health-based screening levels can be calculated and re-compared to site data.

3.3 Tier 3 (Baseline) Human Health Risk Assessments

3.3.1 Purpose

In a site-specific baseline human health risk assessment, alternative models and assumptions are used and fully justified to develop a detailed, comprehensive

human health risk assessment. Portions of the models and assumptions used to develop the CHHSLs may still be retained for some components of the risk assessment. Any baseline human health risk assessment should be carried out under the oversight of the regulatory agency.

Detailed guidance on the preparation of and information for use in site-specific baseline environmental risk assessments is provided in the following references:

Human Health Risk Assessment:

- *Risk Assessment Guidance for Superfund. Volume I, Human Health Evaluation Manual* (Part A) (USEPA 1989a);
- *Soil Screening Guidance: Technical Background Document* (USEPA 1996);
- *CalTOX, A Multimedia Total Exposure Model For Hazardous-Waste Sites* (Cal/EPA 1994a);
- *Preliminary Endangerment Assessment Guidance Manual* (Cal/EPA 1994b);
- *Supplemental Guidance For Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (Cal/EPA 1996a);
- *Exposure Factors Handbook* (USEPA 1997a); and
- *Assessing the Significance of Subsurface Contaminant Vapor Migration to Enclosed Spaces* (Johnson et. al, 1998).

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4 Evaluation of Other Potential Environmental Concerns

The importance of identifying all environmental concerns at sites where releases of hazardous chemicals have occurred is discussed in Sections 1.4 and 2.2. The CHHSLs provided in Tables 1 and 2 specifically address risks to human health posed by exposure to contaminated soil and indoor air. At sites affected by highly toxic but relatively immobile chemicals (e.g., PCBs, DDT, arsenic, etc.), cleanup of contaminated soils to address human health concerns will generally be sufficient to address other potential environmental concerns provided that sensitive ecological habitats are not threatened. In other cases or for other chemicals, additional environmental concerns may still be present even after impacted soils have been remediated to levels sufficient to address risks to human health. This could include leaching of contaminants from soil and subsequent impacts on groundwater resources, toxicity to terrestrial biota, uptake of contaminants in edible fruits or vegetables and nuisance or gross contamination concerns.

A summary of other environmental concerns potentially posed by contaminants in soil is incorporated into Table 1. This summary compares the CHHSLs to the SFBRWQCB's ESLs for leaching, ecotoxicity and nuisance concerns. The ESLs can be found at http://www.waterboards.ca.gov/sanfranciscobay/esl.htm.

For example, the residential CHHSL for endrin in soil (21 mg/kg) is much higher than the corresponding ESL for ecotoxicity concerns (0.06 mg/kg). This means that ecotoxicity concerns may outweigh human health concerns at sites where potentially sensitive habitats are present (designated by an "X" in the Table 1). This is not surprising, since endrin, a pesticide, was specifically formulated to be highly toxic to terrestrial biota.

Additional evaluation should be carried out at sites where the basic conceptual site model indicates that the presence of contaminated soils may pose other environmental concerns or where potential impacts to groundwater, surface water or sediment are identified. It is beyond the scope of this document to present guidance on the proper evaluation of these additional concerns. However, useful references are provided in Figure 4-1. Additional risk assessment guidance should be consulted as needed.

5 References

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SFBRWQCB, 2003, *Screening for Environmental Concerns at Sites with Contaminated Soil and Groundwater* (July 2003): California Regional Water Quality Control Board, San Francisco Bay Region, http://www.swrcb.ca.gov/rwqcb2/esl.htm.

