DEPARTMENT OF TOXIC SUBSTANCES CONTROL
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

PROVEN TECHNOLOGIES AND REMEDIES GUIDANCE

REMEDIATION OF METALS IN SOIL

AUGUST 29, 2008

PREFACE

The Department of Toxic Substances Control (DTSC) is issuing this Proven Technologies and Remedies (PT&R) guidance document for immediate use on cleanups at hazardous waste facilities and Brownfields sites. The PT&R approach described herein is an option for expediting and encouraging the cleanup of sites with elevated concentrations of metals in soil. The approach described herein is designed to ensure safe, protective cleanup and to maintain DTSC's commitment to public involvement in our decision-making process. Please see Chapters 1 through 3 for details regarding the PT&R approach and how to determine whether this guidance is suitable for a given site.

DTSC fully expects that application of the PT&R approach to cleanup metals-impacted sites will identify areas that can be improved upon as well as additional ways to streamline the PT&R cleanup process. As the protocols in this document are implemented, issues may be identified which warrant document revision. DTSC will continue to solicit comments from interested parties for a period of one year (ending August 31, 2009). At that time, DTSC will review and incorporate changes as needed.

Comments and suggestions for improvement of *Remediation of Metals in Soil* should be submitted to:

Kate Burger
Department of Toxic Substances Control
8800 Cal Center Drive
Sacramento, California 95826
kburger@dtsc.ca.gov

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Dr. Kate Burger, PG, PhD, Sr. Engineering Geologist (principal author, principal editor);
Mr. Paul Carpenter, PG, Engineering Geologist, (co-author);
Ms. Kendra Chan, Office Technician (research);
Mr. Mike Finch, PG, Sr. Engineering Geologist (co-author);
Ms. Hortensia Muniz-Ghazi, PE, Sr. Hazardous Substances Engineer (co-author, co-editor);
Dr. Debbie Oudiz, PhD, Sr. Toxicologist (co-author);
Mr. Kevin Shaddy, PE, Sr. Hazardous Substances Engineer (co-author); and
Mr. Jesus Sotelo, PE, Hazardous Substances Engineer (co-author).

Document scope, technical review, and technical guidance were provided by the multi-disciplinary, cross-program members of the PT&R Team. These individuals are as follows:

Mr. Stewart Black, PG, Team Leader, Sr. Engineering Geologist;
Ms. Pauline Batarseh, PE, Supervising Hazardous Substances Engineer I;
Ms. Barbara Cook, PE, Supervising Hazardous Substances Engineer II;
Dr. Stephen DiZio, PhD, Supervising Toxicologist;
Mr. Paul Hadley, PE, Sr. Hazardous Substances Engineer;
Mr. John Hart, PE, Supervising Hazardous Substances Engineer I;
Ms. Orchid Kwei, Staff Counsel III Specialist;
Mr. Ray Leclerc, PE, Sr. Hazardous Substances Engineer;
Ms. Hortensia Muniz-Ghazi, PE, Sr. Hazardous Substances Engineer;
Ms. Janet Naito, Sr. Hazardous Substances Scientist;
Ms. Lynn Nakashima, Sr. Hazardous Substances Scientist;
Dr. Debbie Oudiz, PhD, Sr. Toxicologist;
Mr. Brad Parsons, Sr. Hazardous Substances Scientist;
Mr. Kevin Shaddy, PE, Sr. Hazardous Substances Engineer;
Mr. Jesus Sotelo, PE, Hazardous Substances Engineer; and
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Ms. Yvette LaDuke, Public Participation Specialist (Appendices F1 and F2).
Ms. Janet Naito, Sr. Hazardous Substances Scientist (Appendices C2 and C3);
Ms. Maryam Tasnif-abbasi, Sr. Hazardous Substances Scientist (Appendix C3); and
Mr. Tedd Yargeau, Sr. Hazardous Substances Scientist (Appendix C2).

In addition, the Operation and Maintenance Plan Sample contained in Appendix E2 was modified from an earlier version developed by the Department's Schools Program.

The experience and technical knowledge that each of the individuals listed above provided during preparation of this document has resulted in a high quality analysis of California cleanup technologies for metals in soil and compilation of sample documents that can be used in the PT&R process. Their extensive project experience has also provided the clear road map needed to safely and efficiently clean up a wide variety of sites. Many thanks to each of you for your support on preparing this PT&R document.

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APPENDICES

ABBREVIATIONS AND ACRONYMS

AOC	Area of Contamination
ARARs	applicable or relevant and appropriate requirements
ASTM	American Society of Testing and Materials
bgs	below ground surface
Cal/EPA	California Environmental Protection Agency
Cal-OSHA	California Occupational Health and Safety Administration
CalTrans	California Department of Transportation
CAMU	Corrective Action Management Unit
CEQA	California Environmental Quality Act
CERCLA	Comprehensive Environmental Response and Liability Act
CHHSLs	California Human Health Screening Levels
CMS	Corrective Measures Study
cm/sec	centimeters per second
COPCs	chemicals of potential concern
CSM	conceptual site model
DTSC	Department of Toxic Substances Control
EE/CA	engineering evaluation/cost analysis
EPA	U.S. Environmental Protection Agency
EPC	exposure point concentration
ET	evapotranspiration
FML	flexible membrane liner
FS	Feasibility Study
GC	geosynthetic clay
HASP	health and safety plan
HDPE	high density polyethylene
HSAA	Hazardous Substances Account Act
HSC	California Health and Safety Code
HWCL	Hazardous Waste Control Laws
IC	institutional control
ITRC	Interstate Technology and Research Council
LCCA	life-cycle cost analysis
LDR	land disposal restriction
LUC	land-use covenant
NCP	National Contingency Plan
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List

ABBREVIATIONS AND ACRONYMS (Continued)

O&M	operation and maintenance
PAHs	polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PEA	Preliminary Endangerment Assessment
PI	plasticity index
PT&R	proven technologies and remedies
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	quality assurance project plan
RAP	Remedial Action Plan
RAO	remedial action objective
RAW	Removal Action Workplan
RCRA	Resource Conservation and Recovery Act
RWQCB	Regional Water Quality Control Board
SVOCs	semi-volatile organic compounds
SWPPP	storm water pollution prevention plan
TPH	total petroleum hydrocarbons
UCL	upper confidence limit
USCS	Unified Soil Classification System
VCP	Voluntary Cleanup Program
VOCs	volatile organic compounds

EXECUTIVE SUMMARY

Elevated concentrations of metals in soil are encountered in approximately one-third of existing and former hazardous waste facilities and Brownfields sites in California. The Department of Toxic Substances Control (DTSC) has prepared this *Proven Technologies and Remedies Guidance – Remediation of Metals in Soil* (PT&R guidance) as an option for expediting and encouraging cleanup of sites with elevated concentrations of metals in soil. The approach may be applied at operating or closing hazardous waste facilities and at Brownfields sites. Although expediting cleanup is emphasized, the approach discussed in this guidance is designed to ensure safe, protective remediation and to maintain DTSC's commitment to public involvement in our decision-making process.

This PT&R guidance is applicable on a case-by-case basis at sites where the primary environmental concern involves soils contaminated with metals. This document is intended for use by any government agency, consultant, responsible party, project proponent, facility operator, and/or property owner addressing these types of soils. However, the PT&R guidance will not be applicable to all sites with metal contamination. For example, this guidance may not be applicable to sites contaminated with chemicals in addition to metals or where contamination has impacted groundwater or surface water. Therefore, prior to applying this PT&R guidance to a site cleanup process, the environmental regulatory oversight agency should be consulted and should concur with the use of this approach.

Cleanup of contaminated sites may be governed by one or more federal or state laws, depending on such factors as the source and cause of the contamination, the type of chemical contamination found, and the type of operations conducted. The PT&R approach is consistent with these laws and will yield technically and legally adequate environmental solutions. The remedy selected must be: (1) protective of human health and the environment; (2) able to achieve cleanup objectives and goals; and (3) able to control or remediate sources of releases.

DTSC conducted a study that reviewed and screened data for 188 sites where the primary contaminants were metals. This study found that "containment by capping" and "excavation and off-site disposal" were the most frequently selected cleanup alternatives. Therefore, this guidance was prepared to streamline the cleanup process for sites that are suitable for these PT&R alternatives.

The guidance streamlines the cleanup process by (1) limiting the number of evaluated technologies to two PT&R alternatives: excavation/disposal and containment/capping; (2) facilitating remedy implementation; and (3) facilitating documentation and administrative processes. To gain the maximum cost and time savings, the applicability of the PT&R approach could be discussed during the scoping meeting and initiated as early as possible in the cleanup processes (e.g., during the characterization phase).

The objectives of the PT&R guidance are to:

- Identify the types of sites that would be appropriate for application of the PT&R approach;
- Identify the site data that should be collected to support this approach;
- Provide guidance in establishing background concentrations, screening levels, and cleanup goals;
- Provide guidance for determining when cleanup goals are achieved; and
- Provide sample documents, annotated outlines, and examples for the documents prepared as part of the cleanup process.

This PT&R guidance is not intended to replace the evaluation of innovative and new technologies. DTSC continues to encourage the use and evaluation of emerging technologies.

OVERVIEW OF PT&R APPROACH

The following paragraphs and Figure ES-1 summarize the steps of the PT&R approach. The PT&R approach uses the public participation process identified in the *DTSC Public Participation Manual* (DTSC, 2003).

Determine Suitability for PT&R Approach. In order to determine whether the PT&R process is appropriate for your site, you should evaluate whether the site characteristics make it amenable to a streamlined scoping, site characterization, remedy selection, and remedy implementation. This PT&R guidance targets cleanup at sites where the primary environmental issue is metal contamination in shallow soils. The site characteristics that favor the PT&R approach are summarized in Table ES-1. Refer to Chapter 3 for details regarding these characteristics.

Table ES-1. Site Characteristics that Favor PT&R Approach

• Primarily metals contamination	• No emergency actions required
• Contamination < 15 feet bgs[1]	• Low potential for surface water impact[3]
• Metals in immobile form[2]	• Low potential for groundwater impact[2, 3]
• No ecological habitat or sensitive receptors impacted[3]	

1 Characteristic pertinent for excavation/disposal alternative. The 15-foot depth is a general frame of reference. The actual excavation depth that is feasible for a given cleanup is a site-specific decision.
2 Preferred characteristic for containment/capping alternative.
3 The approach recommended for selection of cleanup goals in this PT&R guidance considers the health impact endpoint, intended use of the property, and number of contaminants. If a site has potential impacts to ecological receptors, groundwater, or surface water, the PT&R approach for establishing cleanup goals is not applicable.

Characterization Phase. The characterization phase establishes the nature and extent of contamination in environmental media such as soil and, if needed, background or

naturally-occurring concentrations of metals. Under the PT&R approach, sufficient data should be collected to determine that the PT&R approach is still applicable and to support remedy selection and the engineering design. As data are gathered, they are compared to screening levels to help determine whether further site characterization, risk assessment, or cleanup may be necessary.

Risk Screening. A human health screening evaluation for chemicals of potential concern (COPCs) is conducted to estimate the potential cancer risks and noncancer health hazards. The PT&R approach uses the risk screening evaluation guidance provided in: (1) *Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994); and (2) *Use of California Human Health Screening Levels (CHHSLs) in Evaluating Contaminated Properties* (Cal/EPA, 2005).

Site-Specific Evaluation and Selection of Remedial Alternatives. The remedy selection document is drafted in accordance with the requirements applicable to the site/facility. The results of the site investigation lay the groundwork for demonstrating the applicability of the PT&R approach to the project conditions. The analysis of alternatives should reference this guidance document and complete the evaluation of the alternatives that meet the remedial action objectives (RAOs). The alternatives would generally include the no action, excavation/disposal, and/or containment/capping alternatives. If appropriate, necessary documents for the California Environmental Quality Act (CEQA) may be prepared concurrently with the alternatives evaluation report. The remedy selection and CEQA documents are circulated for public comment.

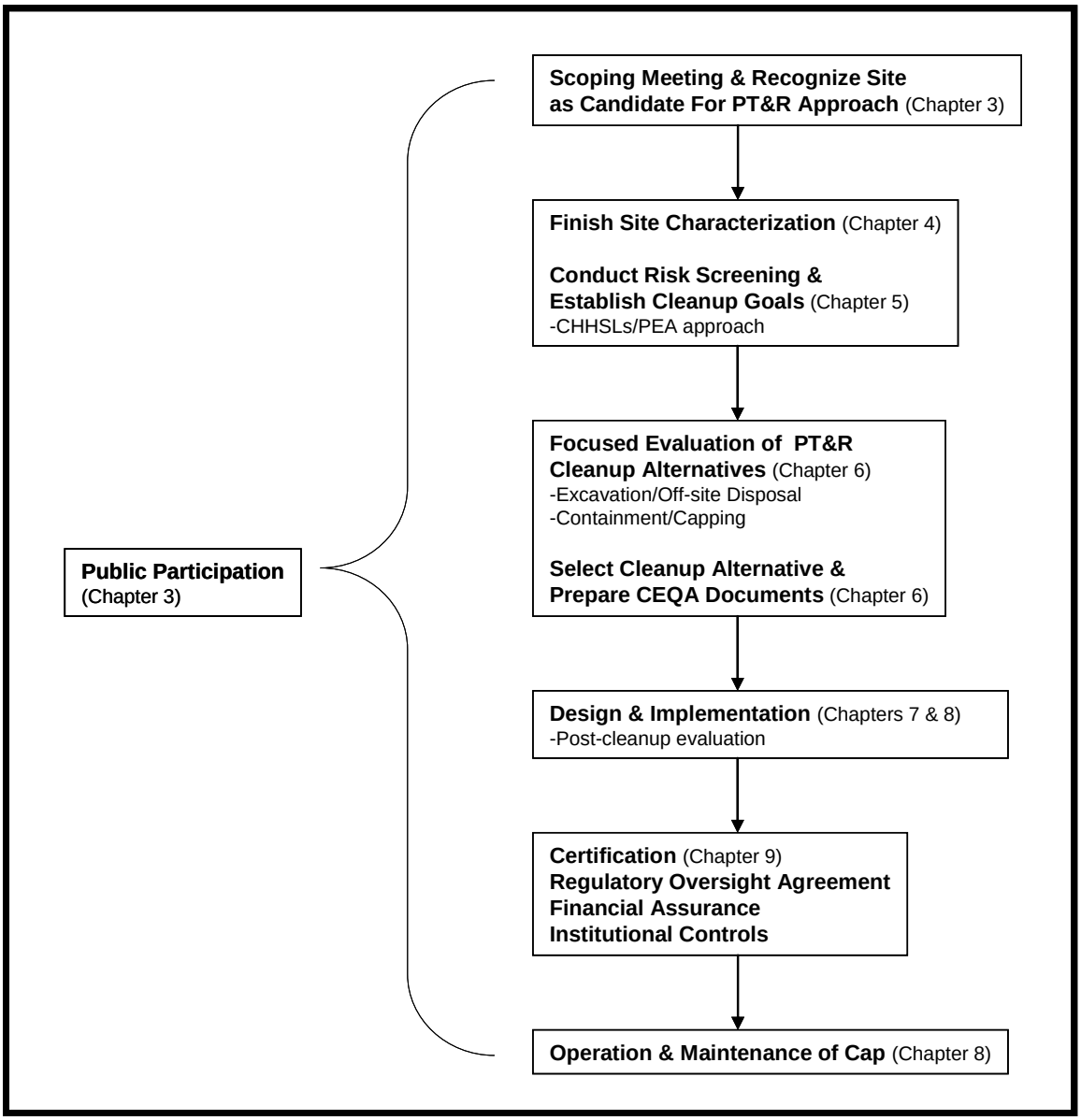
As shown in Figure ES-1, the excavation/disposal alternative has the potential to allow unrestricted use of the site whereas the containment/capping alternative will require long-term stewardship.