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FIGURES

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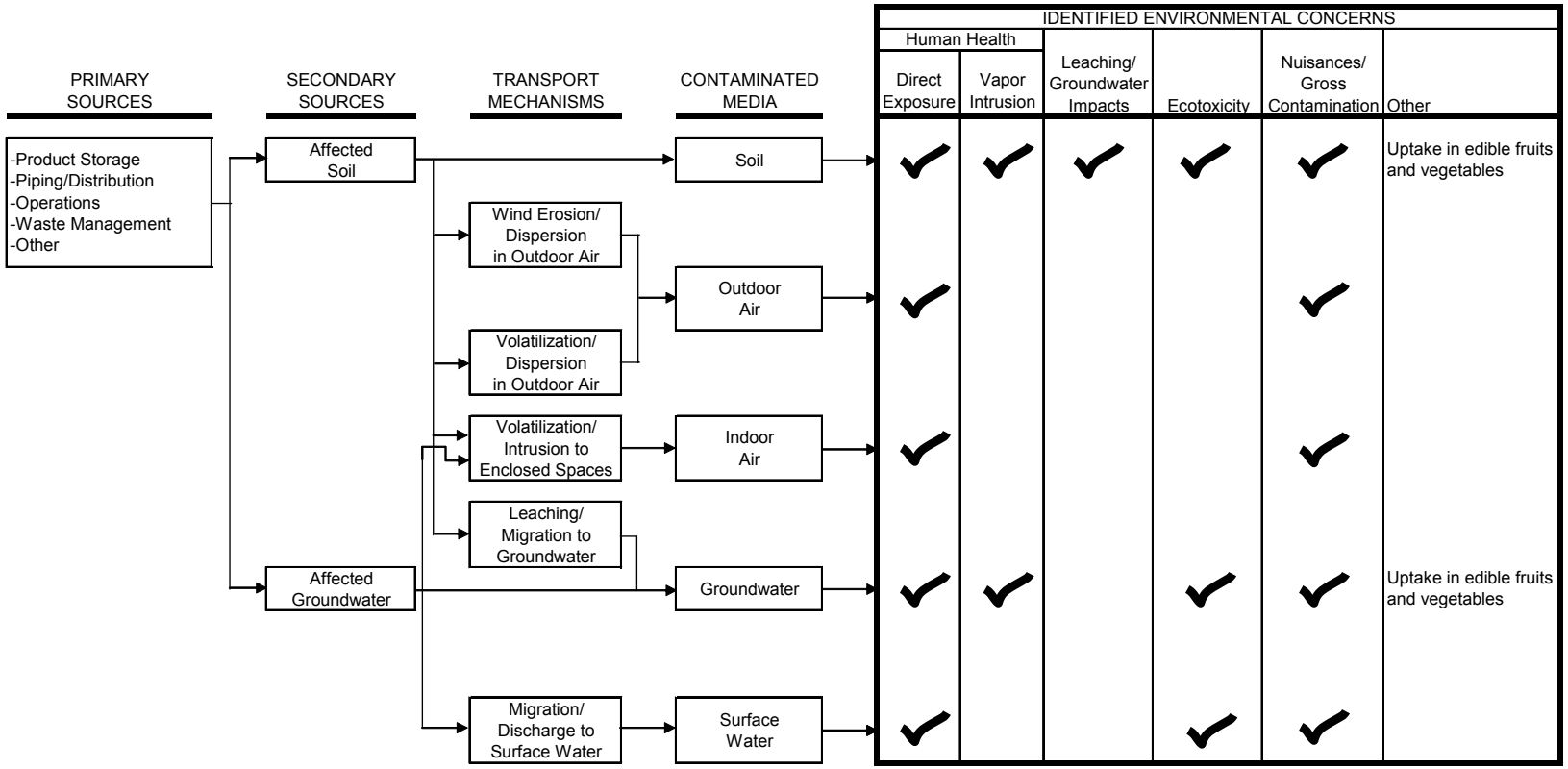

Figure 2-1. Example conceptual site model depicting environmental concerns identified at a site where hazardous chemicals were released to soil and groundwater. See Section 2.2.