Cleanup Design and Implementation. The technical and operational plans for implementing the proposed alternative may be included in the remedy selection document, if appropriate, or prepared as a separate document once a final response action is approved. Once the final response action is implemented, a report documenting its implementation is submitted to DTSC.

Post-cleanup Evaluation for Lead. The PT&R approach recommends a post-cleanup evaluation for sites where lead is a COPC because cleanup approaches for lead may be changing. This evaluation of the residual lead concentrations across the entire site is recommended for risk communication purposes. Confirmation sample results and sampling data collected previously for soil remaining at the site are used to prepare a statistical summary that is included in the remedy completion report.

Certification of Remedy Completion. When the response action has been fully implemented, DTSC will certify the site. Before DTSC issues this certification letter, any requirements for a Land Use Covenant (LUC) or other institutional controls (ICs) and an Operation and Maintenance Agreement/Plan (including establishment of a financial assurance mechanism) must be met.

Figure ES-1. Summary of PT&R Approach for Sites with Metals-Contaminated Soils.



1.0 INTRODUCTION

The *Proven Technologies and Remedies Guidance – Remediation of Metals in Soil* (PT&R guidance) has been prepared to streamline the corrective action and remedial action processes, herein after referred to as the "cleanup process", at sites with soils*[1] contaminated with metals[2]. The proven technologies and remedies (PT&R alternatives) discussed in this document were determined to be effective based on:

- engineering and scientific analysis of performance data from past state and federal cleanups and
- review of the administrative records and procedures used to implement the technologies.

The PT&R guidance outlines an option for streamlining the cleanup process, thus increasing the number of acres that are cleaned up and put back into beneficial use. The approach discussed in subsequent sections can be applied at operating or closing hazardous waste facilities and at Brownfields* sites. Although expediting the cleanup process is emphasized, the approach discussed in this guidance is designed to ensure safe and protective remediation.

Elevated concentrations of metals in soil are encountered in approximately one-third of existing and former hazardous waste facilities and Brownfields sites. The most commonly encountered metal contaminants are arsenic, chromium, lead, and mercury. When released to the soil surface, metals tend to accumulate and persist in the shallow soil unless the metal retention capacity* of the soil is exceeded or geochemical conditions favor downward migration (McLean and Bledsoe, 1992). The depth of metals contamination is a function of several factors, such as how much material is released, the chemical oxidation state* of the metal when it is released, chemical reactions occurring within the soil, and whether the metal tends to solubilize* or form complexes* with more mobile constituents (e.g., organic ligands*). Although elevated levels of metals can occur naturally, metal contamination in soil is typically a result of:

- Mining and ore processing operations in mineralized zones;
- Industrial operations such as metal recycling and recovery, smelters, metal finishing, and plating shops;
- Agricultural applications of pesticides and herbicides (e.g., arsenic, lead);
- Burn piles and open burn pits;
- Dispersal from offsite or mobile sources along transportation corridors (e.g., aerially deposited lead from vehicle emissions); and
- Older buildings covered with lead-based paints.

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[1] If a term is annotated by an asterisk, a definition for the word is provided in the glossary.

[2] For the purposes of this guidance document, the term "metals" is used as a general reference for metallic elements and certain metalloids. Please refer to the glossary for the full definition of "metals" as used in this document.

1.1 PURPOSE AND OBJECTIVE

The purpose of this document is to encourage and support the use of DTSC's past experience and provide guidance on PT&Rs to expedite cleanup of sites with elevated concentrations of metal(s) in soil. The guidance document is intended for use by any government agency, consultant, responsible party and/or property owner addressing potential metal contamination at a site. Prior to applying this PT&R guidance to a site cleanup process, the oversight agency must be consulted and must concur with use of the PT&R approach.

The objectives of the PT&R guidance are to:

- Identify the characteristics that make a site conducive for application of the PT&R approach;
- Provide recommendations for characterizing the nature and extent of contamination and collecting data needed to support the cleanup alternative;
- Provide guidance in establishing background* concentrations, screening levels*, and cleanup goals*;
- Provide guidance for post-cleanup evaluation to characterize the residual concentrations of lead; and
- Provide guidance on associated administrative requirements, such as documentation and implementation of the cleanup alternative selection process.

1.2 TECHNICAL BASIS FOR PT&R APPROACH AT SITES WITH METAL CONTAMINATION IN SOIL

DTSC conducted a study that reviewed and screened data for 188 sites where the primary contaminants were metals (see Section 6.1 for details). The objective of the study was to identify the technologies that were consistently selected for evaluation and to determine the frequency at which these technologies were selected as the remedy. The results of the study revealed that "containment by capping" (containment/capping*) and/or "excavation and offsite disposal" (excavation/disposal) were the most frequently selected cleanup alternatives.

1.3 SCOPE AND APPLICABILITY

This document is applicable at sites where the primary environmental concern involves soils contaminated with metals. However, the approach outlined in the PT&R guidance is not applicable to all sites with metal contamination. Rather, this guidance is most applicable at sites where metals have accumulated in shallow soils[3] as a result of

[3] The term "shallow soils" generally implies depths that are less than 15 feet below ground surface (bgs). The actual depth that can be addressed under PT&R is a site-specific factor based on the constraints of the PT&R cleanup alternatives, site-specific considerations, and costs associated with increasing depth.

discharge to the surface and where site-specific conditions have limited downward migration of the metals.

This guidance may not be applicable to sites that require cleanup measures in addition to the PT&Rs or that may be more efficiently cleaned up by another approach. For example, sites with contamination at depths greater than 15 feet or where groundwater is shallow and the contamination extends to groundwater may require other cleanup approaches. Sites with metals that can be easily mobilized via solubilization*[4] or volatilization*[5] may also require a different approach. Unusual geologic and hydrogeologic conditions, multiple contaminants, or public concerns may require cleanup alternatives that are not included in this PT&R guidance. In these instances, the PT&Rs are not appropriate and a more extensive cleanup technology evaluation should be conducted.

In general, the PT&R approach may not be appropriate for:

- Complex sites (e.g., mining and milling sites);
- Sites where stakeholder concerns would be better addressed under a different cleanup process;
- Sites with metals impact to sensitive habitat or ecological receptors;
- Sites that may benefit from the use of innovative technologies;
- Sites with metal impacts to environmental media other than soil (e.g., groundwater, surface water, sediment, air);
- Sites impacted by multiple chemicals of concern* (i.e., chemicals of concern in addition to metals) that will impact the selection of the cleanup alternative; and
- Sites that treat soil, groundwater, and other environmental media as one operable unit*.

This PT&R guidance is not intended to replace the evaluation of innovative and new technologies. DTSC continues to encourage the use and evaluation of emerging technologies.

[4] e.g., organolead, hexavalent chromium, methyl mercury, ethyl mercury
[5] e.g., methyl mercury, ethyl mercury

2.0 OVERVIEW AND ORGANIZATION

Cleanup of contaminated sites may be governed by one of several federal or state laws[6], depending on such factors as the source and cause of the contamination and the DTSC program under which the site is being addressed. The PT&R approach operates consistently with these laws and will yield technically and legally adequate environmental solutions. Any procedural differences between cleanup authorities will not substantively affect the outcome of the cleanup. There are some differences such as review periods of final response actions and other administrative advantages that should be evaluated. Regardless of the cleanup process, the remedies evaluated and selected must be: (1) protective of human health and the environment; (2) able to achieve cleanup objectives and standards; and (3) able to control or remediate sources of releases.

The PT&R approach is consistent with DTSC's conventional cleanup processes. In a standard cleanup process, sites undergo:

- Site characterization* (also referred to as site investigation);
- Remedy screening and evaluation, such as under a Feasibility Study (FS*) or Corrective Measures Study (CMS*);
- Remedy selection; and
- Implementation of the corrective action and/or remedial action.

The PT&R approach streamlines the remedy screening, evaluation, and selection phases. In addition to being used as a guidance for selecting the final remedy for a site, the PT&R approach is also suitable for interim measures* or actions to prevent or minimize the spread of contamination while final cleanup action alternatives are being evaluated. Because the PT&R guidance identifies excavation/disposal and containment/capping as the preferred alternatives, the data needed to support the remedy selection phase are potentially focused and reduced, thus decreasing time and investigation costs.

The use of the guidance document may have the following benefits:

- **Time and cost savings**. The guidance streamlines the cleanup process by (1) limiting the number of evaluated technologies; (2) facilitating corrective action and/or remedial action implementation by providing sample documents; and, (3) facilitating documentation and administrative processes.

- **Focused site characterization to support cleanup design**. Data needed to support the cleanup design is collected during site characterization activities.

- **Focused remedy selection**. The evaluation of cleanup alternatives is focused on the two most commonly implemented alternatives.

[6] i.e., CERCLA*, RCRA*, HWCL*, HSAA*

As illustrated in Figure 1, the PT&R guidance follows the requirements of the standard cleanup processes. To gain the maximum cost and time savings, the PT&R approach should be initiated as early as possible in the assessment and/or characterization phase.

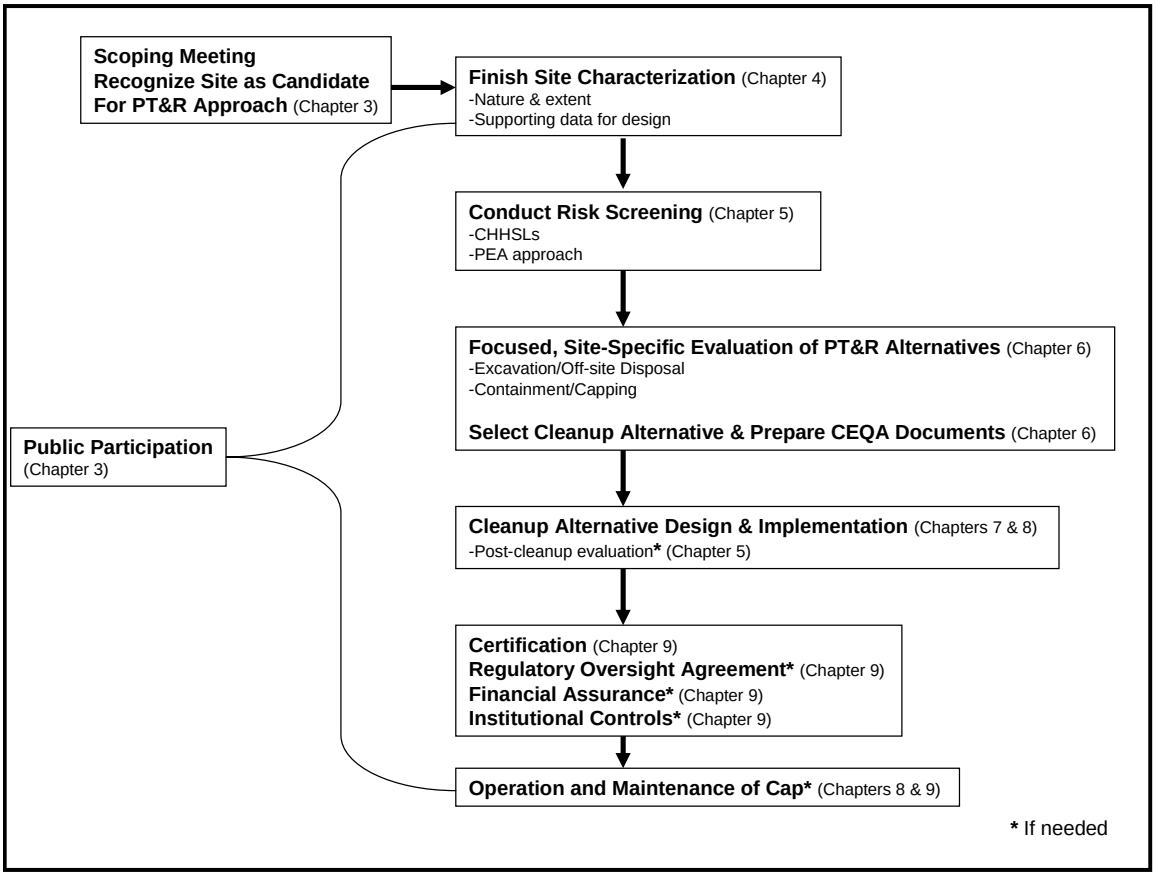
The PT&R guidance is organized into nine chapters:

Chapter 1 presents introductory information, including the purpose, objective, scope, and applicability of the guidance document.