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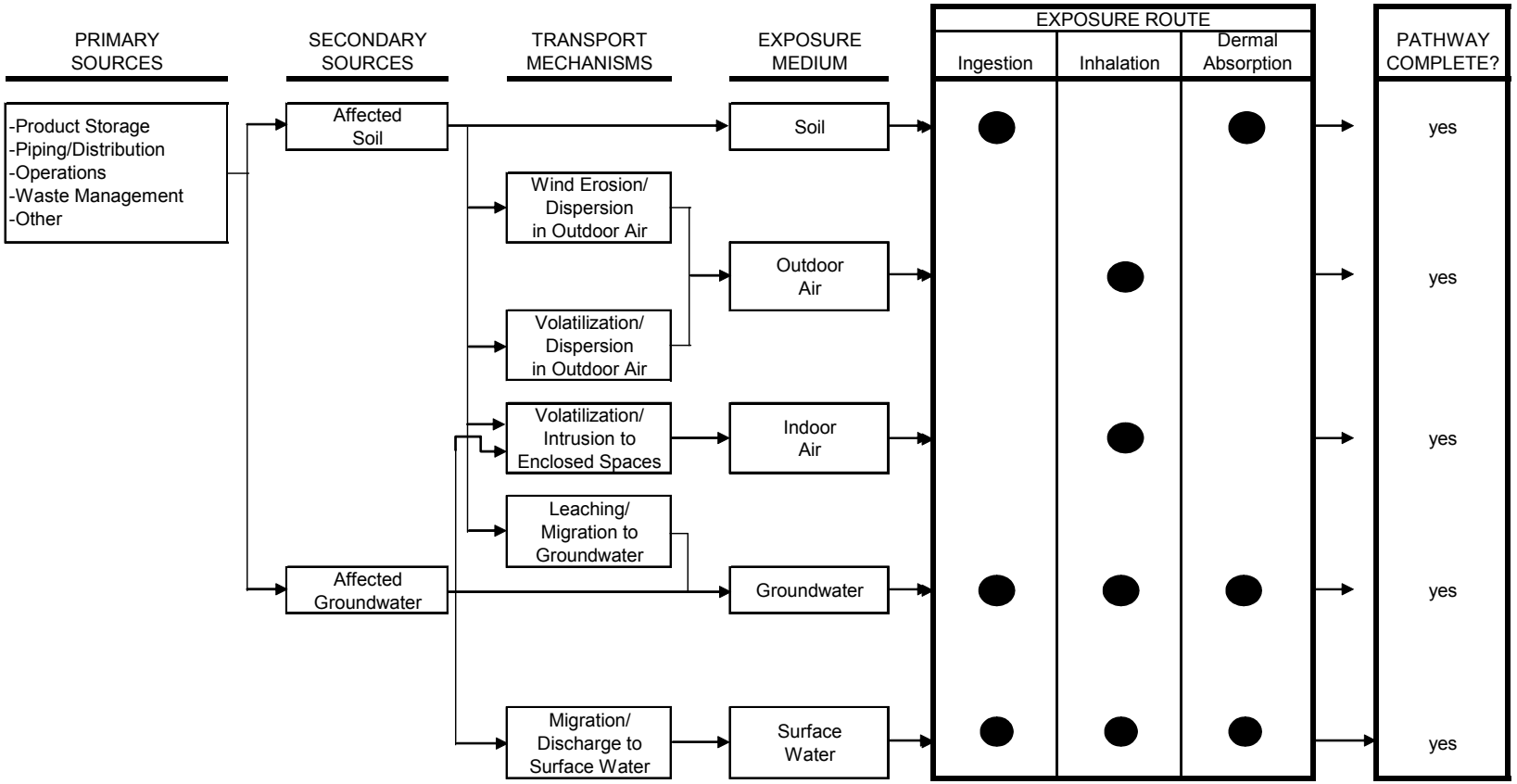

Figure 2-2. Example focused conceptual site model of human health concerns identified at a site where hazardous chemicals were released to soil and groundwater. See Section 2.2.

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Environmental Concern	Reference/Website
Leaching and migration of contaminants to groundwater	USEPA Soil Screening Guidance (USEPA 1996): http://www.epa.gov/superfund/resources/soil/index.htm SFBRWQCB ESL Document (SFBRWQCB 2003): http://www.waterboards.ca.gov/sanfranciscobay/esl.htm. USEPA Synthetic Precipitation Leaching Procedure (USEPA 1994): http://www.epa.gov/epaoswer/hazwaste/test/main.htm. Commonly Used Models: SESOIL, VLEACH
Ecotoxicity	USEPA Ecological Soil Screening Guidance (USEPA 1996): http://www.epa.gov/superfund/programs/risk/ecorisk/ecossl.htm Risk Assessment Guidance for Superfund: Volume II Environmental Evaluation Manual (USEPA 1989b); Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments (USEPA 1997b) Guidance for Ecological Risk Assessments at Hazardous Waste Sites and Permitted Facilities (CalEPA 1996a,b) Ontario MOEE Rational for the Development and Application of Generic Soil, Groundwater and Sediment Criteria for Use at Contaminated Sites in Ontario (MOEE 1996): http://www.ene.gov.on.ca/ SFBRWQCB ESL Document (SFBRWQCB 2003): http://www.waterboards.ca.gov/sanfranciscobay/esl.htm NOAA Sediment Screening Table (NOAA 1999): http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.html
Ingestion via plant uptake	USEPA Soil Screening Guidance (USEPA 1996): http://www.epa.gov/superfund/resources/soil/index.htm USEPA Fertilizer Risk Assessment (USEPA 1999): http://www.epa.gov/epaoswer/hazwaste/recycle/fertiliz/risk/ CalEPA CALTOX model (CalEPA 1994a): http://www.dtsc.ca.gov/ Massachusetts DEP Guidance for Disposal Site Risk Characterization (MADEP 1995): http://www.state.ma.us/dep/ors/orspubs.htm
Nuisance/Gross Contamination	Massachuestts DEP Background Documentation for the Development of the MCP Numerical Standards (MADEP 1994): http://www.state.ma.us/dep/ors/orspubs.htm SFBRWQCB ESL Document (SFBRWQCB 2003): http://www.waterboards.ca.gov/sanfranciscobay/esl.htm

Figure 4-1. Suggested references for evaluation of environmental concerns not currently addressed by the CalEPA CHHSLs.

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TABLE 1: California Human Health Screening Levels for Soil and Comparison to Other Potential Environmental Concerns

Notes:
Always compare soil data for commercial/industrial sites to residential CHHSLs and evaluate need for formal land-use restrictions (see Section 2.10).

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Table 1. California Human Health Screening Levels for Soil And Comparison To Other Potential Environmental Concerns

Chemical	[1]Soil Human Health Screening Levels (mg/kg of dry soil)		[2]Other Potential Environmental Concerns Posed By Contaminated Soil			
	Residential Land Use	Commercial/ Industrial Land Use Only	[3]Leaching	[4]Ecotoxicity	[5]Nuisance/ Aesthetic Concerns	[6]Other
Organic Acidic Chemicals						
2,4-D	6.9E+02	7.7E+03	X	X	o	
2,4,5-T	5.5E+02	6.1E+03	X	X	o	
Pentachlorophenol	4.4E+00	1.3E+01	X	X	o	
Organic Neutral Chemicals						
Aldrin	3.3E-02	1.3E-01	o	X	o	
Benzo(a)pyrene	3.8E-02	1.3E-01	o	X	o	TPH
Chlordane	4.3E-01	1.7E+00	o	X	o	
DDD	2.3E+00	9.0E+00	o	X	o	
DDE	1.6E+00	6.3E+00	o	X	o	
DDT	1.6E+00	6.3E+00	o	X	o	
Dieldrin	3.5E-02	1.3E-01	X	X	o	
1,4 Dioxane	1.8E+01	6.4E+01	X	o	o	
Dioxin (2,3,7,8-TCDD)	4.6E-06	1.9E-05	o	o	o	
Endrin	2.1E+01	2.3E+02	X	X	o	
Heptachlor	1.3E-01	5.2E-01	X	X	o	
Lindane	5.0E-01	2.0E+00	X	X	o	
Kepone	3.5E-02	1.3E-01	X	o	o	
Methoxychlor	3.4E+02	3.8E+03	o	X	o	
Mirex	3.1E-02	1.2E-01	X	X	o	
PCBs	8.9E-02	3.0E-01	o	X	o	
Toxaphene	4.6E-01	1.8E+00	X	X	o	

Table 1. California Human Health Screening Levels for Soil And Comparison To Other Potential Environmental Concerns

Chemical	[1]Soil Human Health Screening Levels (mg/kg of dry soil)		[2]Other Potential Environmental Concerns Posed By Contaminated Soil			
	Residential Land Use	Commercial/ Industrial Land Use Only	[3]Leaching	[4]Ecotoxicity	[5]Nuisance/ Aesthetic Concerns	[6]Other
Inorganic Chemicals						
Antimony and compounds	3.0E+01	3.8E+02	site specific	o	o	
Arsenic	7.0E-02	2.4E-01	site specific	X	o	Ambient background
Barium and compounds	5.2E+03	6.3E+04	site specific	X	o	Construction workers
Beryllium and compounds	1.5E+02	1.7E+03	site specific	X	o	
Beryllium oxide[7]	9.1E-02	4.1E-01	o	o	o	Construction workers
Beryllium sulfate[7]	2.1E-04	9.5E-04	o	o	o	
Cadmium and compounds	1.7E+00	7.5E+00	site specific	X	o	Ambient background
Chromium III	1.0E+05	1.0E+05	site specific	X	X	
Chromium VI	1.7E+01	3.7E+01	site specific	X	o	Construction workers
Cobalt	6.6E+02	3.2E+03	site specific	X	o	Construction workers
Copper and compounds	3.0E+03	3.8E+04	site specific	X	X	
Fluoride	4.6E+03	5.7E+04	site specific	o	o	
Lead and lead compounds	1.5E+02	3.5E+03[9]	site specific	X	o	Uptake in fruits and vegetables
Lead acetate[7]	2.3E+00	1.0E+01	X	o	o	
Mercury and compounds	1.8E+01	1.8E+02	site specific	X	o	
Molybdenum	3.8E+02	4.8E+03	site specific	X	X	
Nickel and compounds	1.6E+03	1.6E+04	site specific	X	X	Construction workers
Nickel subsulfide[7]	3.8E-01	1.1E+04	site specific	o	o	
Perchlorate[8]	pp[8]	pp[8]	X	o	o	
Selenium	3.8E+02	4.8E+03	site specific	X	X	
Silver and compounds	3.8E+02	4.8E+03	site specific	X	X	
Thallium and compounds	5.0E+00	6.3E+01	site specific	o	o	Ambient background
Vanadium and compounds	5.3E+02	6.7E+03	site specific	X	X	

Table 1. California Human Health Screening Levels for Soil And Comparison To Other Potential Environmental Concerns