Chapter 2 provides an overview of the PT&R process and summarizes the organization of the guidance document.

Chapter 3 summarizes the site and community assessment to determine if the site is suitable for the PT&R approach.

Figure 1. Overview of PT&R Approach for Sites With Metals-Contaminated Soils.



Chapter 4 summarizes the necessary site characterization data to support the cleanup process.

Chapter 5 presents the procedures for establishing health screening criteria and establishing site-specific cleanup goals.

Chapter 6 summarizes and documents the study and evaluation conducted by DTSC that is the basis for the PT&R guidance regarding metal-contaminated soils. This chapter also addresses the focused evaluation and selection of the cleanup alternative.

Chapter 7 summarizes the design and implementation considerations for the excavation/disposal alternative.

Chapter 8 summarizes the design and implementation considerations for the containment/capping alternative.

Chapter 9 addresses the site certification process.

Chapter 10 provides the references cited in this guidance document.

3.0 SITE ASSESSMENT

The PT&R approach is initiated by assessing whether this guidance document should be applied to a given site with metals contamination in soil. As discussed in Section 3.1, the decision to apply the PT&R approach can be made in a project scoping meeting between DTSC staff and project proponents. A potential outcome of the scoping meeting could be that the standard DTSC cleanup processes should be implemented and no further steps in the PT&R approach would be applied.

Because it was not realistic to develop a guidance document that addresses every possible site scenario, Sections 3.2 and 3.3 identify favorable site characteristics and potential limitations for applying the PT&R approach. The presence of limitations does not necessarily preclude use of the PT&R approach. If limitations are identified, DTSC staff and project proponents would need to make a determination as to whether it is appropriate and worthwhile to apply the PT&R approach with site-specific adjustments.

3.1 PROJECT SCOPING

The project scoping objectives under the PT&R approach are the same objectives that are used under any DTSC cleanup process. These objectives include:

- Establishing a management approach for the project;
- Developing a site cleanup strategy;
- Developing a project plan;
- Recognizing unique site conditions to be addressed during the cleanup process (e.g., cultural resources, sensitive receptors, endangered species);
- Identifying and assessing stakeholders; and
- Scoping public participation activities.

3.1.1 Scoping Meetings

DTSC staff and project proponents should hold one or more project scoping meetings. Typical discussion topics during these meetings include:

- Site background, physical setting, current/past land uses, and unique site characteristics;
- Status of site investigation and cleanup;
- Current conceptual site model (CSM*) for the site (i.e., types and locations of releases, affected environmental media, contaminant migration, potential risks);
- Regulatory framework for site cleanup;
- Initial scope of work for completing site characterization, filling data gaps, and cleaning up the site;
- Potentially applicable remedial technologies;

- Preliminary identification of response actions and the implications of these actions (e.g., restricted land use, long-term stewardship);
- Preliminary remedial action objectives (RAOs);
- Project planning, phasing, scheduling, and priorities; and
- Stakeholder identification and public participation activities.

The scoping meeting is also a forum for deciding whether the PT&R approach could be applied to all or part of the site cleanup, either as described in this guidance document or with site-specific adjustments (see Sections 3.4). If the PT&R approach may be applied, the scoping meeting should specifically address the potential for an unrestricted land use outcome that is offered by the excavation/disposal alternative versus the long-term stewardship associated with the containment/capping alternative.

Depending on the DTSC process applied to the site, the outcome of the scoping meeting(s) may be summarized in a scoping document that includes the following content:

- Analysis and summary of site background and physical setting;
- Analysis and summary of previous response actions, including all existing data;
- Presentation of the CSM and identification of data gaps;
- Scope and objectives of remaining characterization activities;
- Scope and objectives of the site cleanup;
- Preliminary identification of possible response actions and data needed to support the evaluation of cleanup alternatives; and
- Initial presentation of site remedial strategies (e.g., decision to apply the PT&R approach).

3.1.2 Stakeholder Identification and Assessment

Stakeholder involvement is considered essential for the success of any cleanup action. At the onset of the proposed project, stakeholders should be identified and contacted for input. Stakeholders include any individuals, government organizations, environmental and other public interest groups, academic institutions, and businesses with an interest in the project. The identification of stakeholders is largely based on those entities or individuals who are already involved in the project and contacting others with related interests or those who may be in close proximity to the site. Stakeholders provide information on the preferences of the community and may also identify unaddressed issues. Early identification of stakeholders is necessary to ensure effective and timely participation to meet stakeholder expectations and to improve the decision-making process.

3.1.3 Public Participation Activities

The PT&R approach uses the public participation process identified in the *DTSC Public Participation Manual* (DTSC, 2003). The manual addresses public participation components of the cleanup process and compliance with state and federal laws and regulations. The manual summarizes the public participation elements for each DTSC program, California Environmental Quality Act (CEQA*), and various public outreach activities. The manual provides checklists and recommended content for the public participation plan, fact sheets, public notices, and other public outreach activities. Samples for a fact sheet and other public participation documents are provided in Appendix F.

3.2 SITE CHARACTERISTICS THAT FAVOR THE PT&R APPROACH

This PT&R guidance is intended for cleanup at sites where the primary environmental issue is metal contamination in shallow soils[7]. The following site characteristics favor application of the PT&R approach. As discussed further in Section 3.3, the PT&R approach may also be applied to other sites if site-specific adjustments are made.

SITE CHARACTERISTICS THAT FAVOR PT&R APPROACH		
Favorable Characteristic	**Applicable PT&R Alternative(s)**	**Primary Rationale for Limiting Characteristic**
Primarily metals contamination	• Excavation/disposal • Containment/capping	This guidance document pertains to metals. Multiple contaminant groups may be better addressed by other cleanup approaches.
No emergency actions required		Emergency response actions will be subject to different regulatory requirements and will require a faster response than can be achieved under the PT&R approach.
Low potential for surface water impact		Impacts to surface water may have associated ecological risks. The screening levels recommended by this guidance document do not address ecological risk.
No ecological habitat or sensitive receptors		The screening levels recommended by this guidance document do not address ecological risk.
Low potential for groundwater impact		The screening levels recommended by this guidance document do not address protection of groundwater. Additional remedial measures may be required to address impacts to groundwater.
Shallow contamination[7]	• Excavation/disposal	The excavation alternative has depth constraints. The depth feasible for excavation is a site-specific decision.
Metals in immobile form	• Containment/capping	Metals in mobile forms may continue to migrate downward even after cap placement. The screening levels and RAOs recommended by this guidance document do not address protection of groundwater.

[7] As a general frame of reference, “shallow soils” or “shallow contamination” indicates depths that are less than about 15 feet below ground surface.

3.3 SITE CHARACTERISTICS THAT MAY LIMIT THE USE OF THE PT&R APPROACH

Multiple Contaminant Groups. This guidance may or may not be suitable for sites where metals are co-located with other contaminants. For example, the approach may be appropriate where multiple contaminant groups have a similar vertical and lateral distribution and can both be addressed by the same cleanup strategy. In other instances, multiple contaminant groups may be more effectively or efficiently cleaned up by other cleanup approaches. Additional types of contaminants may affect soil disposal options.

Metals in Mobile Forms. The PT&R approach applies to metals in forms that are largely immobile in soil and therefore have been retained in the upper portion of the soil profile. Any metal may become mobile under favorable geochemical conditions, when it forms soluble* complexes* with organic and inorganic ligands*, or when it is associated with mobile colloidal* materials. Some metals that form complexes with organic ligands can also be volatile*. Examples of mobile metals are summarized below.

METALS WITH HIGH SOLUBILITY**	
Arsenite (As^{3+})	Organometallic complexes
Cadmium chloride	Ethyl mercury
Hexavalent chromium (Cr^{6+})	Methyl mercury
Selenate (Se^{6+})	Tetraethyl lead (organolead)
	Organotins
VOLATILE FORMS OF METALS**	
Arsine (AsH_3)	Ethyl mercury
Methyl arsines	Methyl mercury
	Methyl selenides

**Not intended to be a comprehensive list.

If mobile metals are present in shallow soils and can be removed via the excavation/ disposal alternative, the PT&R approach may be appropriate. Soil containing some forms of mobile metals may require special measures and handling during excavation to manage short-term risks.

Mobile forms will have greater penetration depth, will be more difficult to stabilize, and/or will be more difficult to contain than can be addressed by the containment/capping alternative. If the containment/capping alternative is implemented where metals are present in mobile forms, cap performance objectives that require validation that metals are not migrating to groundwater (e.g., modeling, field measurements, groundwater monitoring) would be needed. These performance objectives are beyond the scope of the containment/capping objectives discussed in Chapter 8.

Shallow Groundwater. The PT&R alternatives are not intended to be the sole cleanup approach for sites where the metals-impacted soils are in contact with groundwater or where the contaminated soils extend to the top of the capillary fringe*. If the PT&R approach is applied to the soils, additional cleanup measures may be needed to address the metals impact to groundwater and consequently, PT&R may not be the most effective or efficient approach. This guidance document does not address cleanup measures for groundwater or recommend cleanup goals for the protection of groundwater.

Potential Ecological Risk. Sites located in areas that are designated as environmentally sensitive (e.g., wetland areas, wildlife refuges, endangered species habitat), or have other characteristics that suggest potential ecological impacts, are not candidates for the PT&R approach. Ecological risks may be present at sites where potential habitat, ecological receptors, surface water drainages, and/or surface water features are present. Because the cleanup process may be more complex, including the development of appropriate cleanup goals, these types of sites may not be suitable for the PT&R approach.

Surface Water Features. Sites with surface water features that are potentially impacted by runoff from metals-impacted soils may not be suitable for the PT&R approach because surface water impacts may be linked to ecological risk or have other risk considerations. The cleanup goals and alternatives recommended by this guidance document do not consider these risks.

Complex Sites. The PT&R approach may not be appropriate for complex sites that require a more elaborate cleanup strategy than is offered by this approach.

- Large sites or sites where more than one environmental medium is impacted may not be suitable for the PT&R approach. These sites may require integration of multiple cleanup approaches and may need to consider ecological risk when selecting the cleanup alternative.
- Sites associated with mining and milling activities have unique features that require a more sophisticated approach than is offered by PT&R. These sites tend to have unusual metals speciation, distribution, and characteristics, can be large in acreage, and can have sensitive ecosystems.
- Unusual geologic or hydrogeologic conditions may also limit the cleanup approaches that are appropriate for a site. For example, a site with shallow groundwater or a site located in a mineralized area with active hydrothermal vents likely would be too complex to be addressed using the PT&R approach.

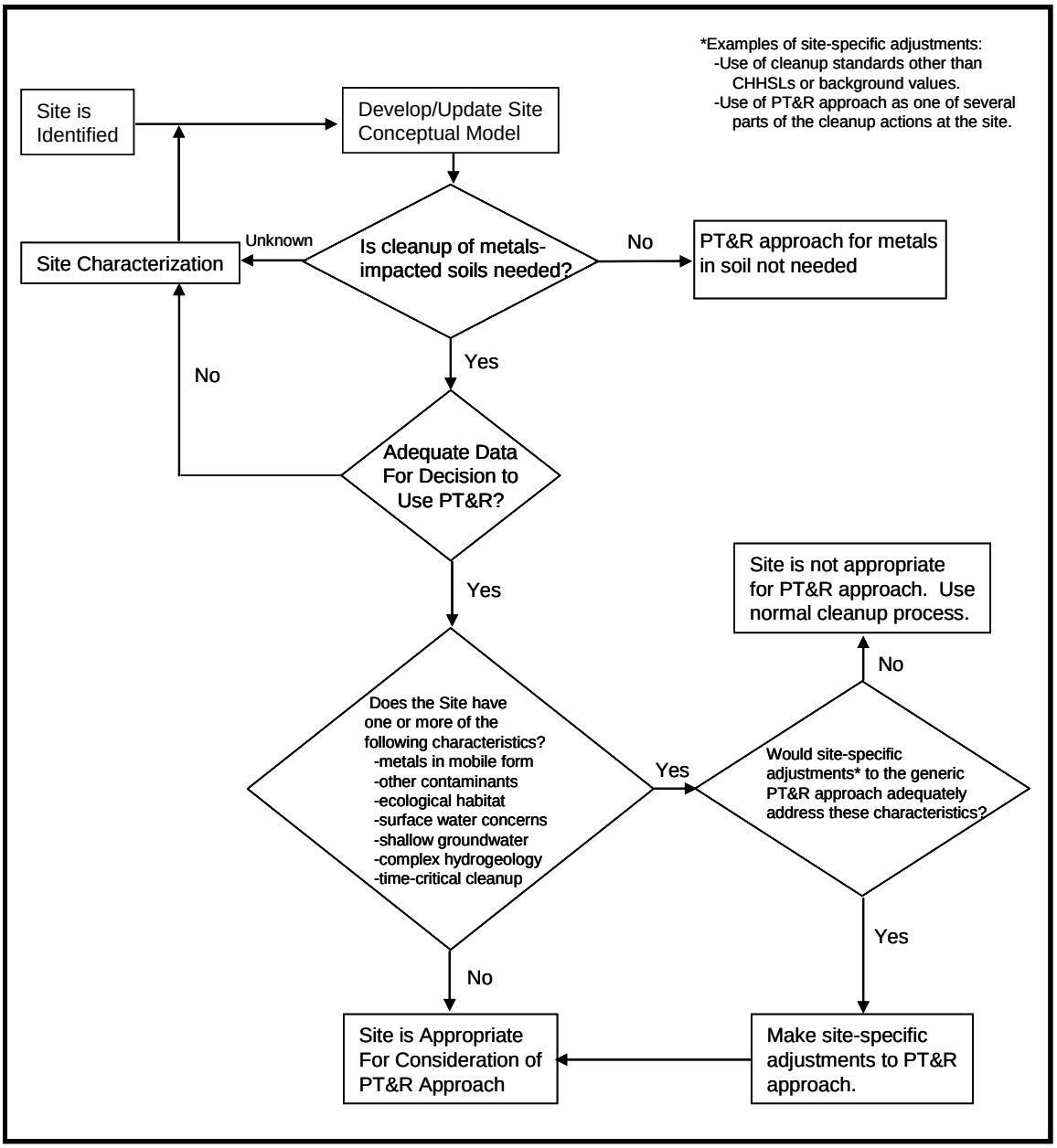
Time-Critical Cleanup/Emergency Response Actions. This guidance is appropriate for response actions where a planning period of at least six months is available before on-site activities must begin. The approach used for time-critical cleanup* or emergency response actions (i.e. removal actions that are imminent and must be carried out immediately) will be more streamlined than the PT&R approach and will be subject to different regulatory requirements than non-time critical cleanup actions.