Chemical	[1]Soil Human Health Screening Levels (mg/kg of dry soil)		[2]Other Potential Environmental Concerns Posed By Contaminated Soil			
	Residential Land Use	Commercial/ Industrial Land Use Only	[3]Leaching	[4]Ecotoxicity	[5]Nuisance/ Aesthetic Concerns	[6]Other
Zinc	2.3E+04	1.0E+05	site specific	X	X	

Notes:

1. Direct-exposure screening levels address human exposure to chemicals in soil via incidental ingestion, dermal absorption and inhalation of vapors and particulates emitted to outdoor air (refer to Appendix 1). Assumes impacted soil is situated at or near the ground surface or could be at some time in the future. Volatile chemicals not included at this time (refer to Section 2.5).
   "Residential Land Use" screening levels generally considered appropriate for other sensitive uses (e.g., day-care centers, hospitals, etc.).
   Commercial/industrial properties should be evaluated using both residential and commercial/industrial CHHSLs. A deed restriction that prohibits use of the property for sensitive purposes may be required at sites that are evaluated and/or remediated under a commercial/industrial land use scenario only.
   Carcinogens: CHHSLs based on target cancer risk of 10^{-6}. Cal/EPA cancer slope factors used when available.
   Noncarcinogens: CHHSLs based on target hazard quotient of 1.0.
   Calculation of cumulative risk may be required at sites where multiple contaminants with similar health effects are present (see Section 2.8).
   Residential and C/I soil CHHSLs for arsenic below background for most sites in California (0.07 mg/kg and 0.24 mg/kg, respectively - see Appendix 1). Use identified or anticipated background as screening level (see Section 2.7).
2. Environmental concerns in addition to direct exposure that may need to be considered in evaluation of contaminated soil. Based on a comparison of soil CHHSLs to soil screening levels for noted concerns compiled by the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB 2003). The need to address other environmental concerns must be evaluated separately in coordination with the lead regulatory agency (See Sections 1.4, 2.2 and Chapter 4).
   "X": Noted concern may outweigh direct-exposure risks at many sites and drive decisions for cleanup actions.
   "o": Potential concern but generally will be addressed if cleanup of contaminated soils to meet direct-exposure CHHSLs is carried out.
   "site specific": Potential concern, but evaluation as to whether this factor is a potential concern must be done on a site specific basis.
3. Leaching of chemicals from soil and subsequent impacts to groundwater. Soil ESLs consider of impacts to drinking water resources, re-emission of volatile chemicals from groundwater into overlying buildings and discharges of contaminated groundwater to surface water. Leaching of metals from soil should be evaluated on a site-specific basis, depending on the potential mobility of the metal species present. Laboratory-based leaching studies are generally preferred over model-derived screening levels.
4. Toxicity to terrestrial flora and fauna. Need to consider ecotoxicity concerns generally determined on a site-by-site basis.
5. Nuisance and gross contamination concerns address odors and aesthetic concerns as well as general resource degradation and presence of potentially mobile free product.
6. Other pertinent environmental concerns and considerations as determined on a site-specific basis.
   Health risk to construction workers may outweigh risk to residents or commercial/industrial workers for chemicals that are carcinogenic due to increased exposure to airborne dust particles and incidental ingestion of soil. Uptake of chemicals in edible fruits and vegetables from soil may need to be considered in some cases for noted chemicals.
7. These metal salts are significantly (greater than 10-fold) more toxic than the values for the metals in general. If it is known that this chemical was used at the site, the screening number for this chemical should be used instead of the screening number for the metal and its compounds.
8. Calculation of a screening number for the chemical has been postponed (pp) until the toxicity criterion currently being developed by OEHHA is published as a final document.
9. This screening number is above the Total Threshold Limit Concentration for lead of 1000 mg/kg, as defined in Title 22, California Code of Regulations. It is also above the US EPA Region IX PRG of 800 mg/kg.

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TABLE 2: California Human Health Screening Levels for Indoor Air and Soil Gas

Notes:
Always compare soil data for commercial/industrial sites to residential CHHSLs and evaluate need for formal land-use restrictions (see Section 2.10).

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Table 2. California Human Health Screening Levels for Indoor Air and Soil Gas

Chemical	[1]Indoor Air Human Health Screening Levels ($\mu g/m^3$)		[2]Shallow Soil Gas Human Health Screening Levels (Vapor Intrusion) ($\mu g/m^3$)	
	Residential Land Use	Commercial/ Industrial Land Use Only	Residential Land Use	Commercial/ Industrial Land Use Only
Benzene	8.40 E-02	1.41 E-01	3.62 E+01	1.22 E+02
Carbon Tetrachloride	5.79 E-02	9.73 E-02	2.51 E+01	8.46 E+01
1,2-Dichloroethane	1.16 E-01	1.95 E-01	4.96 E+01	1.67 E+02
cis-1,2-Dichloroethylene	3.65 E+01	5.11 E+01	1.59 E+04	4.44 E+04
trans-1,2-Dichloroethylene	7.30 E+01	1.02 E+02	3.19 E+04	8.87 E+04
Ethylbenzene	Postponed[3]	Postponed[3]	Postponed[3]	Postponed[3]
Mercury, elemental	9.40 E-02	1.31 E-01	4.45 E+01	1.25 E+02
Methyl tert-Butyl Ether	9.35 E+00	1.57 E+01	4.00 E+03	1.34 E+04
Naphthalene	7.20 E-02	1.20 E-01	3.19 E+01	1.06 E+02
Tetrachloroethylene	4.12 E-01	6.93 E-01	1.80 E+02	6.03 E+02
Tetraethyl Lead	3.65 E-04	5.11 E-04	2.06 E-01	5.78 E-01
Toluene	3.13 E+02	4.38 E+02	1.35 E+05	3.78 E+05
1,1,1-Trichloroethane	2.29 E+03	3.21 E+03	9.91 E+05	2.79 E+06
Trichloroethylene	1.22 E+00	2.04 E+00	5.28 E+02	1.77 E+03
Vinyl Chloride	3.11 E-02	5.24 E-02	1.33 E+01	4.48 E+01
m-Xylene	7.30 E+02	1.02 E+03	3.19 E+05	8.87 E+05
o-Xylene	7.30 E+02	1.02 E+03	3.15 E+05[4]	8.79 E+05[4]
p-Xylene	7.30 E+02	1.02 E+03	3.17 E+05	8.87 E+05

Reference: Appendix 1, OEHHA Target Indoor Air Concentrations and Soil-Gas Screening Numbers for Existing Buildings under Residential and Industrial/Commercial land uses.

Notes:

1. "Residential Land Use" screening levels generally considered adequate for other sensitive uses (e.g., day-care centers, hospitals, etc.). Commercial/industrial properties should be evaluated using both residential and commercial/industrial CHHSLs. A deed restriction that prohibits use of the property for sensitive purposes may be required at sites that are evaluated and/or remediated under a commercial/industrial land use scenario only.
Calculation of cumulative risk may be required at sites where multiple contaminants with similar health effects are present.
Carcinogens: CHHSLS based on target cancer risk of 10-6. Cal/EPA cancer slope factors used when available.
Noncarcinogens: CHHSLS based on target hazard quotient of 1.0.
2. Soil Gas: Screening levels based on soil gas data collected <1.5 meters (five feet) below a building foundation or the ground surface. Intended for evaluation of potential vapor intrusion into buildings and subsequent impacts to indoor-air. Soil gas data should be collected and evaluated at all sites with significant areas of VOC-impacted soil. Screening levels also apply to sites that overlie plumes of VOC-impacted groundwater.
3. Calculation of a screening number for the chemical has been postponed (pp) until the toxicity criterion currently being developed by OEHHA is published as a final document.
4. Representative Screening Numbers for mixed xylenes. The representative value for mixed xylenes is based on the calculated lowest one amongst the three isomers.

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Appendix 1: Human-Exposure-Based Screening Numbers Developed To Aid Estimation of Cleanup Costs for Contaminated Soil

OEHHA (November 2004)

(Revised January 2005)

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APPENDIX 2: Comparison of CHHSLs to Existing Screening Levels and Standards

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Comparison of CHHSLs to Existing Screening Levels and Standards

The U.S. Environmental Protection Agency Region IX office in San Francisco publishes "Preliminary Remediation Goals (PRGs)" for soil, drinking water and ambient air with a focus on risks to human health (USEPA 2004). The San Francisco Bay Area Regional Water Quality Control Board (SFBRWQCB) publishes Environmental Screening Levels (ESLs) for soil, groundwater, surface water and air that provide screening levels for other common environmental concerns as well (SFBRWQCB 2003).

Methods used by the USEPA and the SFBRWQCB to assess potential human exposure to contaminants in soil and air are very similar. The resulting screening levels are therefore almost identical. Similarities and differences between the CHHSLs and these suites of screening levels are summarized below. In addition, federal and state agencies publish screening levels or regulatory standards for hazardous waste that are sometimes confused with environmental screening levels. The applicability of these criteria to contaminated sites is also briefly described.