3.4 DETERMINATION OF SUITABILITY FOR PT&R APPROACH

Figure 2 summarizes the recommended process for determining the suitability of the PT&R approach to a site. While a decision to apply the PT&R approach can be made at any point in the cleanup process, a site can be evaluated for suitability under the PT&R approach as soon as information is available that a response action is necessary.

A CSM should be developed to assist with the determination of suitability for the PT&R approach. The CSM is intended to summarize all currently available information about the site, develop a preliminary understanding of the site, and identify data gaps. An example of a CSM is provided in Appendix A1. The identified data gaps should be used to determine whether sufficient information is available to make a decision that a site is suitable for the PT&R approach.

Figure 2. Process for Determining if the PT&R Approach for Metals in Soil is Appropriate for a Given Site



4.0 SITE CHARACTERIZATION

The primary objective of the characterization phase is to establish the nature, extent, and distribution of contamination in soil and, if needed, background or naturally-occurring concentrations of metals. Under the PT&R approach, another objective of the characterization effort is to collect the data needed to support the engineering design. Sufficient data should be collected during this phase to move the project from the characterization phase through the design phase. The culmination of this step should be to prepare an updated CSM and to ensure that the PT&R approach is still applicable.

Site characterization activities should be conducted in accordance with a DTSC-approved workplan, including a field sampling plan and a quality assurance project plan (QAPP). Because numerous guidance documents are available to assist with the design and implementation of site investigations, this guidance document does not include an extensive discussion of site characterization. Rather, the reader is referred to resources available on the DTSC, U.S. Environmental Protection Agency (EPA), and Interstate Technology Regulatory Council (ITRC) Websites, including the following references:

- *Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994);
- *Guidance on Systematic Planning Using the Data Quality Objective Process, EPA QA/G-4* (EPA, 2006a);
- *Guidance on Choosing a Sampling Design for Environmental Data Collection, for Use in Developing a Quality Assurance Project Plan, EPA QA/G-5S* (EPA, 2002);
- *Data Quality Assessment: A Reviewer's Guide, EPA QA/G-9R* (EPA, 2006b);
- *Data Quality Assessment: Statistical Methods for Practitioners, EPA QA/G-9S* (EPA, 2006c); and
- *Technical and Regulatory Guidance for the Triad Approach: A New Paradigm for Environmental Project Management* (ITRC, 2003b).

In addition, this document provides the following resources to facilitate site characterization:

- Examples for a CSM (Appendix A1);
- Annotated outline for a characterization phase workplan (Appendix A2);
- Annotated outline for a site characterization report (Appendix A3);
- Suggested strategy for estimating background concentrations of metals in soil (Appendix B); and
- Discussion of data needed to support selection and design of the PT&R alternatives (Sections 7.1 and 8.2).

5.0 RISK SCREENING AND ESTABLISHMENT OF CLEANUP GOALS

Following the site characterization, a human health screening evaluation for chemicals of potential concern (COPCs*) should be conducted to estimate the potential cancer risks and noncancer health hazards. The potential risks and hazards associated with the COPCs are used in the risk management decision-making process to determine whether further site characterization, risk assessment*, or cleanup may be necessary for the site. The point of departure for risk management decisions for cancer risk is 1×10^{-6} and for noncancer risk is a hazard index of 1. Sites with risks from metal COPCs in excess of these points of departure may require remediation. Guidance for conducting a risk screening evaluation is provided in the following documents:

- *Preliminary Endangerment Assessment Guidance Manual* (PEA*; DTSC, 1994); and

- *Use of California Human Health Screening Levels (CHHSLs) in Evaluating Contaminated Properties* (Cal/EPA, 2005).

Several assumptions and exposure factors are used when conducting a risk screening*, including identification of the COPCs, land use, exposure pathways, and exposure point concentrations (EPCs*). The CHHSLs* were developed using standard exposure assumptions and chemical toxicity values published by the U.S. Environmental Protection Agency (EPA) and Cal/EPA. The CHHSLs are 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.

5.1 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN AND BACKGROUND METALS

Once the site has been characterized, the next step is to identify what COPCs are present at the site. Because metals occur naturally in the soil, metal concentrations should be compared to background and/or ambient levels to determine if the metals present on the site exceed these values and may therefore indicate a release. All COPCs present above background and/or ambient levels are retained for further evaluation to fully account for the potential cumulative risk (even if the COPCs do not pose a significant risk). The collection of background metal samples should, in general, occur in the vicinity of the site and in similar soil types. For some projects, existing background metal data sets may be applicable whereas others may require additional background sampling. Appendix B provides further discussions about estimating and using background concentrations of metals. A few metals, most notably arsenic, may pose potential health risk at or below background level. For additional discussion, please refer to Section 5.4.2.

There are a number of valid approaches for comparisons to background metals. The following is a simplified approach for comparisons to background for the determination

of COPCs which may be applicable for screening purposes on smaller, less complex sites.

Step 1. Compare the highest site concentration with the highest background concentration. If the site concentration is equal to or less than the background concentration, the metal may be eliminated as a COPC. If the onsite maximum is greater than the background maximum and the detection frequency* is greater than 50 percent, proceed to Step 2. If the detection frequency is less than 50 percent, and the onsite maximum is greater than the background maximum, retain the metal as a COPC.

Step 2. Compare the site and background arithmetic mean concentrations. If the means are comparable, <u>and</u> if the highest site concentration is below the concentration associated with unacceptable risk or hazard, the metal may be eliminated as a COPC. If the metal is not eliminated by this screening, proceed to Step 3.

Step 3. Statistically evaluate the overlap of the background and onsite distributions to determine if they come from the same population. If determined to be from the same population, and if the highest site concentration is below the concentration associated with unacceptable risk or hazard, the metal may be eliminated as a COPC. If not, include the metal as a COPC in the risk evaluation. Further discussion of the statistical comparison of background and onsite data sets is provided in Appendix B.

Additional information on identifying metals as COPCs can be found in Appendix B.

5.2 EXPOSURE POINT CONCENTRATIONS

Following the identification of COPCs, the appropriate soil concentrations to be used in the human health screening evaluation are determined. The DTSC *Preliminary Endangerment Assessment Guidance Manual* recommends the use of the maximum concentration for initial screening purposes. Other statistical approaches may also be appropriate, including the calculation of the 95 percent upper confidence limit (95% UCL*) on the arithmetic mean concentration. Statistical programs, such as EPA's ProUCL, can be used to calculate this level and data should be transformed where necessary. Censored data sets (i.e., data sets having one or more values reported as "not detected") should be added at one-half the detection limit, provided that the detection frequency* for the metal is greater than 50 percent. Appendix B identifies techniques for working with data sets that have a detection frequency less than 50 percent.

Use of this approach is dependent on the size of the data set (a minimum of ten samples are necessary), the distribution of contamination on the site, and the possible existence of localized hot spots. The selection of the exposure point concentrations (EPCs*) for the soil data should be justified based on whether soil contamination is

limited to localized areas (hot spots), spread across the site, or contained within a defined area of concern. It is not appropriate to statistically minimize soil concentrations by including soil data from large areas of the site that are not impacted. If it is unclear whether the site characterization data supports the use of the 95% UCL, the maximum concentrations should be used in risk estimates. Consideration of overall risk from the whole site may be addressed in the post-cleanup evaluation (see Section 5.5).

5.3 HEALTH RISK SCREENING

All risk screening approaches should take into consideration the final end use of the property, such as residential, industrial, or commercial use. In addition, a CSM should be developed to determine all potential exposure pathways for inclusion in the health risk assessment (see example in Appendix A1). Either individual or cumulative cancer risks greater than 1×10^{-6} or noncancer hazards (hazard index) greater than one should be considered for further risk management evaluation.

Use of a risk screening approach other than CHHSLs/*Use of California Human Health Screening Levels (CHHSLs) in Evaluating Contaminated Properties* (Cal/EPA, 2005) and/or the *Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994) will require a site-specific adjustment to the PT&R approach. Consideration of other risk scenarios (i.e., other than residential, industrial, or commercial use) also requires a site-specific adjustment to the PT&R approach.

5.3.1 California Human Health Screening Levels (CHHSLs)

Health risk screening evaluation can be accomplished by comparing appropriate soil concentrations (see Section 5.2) to CHHSLs. The current list of CHHSLs can be found on the Cal/EPA website, and the accompanying *Use of California Human Health Screening Levels (CHHSLs) in Evaluating Contaminated Properties* (Cal/EPA, 2005) should be consulted. In addition, a spreadsheet calculator is available on the Cal/EPA website.

After the metal COPCs have been identified, appropriate soil concentrations (see Section 5.2) should be compared to CHHSLs. Cumulative cancer risks and noncancer hazards should be calculated according to the guidance. Either individual or cumulative cancer risks greater than 1×10^{-6} or noncancer hazards (hazard index) greater than one should be considered for further risk management evaluation.

5.3.2 DTSC Preliminary Endangerment Assessment (PEA)

An alternative risk screening assessment may be performed using the *Preliminary Endangerment Assessment Guidance Manual* (DTSC, 1994) instead of the comparison to the CHHSLs. The PEA guidance should be used if there are no CHHSLs available for a metal COPC.

After the metal COPCs have been identified, appropriate representative soil concentrations (see Section 5.2) should be used in the calculation of risks and hazards. Cumulative cancer risks and noncancer hazards should be calculated according to the guidance. Either individual or cumulative cancer risks greater than 1×10^{-6} or noncancer hazards greater than one should be considered for further risk management evaluation.

5.4 CLEANUP GOALS

Metals occur naturally in soil and therefore the elimination of all risks from metals at a contaminated site is not possible. Cleanup goals are generally developed based on concentrations that do not pose an unacceptable risk or hazard to human health and the environment. Exceptions to this approach include metals that occur naturally in soil at levels which may pose a potential health risk, such as naturally occurring arsenic in soil (see Section 5.4.2).

5.4.1 Health-Based Cleanup Goals

Factors that are considered in the development and selection of cleanup goals include the health impact endpoint (carcinogen vs. noncancer hazard), the intended use of the property (residential vs. industrial/commercial), and the number of COPCs. Cleanup goals based on anything other than unrestricted use (i.e., residential use) will require land use restrictions.

For the purposes of this PT&R guidance, several conditions are not considered in the selection of cleanup goals. These include potential impacts to ecological receptors, groundwater, and surface water. This recommended PT&R approach for establishing cleanup goals is not applicable if any of these conditions exist.

For potential carcinogenic metals, the generally accepted cleanup level for each individual metal should not be greater than 1×10^{-6} cancer risk. For metals with noncancer hazard, the generally accepted cleanup goal should not be greater than a cumulative hazard index of 1. If five or more metal COPCs present at a site require cleanup, the cleanup goals may need to be adjusted for cumulative risk or hazard in order to reduce the overall risk and/or hazard to the acceptable range. Risk management decisions that would allow cleanup goals with greater risks or hazards may be made on a site-by-site basis.

Selection of a cleanup goal is dependent on the most probable end use of the property. For the purpose of the PT&R, two future scenarios are considered. The first is a residential or unrestricted land use and the second is an industrial/commercial land use. Both of these future land use scenarios use standard exposure pathway assumptions for persons who may come into contact with the soil. For the purposes of the PT&R guidance, these exposure assumptions should be identical to either the assumptions used in the development of CHHSLs or the PEA guidance. When properties are remediated to commercial or industrial cleanup goals or waste is left in place under a

cap, institutional controls (ICs*) are required in order to ensure the continued health protectiveness of the selected solution. Please refer to Section 9.3 for further discussion.

For sites where this PT&R guidance is applied, CHHSLs (see Section 5.3.1) may be considered as cleanup goals as a means of streamlining the selection process. CHHSLs for metals are based on the direct exposure of humans to contaminants in soil via incidental soil ingestion, dermal contact, and inhalation of dust in outdoor air. Development of a cleanup goal other than the CHHSL value may be necessary in the following instances:

- The CHHSL value for lead is subject to change. DTSC should be contacted for information regarding the appropriate risk-based value for lead remediation.

- CHHSL values for certain metals (e.g., arsenic) may be less than background concentrations (see Section 5.4.2), and therefore, the cleanup goal may be based on the estimated background and/or ambient levels. Appendix B provides a strategy for estimating background metals concentrations and for developing ambient cleanup goals.

- The regulatory oversight agencies do not concur with the proposed use of CHHSLs. The use of CHHSLs as cleanup goals requires concurrence of both the responsible party and regulatory oversight agencies.

- Instances may arise where a value less than the CHHSL is needed to address a regulatory requirement or environmental concern.

5.4.2 Background-Based Cleanup Goals

For some metals, establishment of a cleanup goal will need to consider the naturally-occurring concentrations of the metal in soil (i.e., background or ambient concentration). DTSC does not generally require cleanup of sites to concentrations that are less than background.

Although there are several metals in soil which may fall into this category, arsenic is the predominant metal where background concentrations usually need to be considered in developing appropriate cleanup goals. Remediation of arsenic contamination in soil has occurred at many sites, and the calculated health-based cleanup goal can be an order of magnitude below background levels. While DTSC recognizes that there are many outstanding scientific questions about the differing forms and sources of arsenic (including arsenic in water versus arsenic in soil) as well as the bioavailability and bioaccessibility of arsenic (particularly when it comes to soil considerations), they are not currently factored into this guidance. Several study groups are investigating these potential impacts on risk estimates and developing cleanup goals. As new DTSC guidance concerning arsenic becomes available, the approaches in this document will be modified.

DTSC has used a strategy for developing cleanup goals based on the entire site data set for arsenic which is described in *Arsenic Strategies, Determination of Arsenic Remediation Development of Arsenic Cleanup Goals for Proposed and Existing School Sites* (DTSC, 2007; included in Appendix B). The same approach may be used for other metals at sites where the health-based cleanup goals are significantly below background levels. Briefly, the strategy utilizes the complete data set from a site, including relevant background samples, in order to statistically determine feasible site-specific cleanup goals. Several statistical approaches are outlined in the guidance.

5.5 POST-CLEANUP EVALUATION FOR LEAD

Following the completion of the remediation, a post-cleanup evaluation may be required for sites where lead is one of the COPCs. Because cleanup approaches may be changing for lead, a more complete evaluation of the residual lead concentrations is recommended for risk communication purposes. When the PT&R cleanup alternative for soil is completed, residual levels of lead will remain at the site because lead occurs naturally in the soil. However, the overall remaining residual concentrations across the site should be lower than the established cleanup goal.

A statistical summary of the complete data set for the entire site remaining after mitigation, excluding the data from the removed or capped areas and including any confirmation samples, should be incorporated into the completion report (see Sections 7.11 and 8.7). For sites where capping has been selected as a remedial alternative, this summary should address the remaining uncapped areas and, where appropriate, data from the capping material. This summary should include the minimum and maximum values, the mean value, the 95% UCL, and the corresponding cleanup goal. Summaries of other metals may be recommended on a site-specific basis. An example of a post-cleanup evaluation for lead is provided in Appendix D4.

This step is different from the assessment and development of the cleanup goals described in Section 5.3. The evaluation more closely considers the expected land use, cumulative effects, and the complete site data set. For some sites where containment/capping are employed, metals concentrations would be the same as those prior to and following cleanup. However, the risk will have been reduced or eliminated by mitigation of the potential exposure pathways.

6.0 EVALUATION OF CLEANUP TECHNOLOGIES FOR METAL-IMPACTED SOIL

In a conventional clean up action, if the results of the risk screening process indicate that a cleanup action is warranted, the next step is an evaluation of the technologies appropriate for remediation of soils. This chapter provides the administrative record, technical basis, and evaluation necessary for streamlining the cleanup alternative evaluation. This chapter also addresses the site-specific evaluation and remedy selection process for cleanup of metal-contaminated soils. Much of the streamlining is achieved by the DTSC study summarized in Section 6.1. The streamlined approach for evaluating remedial alternatives can be documented by:

- including pertinent sections of this PT&R guidance in the administrative record[8] and
- including a discussion regarding the use of the PT&R approach for the cleanup alternative selection in the decision document.

6.1 TECHNICAL BASIS FOR PT&R GUIDANCE TO ADDRESS SITES WITH METAL SOIL CONTAMINATION

DTSC conducted a study of sites where the primary contaminants of concern were metals. The objective was to identify the technologies that were consistently evaluated as potential remedies and to identify the remedies that were subsequently selected at a site. The study is equivalent to the screening and evaluations conducted under a Feasibility Study (FS) or Corrective Measures Study (CMS).

The study included the following activities:

- Review of literature relevant to sites with metal soil contamination. A table summarizing the technologies applicable at sites with metals in soil is included in Appendix C1.
- Identification of a representative number of DTSC sites with metal contaminated soils.
- Review of the decision documents to determine which cleanup alternatives were routinely either screened out or selected for the remedy.
- Identification of the rationale for selection of remedy.

DTSC reviewed the Site Mitigation and Brownfields Reuse Program database (EnviroStor) and the Hazardous Waste Management Program database to identify sites with metal contaminated soils. The initial list of sites was reduced to 188 sites for which remedy selection or implementation occurred between January 2001 and January 2007. This timeframe was selected to narrow the review and to reflect the best management

[8] Alternatively, include the PT&R guidance as an electronic appendix to cleanup alternative evaluation document.

practices for cleanup of sites with metal contaminated soils. The types of DTSC sites included in this analysis are summarized in Table 1.

Table 1. Cleanup Options Selected for the Sites Evaluated by DTSC Study

DTSC Site Type (no. of sites)	Cleanup Option Selected (No. of Sites)							
	No Action	ICs	Capping in Place	Consolidation/ Capping	CAMU	Excavation/ Disposal	Reuse/ Recovery	Treatment
Schools Properties (32*)	0	0	0	1	0	32	0	0
Military Facilities (55*)	3	5	3	1	9	37	3	3
Voluntary Cleanup (51*)	0	1	8	5	0	40	5	1
State Response/ NPL (32*)	0	0	5	7	0	22	0	4
Corrective Action (7)	0	0	0	0	3	4	0	0
Facility Closure (11)	0	0	0	0	0	11	0	0

Notes:
* Some sites in this category selected multiple cleanup options (i.e., this number is not simply the sum of frequencies listed in this row).
CAMU is corrective action management unit
IC is institutional control

DTSC reviewed the cleanup alternative decision documents for the 188 sites identified in the database review. The review focused on the cleanup alternatives that were considered and the factors that led to the selected cleanup alternative. The document review also considered the project type, site activities, types of metals present, types of other contaminants present, other affected media, and impacted volume. Based on the data collected, DTSC evaluated three variables in detail:

- Frequency of selection of the cleanup alternatives provided in this document;
- Rationale for selection of the cleanup alternatives provided in this document; and
- Rationale for rejection of the cleanup alternatives considered by the selection process.

Based on the decision documents reviewed, lead and arsenic are the most frequently encountered metals requiring a response action. Lead-impacted soils had the widest variety of selected remedies and had the most number of sites that incorporated a treatment process into the selected remedy (see Table C1-1 in Appendix C1 for details).

The data indicates that excavation/disposal was the most frequently selected cleanup alternative. Containment/capping and consolidation/capping were the next most frequently chosen cleanup alternatives. The selection of the cleanup alternative as the

preferred approach does not appear to be correlated with impacted volume, contaminant types present, or affected environmental media (see Table C1-1 in Appendix C1 for details). Rather, factors affecting selection of excavation/disposal and containment/capping included proven effectiveness, ability to meet the project timeframes, and the current and reasonably foreseeable future land use. The excavation/disposal alternative was selected if the objective was to allow unrestricted land use. Containment/capping or consolidation/capping was selected if a cap was compatible with the current and reasonably foreseeable future land use and the associated land use restrictions were not an issue with interested parties.

Table 2 summarizes the frequency of the National Contingency Plan (NCP*) criteria used to support selection and rejection of a particular cleanup alternative for the 188 sites. A detailed summary of the primary rationale for selecting and rejecting a given technology is provided in Appendix C1. The excavation/disposal alternative frequently was rejected based on cost. Containment/capping and consolidation/capping were most often rejected due to existing or planned land use, or because of the long-term operation and maintenance requirements. Solidification/stabilization* and chemical fixation* were rejected for several reasons, including costs, long-term effectiveness, soil volume increases, and time to conduct treatability studies*. Soil washing* was rejected because of uncertain effectiveness, associated costs, and implementability. Recovery/reuse applications typically were rejected because of the inability to implement within the timeframe of the project. If evaluated, other treatment alternatives could also be rejected because of the associated costs and ability to implement.

Table 2. Cleanup Options Considered for the Sites Evaluated by DTSC Study

Technology	Number of Site Alternatives Analyses Considering Technology	Number of Site Alternatives Analyses Rejecting Technology	Reason for Rejection During Cleanup Alternative Analysis						
			Overall Protection	Compliance with ARARs	Reduction of Toxicity, Mobility, Volume	Long-term Effectiveness	Short-term Effectiveness	Cost	Implementability
No Action/ ICs	188	181	172	11	0	6	0	0	0
Excavation/ Off-Site Disposal	183	36	4	0	0	2	1	30	6
Containment by Capping, Capping/Consolidation, Capping/CAMU	113	78	8	0	1	61	0	13	4
Solidification/Stabilization, Chemical Fixation	43	38	0	0	13	14	1	17	11
Reuse or Recovery	23	10	3	0	1	2	0	2	6
Soil Washing	21	21	0	0	1	11	0	7	6
Treatment (non-specific)	12	10	0	0	1	1	1	5	4
Vitrification	4	4	0	0	0	0	0	4	1
Soil Flushing / Leaching	3	3	0	0	0	0	0	2	3

Notes:
ARARs - applicable and or relevant and appropriate requirements
CAMU - corrective action management unit
ICs - institutional controls

6.2 FOCUSED EVALUATION AND SELECTION OF CLEANUP ALTERNATIVE

Under state and federal law, an analysis of alternatives is required for sites undergoing remediation. Following an initial evaluation, a more detailed and focused evaluation that considers the site characteristics must be conducted on the PT&R alternatives. Because the cleanup alternatives evaluation presented in Section 6.1 and Appendix C1 was conducted in accordance with the initial screening requirements of a FS and CMS, it may be used in lieu of a site-specific initial screening for sites undergoing the streamlined PT&R approach, provided that the use of the PT&R evaluation is cited in the administrative record.

The next step in the PT&R approach is to determine whether excavation/disposal or containment/capping is the most appropriate cleanup alternative. The alternatives evaluation may consist of a site-specific evaluation of the no action, excavation/ disposal, and containment/capping alternatives. Focusing on these PT&R alternatives is consistent with the NCP which provides that: the number of alternatives evaluated for a site should be reasonable; the number of alternatives evaluated should be based on the scope, characteristics, and complexity of the site; and detailed analyses need only be conducted on a limited number of alternatives that represent viable approaches to the cleanup. Application of the PT&R approach in this guidance does not preclude consideration of additional cleanup alternatives if determined to be appropriate for a site. However, use of the PT&R approach would still reduce the burden of the number of cleanup technologies to be screened and evaluated.

As illustrated in Figure 3, the excavation/disposal alternative has the potential to allow unrestricted use of the site whereas the containment/capping alternative will require ICs, long-term operation and maintenance and regulatory oversight.

The focused alternatives evaluation may be prepared under state or federal guidelines, as summarized in Table 3.

In addition to using the DTSC initial alternatives evaluation (Section 6.1), the following site-specific elements of the remedial alternative evaluation process should be addressed in the appropriate remedy selection document:

- Establishment of site-specific remedial action objectives (RAOs);
- Identification of applicable federal/state/local requirements (known as ARARs* under the CERCLA process); and

Figure 3. Summary of PT&R Cleanup Alternatives

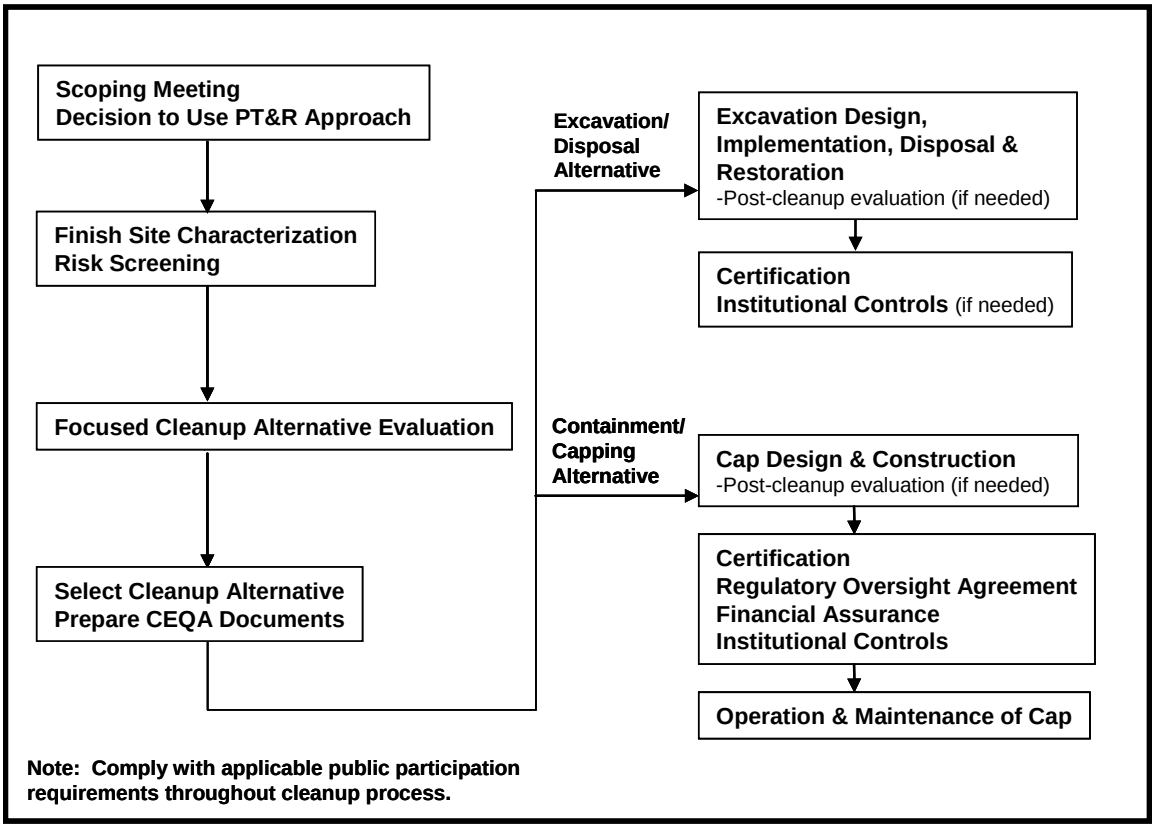


Table 3. State and Federal Guidelines for Focused Alternatives Evaluation

Law	Process	Description	Resource Provided in This Guidance Document	Suggested Reference(s)
HSAA	Remedial Action Plan (RAP)	Process for developing, screening, and detailed evaluation of alternative remedial actions for sites. Remedy selection document under HSC §25356.1.	A RAP Sample is provided in Appendix C2	DTSC, 1995
	Removal Action Workplan* (RAW)	Prepared when a proposed, non-emergency removal action or a remedial action is projected to cost less than $1,000,000. Remedy selection document under HSC §25356.1.	A RAW Sample is provided in Appendix C3	DTSC, 1993, 1998
CERCLA HSAA	Feasibility Study (FS)[1]	Process for the development, screening, and detailed evaluation of alternative remedial actions for sites.	--	EPA, 1988, 1999
	Engineering Evaluation/ Cost Analysis (EE/CA)	Analogous to, but more streamlined than, the FS. Identifies the objectives of the removal action and analyzes the effectiveness, implementability, and cost of various alternatives that may satisfy these objectives.	--	EPA, 1993
RCRA or HWCL	Corrective Measures Study (CMS)	Mechanism used by the corrective action process to identify, develop, and evaluate potential remedial alternatives.	A CMS Scope of Work is provided in Appendix C4. An example Statement of Basis is provided in Appendix C6.	EPA, 1991a, 1994, 1997a
HSAA, HWCL, RCRA, CERCLA	Interim Measures (IM) or Interim Actions	Actions to control and/or eliminate releases of hazardous waste and/or hazardous constituents from a facility prior to the implementation of a final corrective measure or remedy.	An IM Scope of Work is provided in Appendix C5.	