USEPA Region IX PRGs

The USEPA Region IX "Preliminary Remediation Goals" or "PRGs" address the direct exposure of residents and commercial workers to contaminants found in soil, drinking water and air (USEPA 2004). These PRGs may be found at http://www.epa.gov/region09/waste/sfund/prg/index.htm. Equations and assumptions used to develop the PRGs are consistent with the human health risk assessment guidance prepared by Cal/EPA, including the CalTOX model (Cal/EPA 1994a) and the *Preliminary Endangerment Assessment Guidance Manual* (Cal/EPA 1994b) and *Supplemental Guidance for Human Health Multimedia Risk Assessments of Hazardous Waste Sites and Permitted Facilities* (Cal/EPA 1996a).

The USEPA approach for developing the PRGs was adopted to develop the CHHSLs with minor modifications. The CHHSLs are an adjustment of soil and ambient air PRGs by using Cal/EPA-specific toxicity factors. For the majority of the chemicals listed, Cal/EPA toxicity factors are slightly more stringent or equal to those used by the USEPA to develop the PRGs. Some CHHSLs are significantly more restrictive.

A detailed discussion of the USEPA Region IX PRGs models is provided in Appendix 1. As discussed in the USEPA Region IX document, the PRGs are intended to address human direct-exposure with impacted soil and "...do not consider impact to groundwater or address ecological concerns" and cannot be used

as a stand-alone tool for the evaluation of contaminated sites (USEPA 2004). The same is true for the CHHSLs.

USEPA Soil Screening Levels

The USEPA Office of Emergency and Remedial Response document *Soil Screening Guidance: Technical Background Document* presents methodologies and related soil screening levels for evaluation of direct-exposure concerns, leaching of contaminants from soil and subsequent impacts to groundwater, uptake of contaminants into plants and the intrusion of volatile chemicals into buildings (USEPA 1996). Although subsequent guidance documents on specific topics have since been prepared by USEPA and other agencies (USEPA PRGs, USEPA vapor intrusion guidance document, etc.), the Soil Screening Guidance nonetheless provides a valuable resource for evaluation of these environmental concerns.

Soil screening levels for direct exposure concerns are based on USEPA toxicity factors and similar exposure models used to develop the USEPA Region IX PRGs and the Cal/EPA CHHSLs. Screening levels are presented for specific pathways (e.g., ingestion, inhalation of outdoor air, etc.), rather than for combined exposure routes as now presented in the PRGs and the CHHSLs. Dermal absorption was not considered in calculation of the direct-exposure screening levels. This pathway was included in calculation of the PRGs and CHHSLs, however. The ultimate difference in screening levels is in most cases minimal.

Soil screening levels for leaching concerns are based on a simplistic contaminant equilibrium partitioning model. The model uses USEPA maximum contaminant levels (MCLs) for drinking water as target groundwater impact goals. Generic dilution factors of "1" and "20" are presented for mixing of leachate in groundwater and subsequent dilution of contaminant concentrations. The leaching based soil screening levels are presented in the USEPA Region IX PRG document.

The Soil Screening Guidance model does not take into account fate and transport of leachate in the vadose zone and can be excessively conservative for highly volatile or highly sorptive chemicals or for use at sites where groundwater is greater than ten meters or more below the base of contaminated soil. The document also presents leaching based screening levels for inorganic (contaminants, primarily metals). Leaching of metals from soil is highly dependent on the actual specifies of the metal present and site-specific soil factors. Laboratory-based studies are generally preferable over model-based approaches for evaluation of leaching of metals and other inorganic chemicals from soil.

The uptake of contaminants in edible plants is briefly discussed in the Soil Screening Guidance document. Screening levels are presented for a limited number of inorganic contaminants. The report concludes that uptake of contaminants into plants may be of particular concern for arsenic and cadmium. With the exception of these compounds, the report notes that inorganic contaminants in soil are likely to be toxic to the plants themselves at levels far lower than would be of concern for uptake and consumption of the plants by humans. (DTSC also considers the uptake of lead in edible plants. Refer to Table 1 of the main document).

A brief discussion of the Johnson and Ettinger model for vapor intrusion from contaminated soils into buildings is provided in the Soil Screening Guidance document. Soil screening levels for this concern are not presented, however, due to concerns that the soil model significantly overestimates potential impacts to indoor air. The document instead recommends that soil gas data be used to evaluate this concern, although screening levels are likewise not provided. Soil gas CHHSLs presented in Table 2 of this document reflect more up-to-date USEPA methods for evaluation of vapor intrusion concerns (see Appendix 1). The USEPA is currently developing additional guidance on this subject.