Notes:
1 A feasibility study is not required for RAW process.
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
HSAA – Hazardous Substance Account Act
HWCL – Hazardous Waste Control Law
RCRA – Resource Conservation and Recovery Act

- Evaluation of the PT&R cleanup alternatives and the no action alternative against the applicable NCP criteria[9]:

  Threshold Criteria
  1) overall protection of human health and the environment,
  2) compliance with federal/state/local requirements,

  Balancing Criteria
  3) long-term effectiveness and permanence,
  4) reduction of toxicity, mobility or volume through treatment,
  5) short-term effectiveness,
  6) implementability based on technical and administrative feasibility,
  7) cost,

  Modifying Criteria
  8) state and local agency acceptance,
  9) community acceptance.

Appendix C provides further guidance on the content of the RAW, FS/RAP, and CMS Report. Regardless of the process used to evaluate and select the cleanup alternative for a site, the alternatives evaluation report generally should:

- discuss and present documentation showing that the PT&R approach is appropriate;
- identify and provide the rationale for the preferred alternative for the site;
- document the site-specific RAOs, regulatory requirements, and the detailed alternatives analysis; and
- include preliminary design information for implementation of the final remedy.

Necessary documents for the California Environmental Quality Act (CEQA*) are usually prepared concurrently with the alternatives evaluation reports, if not sooner (see Section 6.4 for further discussion of CEQA requirements). Once approved by DTSC or a Regional Water Quality Control Board (RWQCB), the draft alternative analysis and draft CEQA documents are circulated for public comment (DTSC, 2003).

The administrative record for the site should, among other things, include the following elements:

- Copy of pertinent sections of this PT&R guidance. (Alternatively, include the PT&R guidance as an electronic appendix to cleanup alternative evaluation document);
- A bridging memorandum that describes how use of the PT&R approach differed from the conventional cleanup process; and
- Responses to any comments pertaining to the decision to use the PT&R approach.

[9] Only the effectiveness, implementability, and cost criteria apply to the DTSC RAW process.

An example for a bridging memorandum is included as Appendix C7.

6.3 DESIGN AND IMPLEMENTATION OF SELECTED CLEANUP ALTERNATIVE

The operational and technical plans for implementing the selected cleanup alternative should be prepared and submitted to DTSC, either in the remedy selection document (if appropriate) or provided as separate submittals. Examples of operational plans include the health and safety plan, transportation plans, and soil confirmation sampling plan. The technical plans contain the specific engineering design details of the proposed cleanup approach, including designs for any long-term structures (e.g., caps). As applicable, the design plans should include the design criteria, process diagrams, and final plans and specifications for the structures as well as a description of any equipment to be used to excavate, handle, and transport contaminated soil. Field sampling and analysis plans that address sampling during implementation and soil confirmation sampling to assess achievement of the cleanup objectives could also be prepared.

Chapters 7 and 8 provide further discussion of the design and implementation for the PT&R cleanup alternatives.

6.4 CALIFORNIA ENVIRONMENTAL QUALITY ACT

Site cleanups using the PT&R approach must meet all applicable local, state and federal requirements including the California Environmental Quality Act (CEQA*). Signed into law in 1970 (Public Resources Code, section 21000 et seq.) and updated in 1993, CEQA requires public agencies carrying out or approving a project to conduct an environmental analysis to determine if project impacts could have a significant effect on the environment. Public agencies must eliminate or reduce the significant environmental impacts of their decisions whenever it is feasible to do so.

All proposed projects for which the DTSC has discretionary decision-making authority are subject to CEQA if they potentially impact the environment. Examples of approval actions which require CEQA review and documentation include: RAPs, interim measures, RAWs, and corrective actions. As shown by these examples, certain steps in the PT&R approach are subject to CEQA.

For further information, DTSC's CEQA-related polices and procedures are available on the DTSC Internet site.

7.0 DESIGN AND IMPLEMENTATION OF EXCAVATION/DISPOSAL ALTERNATIVE

This chapter describes the approach that will be used to complete the soil removal action and the disposal requirements for the excavated soil and restoration of the excavated site. The objective is to remove soil contaminated at levels exceeding site cleanup goals. The excavation and disposal alternatives discussed in subsequent sections can be applied to either an interim action (i.e., early measure to reduce the risk of releases of hazardous substances before the initiation of more complicated, comprehensive, and long-term cleanup remedies) or the final remedy at a site.

7.1 DATA NEEDED TO SUPPORT EXCAVATION DESIGN

At a minimum, the following data is necessary to adequately address the excavation limits and design:

- Vertical and horizontal distribution of contaminants (i.e., areal extent of impacted soils, depth of impact) and volume of soils to be excavated;
- Identification of soil conditions that affect the selection of excavation equipment;
- Average depth to groundwater;
- Climatology/ seasonal variations;
- Survey map of site features (e.g., topography, existing structures, utilities, wells, surface water control measures, property boundaries, areas to be shored), if applicable;
- Geotechnical data for each soil type (i.e., USCS classification, Atterberg limits, moisture content, bulk density), if applicable; and
- Structural contour map of the top of competent bedrock, if applicable.

Ideally, these data will be collected during the characterization phase of the project (see Chapter 4) rather than requiring another field mobilization during the design phase.

7.2 EXCAVATION, DISPOSAL, AND RESTORATION PLAN

A workplan identifying the logistical procedures and site activities associated with excavation, disposal and site restoration should be prepared. The actual title of this plan will depend on the cleanup process applied to the site. For example, DTSC's RAW process incorporates the required plan elements into the RAW. DTSC's RAP and corrective action processes often require preparation of a separate plan. However, additional streamlining under the PT&R approach could be achieved if the plan is included in another document (e.g., as an appendix to the RAP). For the purposes of this chapter, the workplan is referred to as the "excavation, disposal, and restoration plan".

Major topics and elements of the excavation, design, and restoration plan include the following:

- site background, nature and extent of contamination;
- objectives and scope of plan;
- project organization and schedule;
- description of the technical basis for the approach (e.g., why excavation/disposal was selected as the cleanup alternative; estimated extent of excavation, estimated volume of soil to be excavated);
- pre-excavation activities;
- excavation activities;
- waste management;
- backfill and site restoration activities;
- quality assurance and quality control;
- health and safety monitoring; and
- reporting.

The excavation, design, and restoration plan should be supported by the following documents, as applicable. These documents can be submitted separately or as appendices to the plan.

- site-specific health and safety plan;
- storm water pollution prevention plan (SWPPP);
- community air monitoring plan;
- soil confirmation sampling plan;
- public participation plan;
- stockpile sampling plan; and
- transportation plan.

Selected topics related to the excavation, design, and restoration plan are discussed further in the following sections.

7.3 PRE- EXCAVATION ACTIVITIES

Prior to conducting fieldwork, a series of project management and regulatory tasks should be completed. The general areas that require preparatory activities include:

- site access;
- permits;

- location of underground utilities;
- health and safety;
- waste management;
- schedule for staff and equipment resources;
- coordination with laboratory for analysis and assessment;
- coordination with off-site disposal facility; and
- notifications.

Local jurisdictions, such as municipal public works departments and air districts, often require excavation or grading permits. In addition, depending on the amount of soil to be excavated or disturbed, the RWQCB may specify waste discharge requirements, preparation of a SWPPP, and/or an NPDES permit. The key elements of the permit application specific to the location of the excavation should be identified. Some municipalities have restrictions on the type of equipment that can be used within a specified distance from water mains, sewer lines, and utility lines. In addition, air districts may require a similar application that identifies the mitigation measures to reduce or eliminate air dispersal of contaminants.

7.3.1 Dust Control and Air Monitoring

The design should reiterate the actions (specified in the remedy selection document) that will be implemented to control fugitive dust and emissions during implementation of the remedy. Dust control is required during construction, demolition, excavation, and other earthmoving activities, including, but not limited to, land clearing, grubbing, scraping, travel on site, and travel on access roads to and from the site.

Most air districts have recommended or required dust mitigation measures and/or engineering controls. Applicable air pollution regulations, performance criteria and acceptable control strategies should be cited and described. The following items are generally considered:

- Wind breaks and barriers, or ceasing work when wind speeds are above a certain level;
- Frequent water applications;
- Application of soil additives;
- Control of vehicle access;
- Vehicle speed restrictions;
- Covering of piles;
- Use of gravel and rumble strips at site exit points to remove caked-on dirt from tires and tracks;

- Decontamination and tracking pad to thoroughly wash and decontaminate vehicles before leaving the site;
- Wet sweeping of public thoroughfares; and
- Cause for work stoppage.

The dust mitigation measures and/or engineering controls are intended to ensure that project activities will not have an adverse impact on the environment or the community.

7.3.2 Community Air Monitoring

Community air monitoring should be considered for activities occurring near residential communities, schools, and other sensitive receptors (e.g., elderly or high use community areas) to ensure that the implementation of the remedy does not pose a potential threat to off-site receptors. Site-specific risk-based action levels should be calculated, in consultation with DTSC, and included in the remedy design.

7.4 EXCAVATION ACTIVITIES

7.4.1 Safety Standards for Trenching and Excavations

The excavation, design, and restoration plan should address the applicable Cal-OSHA safety requirements for excavations (Cal. Code Regs., tit. 8, §1540, §1541, §1541.1). These requirements state that workers exposed to potential cave-ins must be protected by shoring, sloping, or benching the sides of the excavation, or placing a shield between the side of the excavation and the work area. These safety standards also provide for protection of the stability of adjacent structures. Any excavation four feet or deeper must have adequate means of access/egress every 25 feet of lateral travel from workers. Excavations greater than four feet deep require testing for hazardous atmospheres and protection from hazards associated with water accumulation. Entry into some excavations/ trenches may require a Cal-OSHA permit and compliance with Cal-OSHA regulations for trenching and excavation.

7.4.2 Surface Water Control Measures

If there is the potential for rainfall during the excavation activities, the excavation, design, and restoration plan should address surface water runoff, erosion control, and sediment control measures. These measures should conform to state and local requirements and should provide for segregation of surface water runoff from impacted and non-impacted areas.

7.5 WASTE MANAGEMENT

7.5.1 Management and Profiling of Excavated Soil

Contaminated soil that is excavated must be managed and disposed of as hazardous waste if it is identified as a RCRA listed or characteristic waste. If the waste is regulated under RCRA, it must be disposed of in a landfill authorized to accept RCRA hazardous waste. Soil identified as California only hazardous waste is generally disposed of in a Class I landfill.

Excavated soil may either be directly hauled off site for disposal, provided arrangements have been made with a disposal facility or may be stockpiled on site for further profiling. A schematic or scaled map of the areas to be excavated and the locations where soil will be stockpiled should be included. Excavated soil should be segregated and stockpiled based on the existing site data. The stockpiles should include any of the applicable categories summarized in Table 4.

Table 4. Disposal Alternatives for Excavated Soil

LEVEL OF CONTAMINATION	DISPOSAL ALTERNATIVES
Not impacted	Can remain on site and used for backfill
Impacted at levels above acceptable risk levels but below hazardous levels	Disposal at Class I or Class II landfill
Impacted at California only hazardous levels	Disposal at Class I or Class II landfill
RCRA hazardous waste	Stabilization before disposal at Class I landfill

Temporary stockpiles should be managed in accordance with the excavation, design, and restoration plan. The plan should be prepared in compliance with the applicable requirements of the California Code of Regulations, title 22, division 4.5. The excavation, design, and restoration plan should designate the locations for placement of stockpiles, should address measures to prevent migration and/or dispersal of the soil (e.g., liners, covers), and identify the appropriate distance from the upper edge of any excavation.

Composite samples should be collected and analyzed from the stockpiles to verify that the soil has been appropriately segregated. Disposal of soils will be based largely on the Land Disposal Restrictions (LDRs*). LDRs apply if the excavated soils are contaminated with a listed RCRA waste or if the contaminated soils exhibit a RCRA hazardous waste characteristic. If analytical data demonstrate that the soil is a RCRA hazardous waste, the soil must be treated to meet specific LDRs limits prior to land disposal. In addition, if the soil is a RCRA characteristic waste, all other underlying soil must meet its associated LDRs prior to disposal. If the excavated soil is below the

specified LDR concentrations, the soils do not need to be treated prior to off-site land disposal and can be disposed of appropriately at a landfill.

The sampling results from the soil stockpiles must be included in the waste profile form for the landfill to review and determine if the profile meets its acceptance criteria. Upon acceptance by a landfill, the soil stockpiles are loaded into the transport container (e.g., truck, rail car, bin) and transported to either a Class I landfill under a hazardous waste manifest or a Class II landfill under a bill of lading. Soils not contaminated above the site cleanup goal may be left on site and reused to backfill the excavated areas.