SFBRWQCB Environmental Screening Levels (ESLs)

The SFBRWQCB ESLs are a compilation of screening levels specific for use at sites overseen by that agency in the San Francisco bay area for a number of different environmental concerns, including risk to human health. The July 2003 edition (updated February 2004) of the SFBRWQCB ESLs includes screening levels for the following exposure pathways and/or environmental concerns:

Soil:

- Protection of human health
- Direct/indirect exposure to impacted soil (ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);
- Emission of subsurface vapors to building interiors;
- Protection of groundwater quality (leaching of chemicals from soil);
- Protection of terrestrial (nonhuman) biota;
- Protection against nuisance concerns (odors, etc.) and general resource degradation;

Indoor Air:

- Protection of human health;

Shallow Soil Gas:

- Emission of subsurface vapors to building indoor air.

Similar ESLs are also provided for the environmental media of groundwater and surface water. In the ESL document, soil screening levels for individual environmental concerns are compared and the lowest of these levels (i.e., the concentration of the chemical at which all other environmental concerns would likewise be addressed) is presented in the ESL summary lookup tables.

By comparison, the CHHSLs reflect a subset of the screening levels considered in the ESL document specific to human health concerns. CHHSLs were developed for the follow concerns only:

Soil:

- Direct/indirect exposure to impacted soil (nonvolatile chemicals only - ingestion, dermal absorption, inhalation of vapors and dust in outdoor air);

Indoor Air:

- Protection of human health;

Shallow Soil Gas:

- Emission of subsurface vapors to building indoor air.

For comparative purposes, the most current ESLs may be found at http://www.waterboards.ca.gov/sanfranciscobay/esl.htm. The soil direct exposure CHHSLs and ESLs for nonvolatile chemicals and soil gas CHHSLs and ESLs for volatile chemicals are essentially identical. Soil and indoor air ESLs for human health concerns were developed by incorporating Cal/EPA toxicity factors into the USEPA PRG models for direct exposure to contaminated soil and USEPA models for the intrusion of soil gas into buildings. Since this mimics the approach used to develop the CHHSLs, the resulting screening levels are very similar.

The primary difference is the assumption in the ESL soil and indoor air screening levels for human health that up to five chemicals with similar noncancer health effects may be present at a given site. This allows potential cumulative health risks to be conservatively taken into account at most sites without requiring that the screening levels be adjusted on a site-by-site basis (see Section 2.8). This was done by simply dividing the initial screening level based on a hazard quotient of 1.0 by a factor of five (adjusting the target Hazard Quotient to 0.2). Future editions of the ESL document will directly incorporate the Cal/EPA CHHSLs for soil and indoor air as part of that document, again adjusted to address cumulative risk concerns at a Tier 1 level.

Hazardous Waste Regulations

California Total Threshold Limit Concentrations (TTLC) criteria for solids and Soluble Threshold Limit Concentration (STLC) are used to determine whether a waste is a hazardous waste (Title 22, California Code of Regulations, section 66261.24(a)(2)(A) and (B)). If a waste is determined to be a hazardous waste, specific regulations and statues regarding the management, storage, transportation and disposal must be met.

In most cases, TTLC values exceed the most conservative environmental screening levels presented in this document. In the case of Endrin and DDT/DDE/DDD, however, the TTLC is somewhat lower than the screening levels for human health concerns. The TTLC for combined DDT/DDE/DDD is 1.0 mg/kg while the residential, direct-exposure soil screening for each compound ranges from 1.6 mg/kg to 2.3 mg/kg, for a sum of 5.5 mg/kg (see Table 1).

In practice, the extent of soil contaminated above 1.0 mg/kg versus 5.5 mg/kg total DDT/DDE/DDD may not be significant in the field following cleanup to the risk-based CHHSLs. However, it may be prudent to use TTLCs as final cleanup values for residential sites where the TTLC is less than cleanup values that were based on actual risk to human health and the environment. This may help to avoid potential future problems with soil management and disposal.

TSCA Cleanup Levels for PCBs

The treatment, storage and disposal of polychlorinated biphenyls (PCBs) are regulated under the federal Toxics Substance Control Act (TSCA), as described in 40 CFR Part 761 (revised 7/1/99), which is administered by the USEPA Toxics Section. If PCBs are found at a site, the regulation should be consulted to determine its applicability and to ensure that the appropriate notifications are provided to and approvals are obtained from USEPA (refer also to *Guidance on remedial Actions for Superfund Sites with PCB Contamination,* USEPA 1990). To obtain more information regarding regulations and guidance, the USEPA's PCB web page can be accessed at: http://www.epa.gov/opptintr/pcb/

Within each USEPA Region, the Regional Administrator has designated Regional PCB Coordinators to oversee the development of PCB efforts. The staff of the Region IX PCB Program is available to members of the regulated community and others who have questions concerning the manufacture, processing, distribution in commerce, use, cleanup, storage and disposal of PCBs and PCB articles. The Region IX PCB web page can be accessed at:
http://www.epa.gov/region09/toxic/pcb/index.html

USEPA Region IX staff can be contacted at:

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