7.5.2 Loading, Transportation, and Manifesting

Soil transported for offsite management or disposal must be transported in accordance with applicable state and federal laws. Loading of transport containers should be adjacent to stockpiles or excavations, just outside designated exclusion zones. Any soil falling to the ground surface during loading should be placed back into the container. Loaded containers should be inspected to ensure that they are within acceptable weight limits and should be covered and inspected prior to departure to minimize the loss of materials in transit. The waste profile analyses should accompany the shipping document (i.e., bill of lading or hazardous waste manifest) to the offsite facility.

7.6 BACKFILL AND RESTORATION

Backfilling typically occurs after the cleanup objectives have been met. Confirmation samples are collected from the sides and bottom of the excavation to confirm that the clean up goals have been achieved. An annotated outline for a soil confirmation sampling plan is included in Appendix D3.

Once the cleanup goals have been achieved, backfill operations can begin. Backfill soils should have physical properties consistent with engineering requirements for the planned site use. The Uniform Building Code typically requires a compaction between 90 and 95 percent. The excavated areas should be restored to be consistent with its continued use and graded to ensure proper runoff.

7.6.1 Borrow Source Evaluation

When selecting material for backfilling excavated areas, steps should be taken to minimize the chance of introducing soil to the site that may pose a risk to human health and the environment at some future time. As a general rule, fill should not be obtained from industrial areas, from sites undergoing environmental cleanups, or from commercial sites with potential impacts (e.g., former service stations, dry cleaners).

The *DTSC Information Advisory, Clean Imported Fill* (DTSC, 2001) suggests that two approaches can be used to demonstrate acceptable backfill materials: (1) providing appropriate documentation and conducting analyses as needed; or (2) collecting

samples from the borrow area or borrow area stockpile and analyzing the samples for an appropriate list of parameters.

The selected analytes should be based on the source of the fill and knowledge of the prior land use. Table 5 summarizes potential contaminants based on the fill source area.

Table 5. Potential Contaminants Based on Land Use in Fill Source Area

FILL SOURCE AREA	POTENTIAL TARGET COMPOUNDS
Land near an existing freeway	Lead, PAHs
Land near a mining area or rock quarry	Metals, Asbestos, pH
Agricultural land	Pesticides, Herbicides, Metals
Residential or commercial land	VOCs, SVOCs, TPH, PCBs, Metals, Asbestos

From DTSC (2001).

A standard laboratory data package, including the quality assurance/quality control (QA/QC) sample results should accompany all analytical reports. Chemicals detected in the fill material should be evaluated for risk in accordance with the DTSC *Preliminary Endangerment Assessment Guidance Manual* or against the CHHSLs. If contaminant concentrations exceeding acceptance criteria are identified in the soil, the fill should be deemed unacceptable and new fill material should be obtained, sampled, and analyzed.

Fill documentation should include detailed information on the previous land use(s) in the area from which the fill is taken, the findings of any environmental site assessments, and the results of any testing. If such documentation is inadequate, samples of the fill material should be collected and analyzed for an appropriate list of parameters. This alternative may be the best alternative when very large volumes of fill material are anticipated or when larger areas are considered as borrow areas.

If limited fill documentation is available, samples should be collected from the potential borrow area and analyzed for an appropriate list of parameters. If fill material is not characterized at the borrow area, it will need to be stockpiled until analyses have been completed. Approximately one sample should be collected and analyzed per truckload. Table 6 provides recommended sampling frequencies for the fill soil. This sampling frequency may be modified upon consultation with appropriate regulatory agencies if all fill material is derived from a common borrow area.

Table 6. Recommended Fill Material Sampling

EXTENT OF INDIVIDUAL BORROW AREA	NUMBER OF SAMPLES
2 acres or less	Minimum of 4 samples
2 to 4 acres	Minimum of 1 sample for every 0.5 acres
4 to 10 acres	Minimum of 8 samples
Greater than 10 acres	Minimum of 8 locations with 4 subsamples per location
VOLUME OF BORROW AREA STOCKPILE	**NO. OF SAMPLES**
Up to 1,000 cubic yards	1 sample per 250 cubic yards
1,000 to 5,000 cubic yards	4 samples for first 1,000 cubic yards; 1 sample per each additional 500 cubic yards
Greater than 5,000 cubic yards	12 samples for first 5,000 cubic yards; 1 sample per each additional 1,000 cubic yards.

From *DTSC Information Advisory, Clean Imported Fill* (DTSC, 2001).

Composite sampling for fill characterization may or may not be appropriate, depending on the quality and homogeneity of the source/borrow area and the potential contaminants. The *DTSC Information Advisory, Clean Imported Fill* (DTSC, 2001) provides further discussion on the use of composite samples for certain contaminant groups.

7.7 QUALITY CONTROL / QUALITY ASSURANCE

The workplan should address the quality assurance and quality control (QA/QC) procedures that will be followed. If a quality assurance project plan (QAPP) was prepared during the characterization phase, the plan may be amended to address the pertinent changes for the excavation plan.

Excavation is selected as the remedy of choice when removal of the top layers of contaminated soil will prevent the direct contact and exposure to receptors. Soil samples from the outer limits of the excavation are typically collected to ensure that the clean up objectives have been met. The approximate locations, sampling frequency, number of samples, and the associated detection limits for confirmation samples should be identified (see annotated outline for soil confirmation sampling plan in Appendix D3). The documentation of activities should be included, ensuring site activities were conducted in accordance with the approved workplan.

Under unusual circumstances the removal action may not be carried out as planned because conditions not anticipated in the workplan were encountered. Institutional controls (ICs) or other actions may be required if the cleanup goals cannot be achieved.

7.8 HEALTH AND SAFETY MONITORING

The workplan should reference the health and safety plan (HASP) that addresses site-specific excavation and restoration and the health and safety issues that may arise at the site. These health and safety requirements should be followed by all personnel, including contractors and subcontractors conducting work at the site. The HASP used during site characterization activities may be amended to include excavation and restoration activities. The HASP should be prepared in accordance with the requirements of California Code of Regulations, title 8, section 5192 and all applicable federal, state and local laws, ordinances, and regulations and guidelines.

The HASP should at a minimum address the following:

- Identification of activities being carried out, the associated risks and the measures in place to prevent injury;
- Names and titles of personnel in charge;
- Emergency action plan;
- Location of HASP, a copy should be on site at all times;
- Method utilized to train all personnel on site on HASP and excavation safety awareness (e.g. tail gate meetings and frequency);
- Method for identifying hazards, documentation and correction of hazards;
- System in place to ensure that all workers comply with the rules to maintain a safe work environment. (e.g. disciplinary methods for workers who fail to comply)

7.9 COMPLETION REPORT

The workplan should briefly identify the key elements that will be covered in a completion of work report[10] (hereafter referred to as the “report”) and the anticipated date of submittal. The report should be signed by a professional engineer or a professional geologist licensed in California with expertise in hazardous substance site cleanup.

An annotated outline for the report is provided in Appendix D5. At a minimum, the report should provide the following:

- Summary of the work performed;
- Any difficulties or unexpected conditions encountered;

[10] The title of this document will vary depending on the cleanup process.

- Deviations from the approved workplan;
- The results of post-excavation sampling (i.e., before backfilling and restoration), and compliance with performance standards;
- Determination as to whether the goals and objectives of the cleanup were met;
- Results of the post-excavation evaluation for lead (if applicable, see Section 5.5);
- Written and tabular summary of disposal activities;
- As-constructed drawings and results of post-restoration activities on habitat if applicable;
- Health and safety activities including any analytical results;
- Compliance with all permit requirements;
- Copies of permits for the project; and
- Copies of manifests and bills of lading.

7.10 CERTIFICATION

When the final cleanup actions are fully implemented, DTSC issues a certification letter that the site has been remediated to levels required in the regulatory decision document. Any requirements for a Land Use Covenant (LUC) or other ICs, and an Operation and Maintenance Agreement/Plan[11] (including establishment of a financial assurance mechanism) must be met prior to site certification. See Section 9.4 for further discussion regarding LUCs.

[11] The title of this document will vary depending on the cleanup process.

8.0 DESIGN AND IMPLEMENTATION OF CONTAINMENT/CAPPING ALTERNATIVE

This chapter describes the approach that could be used to select the type of cover/cap to be installed at a site and to prepare a cap/cover design and implementation plan. It provides general guidelines regarding cover/cap selection and design that are intended to enhance the efficiency of, but not replace, site-specific decisions made on the basis of individual site characteristics, applicable laws and regulations, and the principles of good engineering design.

The intent of this chapter is to provide guidance to the preparer of a design and implementation plan that will help them identify and design a cover/cap system that is fully protective of human health and the environment, achieves site-specific remedial action objectives (RAOs), is compatible with reasonably foreseeable future uses of the site, and which meets specific requirements of the regulatory process under which the site is being addressed. Under the PT&R approach, a basic cap design for the least complex sites must effectively eliminate ingestion, inhalation, and dermal contact as complete routes of exposure and preclude contaminant dispersion through the air and surface water run-off. As site complexity increases, or where site-specific circumstances produce additional objectives, this chapter provides the latitude to pursue a full range of design options.

8.1 DESIGN OBJECTIVES

For some of the sites addressed under the PT&R process where containment/capping has been selected as the preferred remedy in the remedy selection document, the protection of human health and the environment can be assured by meeting the following RAOs:

- Elimination of receptor contact with contaminants in shallow soil which exceed cleanup goals; and
- Isolation of contaminated soil to eliminate wind and surface water dispersion.

As a result, the installation of a soil cover, or a cover constructed of a single layer of asphalt and/or concrete, along with provisions for appropriate long-term stewardship may be adequate. For other sites, additional RAOs may be identified in the remedy selection document. These additional RAOs may result in the need to adopt a more complex design.

Often, site-specific considerations may affect the specific design selected for a site. The considerations may be associated with planned development or future use of the property, or may be connected to the site's physical location, features, or surroundings. Some examples include:

- Anticipated future use of the property (both short and long term);

- Utilization of construction features such as a building foundation or parking lot as a cover/cap;
- Climatic conditions and their impact on construction materials and cap performance;
- Storm water management;
- Potential seismic impacts to the cap;
- Erosion control;
- Support for vegetation; and
- Operation and maintenance needs.

8.2 INFORMATION NEEDED TO SUPPORT COVER/CAP SELECTION AND DESIGN

The following table summarizes the data and information that may be needed to adequately address the selection and design of an appropriate cover/cap.

ALL COVER/CAP TYPES
• Lateral and vertical extent of impacted soils exceeding cleanup goals • An assessment of the mobility of metal contaminants (i.e., the potential for groundwater impacts) based on historical observations, methodical evaluations, and/or modeling • Average depth to groundwater • Survey map of site and surrounding features (e.g., topography, existing structures, utilities, wells, surface water control measures, property boundaries) • Geotechnical data for native and imported soil types (e.g., USCS classification, Atterberg limits, moisture content, bulk density, saturated hydraulic conductivity, shrink-swell potential) • Identification of site conditions that affect the selection of construction equipment
SOIL AND EVAPOTRANSPIRATION COVERS/CAPS
• Climatology/seasonal variations • Identification of native plant species • Estimates of evapotranspiration rates • Location and soil properties of borrow materials (see Table 7) to be used for cap construction

Ideally, these data will be collected during the characterization phase of the project (see Chapter 4) rather than requiring another field mobilization during the design phase.

8.3 DESIGN CONSIDERATIONS

8.3.1 Factors to Consider When Selecting an Appropriate Cap

Existing and planned land use. To the extent possible, cover/cap design should be compatible with both short and long-term land use plans. This may entail integrating cap design into the construction of site improvements such as utilizing building foundations or parking lot improvements as design elements. Or, it could involve designing the cap to allow future construction to occur with minimal disruption of contaminated materials.

Migration potential. Based on a pre-remediation evaluation of the potential for infiltration-driven migration that is acceptable to the lead oversight agency, an assessment should be made as to the need for, and degree of, infiltration control that must be addressed by the cap design. While the need for infiltration control will most often be captured as an RAO, significant design decisions will still need to be made due to the multitude of design options that are capable of achieving the degree of infiltration control that will likely be required.

Climatic conditions. Climatic conditions such as high rainfall or extremely low temperatures may indicate a need for enhanced cap design features. Conversely, low rainfall and high year-round evapotranspiration rates may support a simple soil cover design.

Foundation conditions. When the subgrade soil does not meet strength and compressibility requirements, additives can be combined with the in-place soil to improve its properties. This alternative uses either cement or lime to stabilize clay or sandy soil. The cement stabilization alternative is recommended for unsuitable soils with small percentages of clay and a high percentage of sand. Lime stabilization is recommended for unsuitable soils with a high percentage of clay.

Build-up of gases. If substances may be present in the vapor phase below the cap (e.g. methane), the design may need to allow venting through the cap.

Terrain. Site factors such as very uneven terrain or location within a floodplain may at a minimum complicate cap design and could potentially eliminate capping as a viable remedy.

RCRA cap versus “non-RCRA” cap. Installation of a RCRA standard cap in accordance with Subtitle C or equivalent may be necessary if remediation is being pursued under certain regulatory requirements, or if those requirements are identified as ARARs in the remedy selection document.

8.3.2 Consolidating Impacted Soils

The consolidation of metals-impacted soils may be desirable or necessary prior to cover/cap construction at many sites. Consolidation may be used to clean up the edges of a single contiguous contaminated area to make it more geometrically regular, reduce

the size of the area being capped, or to combine soils from one or more contaminated areas into a single area at a site. Anticipated future land use or specific development plans may also result in consolidation being identified as an appropriate step prior to cap construction.

In most cases and depending on site-specific circumstances, consolidation of metals-impacted soils can be accomplished through the application of either the Area of Contamination (AOC) approach or in accordance with Corrective Action Management Unit (CAMU) regulations (Cal. Code Regs., tit. 22, §66264.550, §66264.551, §66264.552, §66264.552.5).

For the purpose of implementing a consolidation and capping remedy under this guidance, the AOC approach is generally preferred unless site-specific conditions or regulatory considerations make the use of the CAMU regulations, and their added flexibility, necessary. Those parties interested in pursuing a consolidation and capping remedy are cautioned to work closely with DTSC staff to ensure that the appropriate option is selected and properly implemented.

The following information on the AOC approach and CAMU regulations is intended only as a brief summary. The reader is cautioned to read the more detailed discussions presented in the AOC references provided below and the CAMU regulations in order to fully review the complexities involved in their use.

Area of Contamination (AOC) Approach

The AOC approach will provide an adequate basis for the consolidation of metals-impacted soils at many of the sites being cleaned up in accordance with this PT&R guidance. It is based on an interpretation of federal regulations which allow for the movement of hazardous wastes within a contiguous area of generally dispersed contamination without being considered land disposal and without triggering land disposal restrictions (LDRs) or minimum technology requirements.

The AOC approach was initially discussed in detail in the preamble to the National Contingency Plan (NCP; 55 *FR* 8758-8760, March 8, 1990). The NCP discusses using the concept of “placement” to determine what requirements might apply within an AOC. The placement of hazardous wastes into a land-based unit is considered land disposal, which would trigger LDRs and other requirements. The NCP provides that, “placement does not occur when waste is consolidated within an AOC, when it is treated in situ, or when it is left in place.” The concept of placement can similarly be applied in determining that consolidation within an AOC does not, in and of itself, constitute a release of a hazardous substance.

While no formal designation of an AOC is necessary, appropriate regulatory oversight is recommended to ensure that the AOC approach is properly applied. Additionally, for most consolidation and capping remedies, regulatory oversight and approval will be necessary to:

- take advantage of certain permit exclusions,
- ensure that the remedy is properly designed,
- ensure that the remedy will remain protective over the long term through the use of ICs and implementation of proper operation and maintenance activities, and
- obtain agency certification of the completed response action.

The AOC approach may not be applicable to some sites because of the nature and timing of the original release, or as a result of the specific regulatory authority under which the sites are being cleaned up.

Additional information regarding the AOC approach can be found in the following documents:

- Preamble to the National Contingency Plan (55 *FR* 8758-8760, March 8, 1990);
- *Management of Remediation Wastes Under RCRA* (EPA, 1998); and
- *Area of Contamination Policy* (EPA, 1996).

Corrective Action Management Unit (CAMU) Approach

CAMUs can provide an effective means for implementing consolidation with capping remedies at metals-impacted sites being cleaned up in accordance with this PT&R guidance. They provide similar features to those of the AOC approach with the added flexibility of being able to receive wastes from more than one contaminated area and being constructed in an uncontaminated area at a facility. CAMUs must be formally designated by DTSC. They may be used only for managing remediation wastes associated with corrective action or cleanup at a facility. CAMUs must be located within the contiguous property under the control of the owner or operator where the wastes to be managed in the CAMU originate. One or more CAMUs may be designated at a facility.

The placement or consolidation of remediation wastes into or within a CAMU does not constitute land disposal of hazardous wastes, does not trigger LDRs, and does not create a unit subject to minimum technology requirements.

For further information, the reader should review the CAMU regulations (Cal. Code Regs., tit. 22, §66264.550, §66264.551, §66264.552, §66264.552.5).

8.3.3 Source of Borrow Materials

The source of borrow materials to be used for cap construction is identified during the design phase. In addition to material and transportation costs, the selection process for borrow materials should consider the preferred properties of each layer and the objective that the materials will not introduce new contamination to the site (see Section 7.8).

8.3.4 Storm Water Runoff Control

Surface water collection and diversion may be needed to control run-on and run-off. Storm water drainage and piping is a drainage system which refers to the use of subsurface drainage controls that collect and redirect runoff/run-on from rainfall events from the asphalted surface to a retention pond or other predetermined location. A drainage system may consist of inlet grates and pipes.

8.3.5 Erosion Control

Design of the cap should include measures to control erosion around the cap perimeter and on the main body of the cap. Additional erosion control measures will be needed for soil caps, such as selecting an appropriate slope length and steepness to minimize erosion and such as incorporating an upper vegetation layer.

8.3.6 Side Slope of Cap

Applicable cap side slopes are dependent on regulatory requirements and guidelines that vary from locality to locality. An example of side slopes would be a ratio of 5:1 (20 percent), where five is the horizontal run and one is the vertical rise. Generally, the maximum side slopes that can be implemented are 3:1 (33 percent). Steeper slopes may cause the underlying layers of sand, gravel, or geotextiles to slide or fail along the contact interface. Also, steeper slopes increase maintenance and the potential for erosion and soil loss. The benching of slopes at steeper grades may be needed to control potential erosion and promote stability of the cap.

8.4 TYPES OF CAPS

As indicated in Sections 8.1 and 8.3, the type of cover/cap used at a site depends on a variety of site-specific factors. Caps may be temporary and/or final, their selection and design may be based upon site-specific RAOs, or they may be subject to prescriptive requirements in accordance with the regulatory authority under which they are being addressed. They may consist of a generic standard design, a composite of multiple elements of standard designs, or a unique design that addresses an unusual combination of site-specific objectives. It is anticipated that covers/caps selected for PT&R metal sites will consist of one or more of the following types (listed in order of increasing complexity):

- Soil cover/cap,
- Evapotranspiration (ET) cover,
- Asphalt and/or concrete cover/cap,
- Low permeability composite soil and vegetation cover/cap,
- Geosynthetic/composite cap, and
- Standard RCRA cap (RCRA Subtitle C cap).

The California Department of Transportation (CalTrans) has developed substantial information on the design and properties of both asphalt and concrete utilized in highway construction (e.g., CalTrans, 2006). There is also a great deal of information available on the design requirements for a RCRA Subtitle C cap available through EPA and other sources. In 1991, the EPA issued a revised guidance document concerning closure and final cover for hazardous waste facilities (EPA, 1991b). Information on the design, installation, and monitoring of alternative landfill covers has been published by the Interstate Technology and Regulatory Council (ITRC, 2003a). This document draws information from these and other sources in an effort to provide foundational information on the cover/cap types listed above. It does not however attempt to provide detailed information on the design aspects of the various alternatives discussed, the reader is instead left to review these source materials if more detail is desired.

8.4.1 Soil Cover/Cap

Soil covers/caps can range from a single layer of vegetated soil to multiple layers with varying hydraulic conductivities. Under favorable conditions a single layer of vegetated clean native soil, or soil with properties similar to native soils, may be sufficient to achieve site-specific goals. In other cases climatic conditions, contaminant mobility characteristics, regulatory concerns, or land use issues may dictate a multilayered design.

For a single layer, design consideration should be given to:

- Cap thickness for the purpose of minimizing the potential for accidental/incidental penetration of the clean cap material into the underlying contaminated soil;
- The utilization of a demarcation layer (permeable mat) between the cover material and underlying contamination to indicate when contaminated materials have been or might be encountered;
- The relationship between compaction and both water-holding capacity and support of vegetation;
- Long-term care of the cover; and
- Land use and construction plans.

For single layer designs, a minimum cover thickness of approximately two feet will be adequate for most sites provided intrusion risks are low. As infiltration and surface water management issues become more important, soil with higher water-holding capacity and the use of evapotranspiration-enhancing vegetation may help address those concerns. Where the construction of buildings or other improvements is likely to occur, design properties will need to be adjusted to address those building needs without compromising the health and environmental protectiveness of the cover.

Where single layer designs are found to be unsuitable, a multilayered design made up of different soil types may be appropriate. Multilayer designs can provide infiltration control, drainage management and support for vegetative covers or future construction

through the careful selection and design of soil layers. Good design practices dictate that specific soil properties be exploited to achieve the desired results. Table 7 identifies various soil properties that should be considered when selecting soils for various layers in the soil cover.

Table 7. Critical Parameters for Soil Cap Material

PARAMETER	PREFERRED PROPERTIES	RECOMMENDED TESTS
Materials	The primary requirement is that the material is capable of being compacted to produce a suitable low conductivity layer or substrate.	
Fines	The soils should contain at least 20% fines. Soil screened on a dry-weight basis of passing a No. 200 sieve are considered fines.	ASTM D-422, ASTM D-1140 ASTM D-2487, USCS Soil Classification, ASTM D-3282, AASHTO Soil Classification tests
Plasticity Index (PI)	The soils should have a PI of at least 10%. Some soils may be slightly lower PI may still be suitable. Soils with PIs greater than 30 to 40% may be to difficult to work with as they may form hard chunks when dry and to be sticky when wet. Ideally soils with a PI between 10 to 35% are good for this purpose.	ASTM D-4318, Atterberg Limit Test
Percentage of Gravel	A maximum of 10% gravel is generally acceptable. The percentage of gravel is defined as the amount of soils retained on a No. 4 sieve.	ASTM D-422, ASTM D-2487, USCS Soil Classification, ASTM D-3282, AASHTO Soil Classification tests
Stones and rocks	Soil containing stones or rocks larger than 1 to 2 inches should not be used in liner materials.	ASTM D-2487, USCS Soil Classification, ASTM D-3282, AASHTO Soil Classification tests
Water Content	The water content of the soil at the time it is compacted is an important variable controlling the engineering properties of the soil liner.	ASTM D698 Proctor Test, ASTM D1557, Modified Proctor Test, ASTM D-2216, ASTM D-3017 ASTM D-4643
Compactive Strength	The hydraulic conductivity of a soil that is compacted wet of optimum could be lowered one to two orders of magnitude by increasing the energy of compaction.	ASTM D-698; ASTM D-1556, ASTM D-2167, ASTM D-2922, ASTM D-2937, California Test Method (CTM) 301
Size of Clods	Soils with low plasticity do not form very large clods. For soils that form clods, the clods need to be remolded into a homogeneous mass that is free of large inter-clod if low hydraulic conductivity is to be achieved.	

Soil caps may be utilized to provide increased separation between contaminated soils and building foundations, thereby minimizing the potential for construction worker exposure to contaminants during site preparation and utility installation activities. When overlain by building foundations, or other constructed surface features, the combined “cap” system will result in an easy to maintain, health and environmentally protective long-term solution for many contaminated sites.

In summary, site-specific RAOs in conjunction with site-specific considerations such as climatic conditions, future land use and development plans will guide the selection and design of suitable soil caps.

8.4.2 Evapotranspiration (ET) Cover

Because of the water-holding properties of soils and the fact that most precipitation returns to the atmosphere via evapotranspiration, it is possible to devise a cover that meets the requirements for remediation and yet does not contain a barrier layer. Plants and soils play a dominant role in all aspects of the hydrologic cycle. It is necessary to understand both the requirements for plant growth and the properties of the soil used in an ET cover in order to successfully design and construct the cover. ET covers are generally used in arid areas where clay and other barriers may not be ideal because of the high potential for cracking and settlement. Resources for design, construction, and long-term management of ET covers are provided on the ITRC and the Desert Research Institute Websites (www.itrcweb.org and www.dri.edu, respectively). An EPA fact sheet on ET landfill cover systems is also available (EPA, 2003).

8.4.3 Asphalt / Concrete Cap

Asphalt and/or concrete pavement is suitable for providing a cap for many sites. Both asphalt and concrete are especially well suited as a cap for developed areas where there is a need to combine containment with continued or new commercial or industrial use (e.g., parking lot, building foundation). Paving requires higher maintenance than caps with soil or synthetic elements, and is prone to cracking and deterioration. Paving may increase storm water run-off and could increase erosion of surrounding areas. However, these issues are easily addressed through appropriate design, inspection and maintenance activities. Storm water runoff associated with a cap that is integrated into a site development project is no different than would be expected from the development itself and would normally be addressed through development-related storm water management requirements. For stand alone pavement caps, storm water control features can be incorporated into the design.

An asphalt cap may consist of two or more components, including:

- Top cover of asphalt or concrete (may be multiple layers);
- Base rock;

And on a case by case basis,

- An impervious layer, that may be below the base rock and a protective layer or may be sandwiched between asphalt layers.

Top Cover of Asphalt or Concrete. In addition to isolating metal contaminated soil, pavements may be engineered to distribute stresses imposed by loading such as traffic or building(s) to the subgrade. Where loading is a significant design factor, the subgrade condition is a principal factor in selecting the pavement structure. Before a

pavement is engineered, the structural quality of the subgrade soil should be evaluated to ensure that it has adequate strength to carry the predicted loads during the design life of the pavement. The pavement should also be engineered to limit the expansion and loss of density of the subgrade soil.

The top cover material for the asphalt cap is normally comprised of hydraulic asphalt concrete, which serves as a hydraulic barrier as well as a physical barrier. Asphalt can be designed with consideration for vehicle use, or it can be modified for the purpose of enhancing its weatherability and permeability characteristics. Refer to the *California Department of Transportation Highway Design Manual* (CalTrans, 2006) for traffic load/design criteria.

Base Rock. The base rock layer is used to support the asphalt layer of the cover. The crushed base rock will be spread over the entire area of the cap. The typical range of base rock material depth is 6 to 12 inches and is dependent upon the type of loading that is anticipated.

Optional Impervious Layer. An impervious layer which reduces the amount of infiltration may be added to the design when site-specific conditions indicate the need. The barrier formed by the impervious layer reduces the potential for contaminant migration toward groundwater. This layer in a pavement cap may consist of a flexible membrane liner (FML), or it may be incorporated as a fabric and liquid asphalt layer between two asphalt lifts.

FMLs provide a low hydraulic conductivity layer that is placed beneath a protective layer of sand or fabric which separates it from the base rock. There are several acceptable materials that are commonly used including:

- 40 mil high density polyethylene (HDPE);
- 60 mil HDPE;
- 80 mil HDPE;
- 30 mil polyvinyl chloride (PVC);
- 40 mil PVC.

8.4.4 Geosynthetic/ Composite Cap

A geosynthetic/composite cap may consist of anywhere from two to five layers. At a minimum it will consist of a geosynthetic clay (GC) layer and an overlying soil layer that is typically vegetated. Often a drainage layer is included immediately above the GC layer. A low-permeability soil may be added to reduce permeability and a rodent control layer may also be incorporated. This complex design, although implementable, is generally more difficult to install and more expensive than soil or asphalt/concrete caps. For sites using the PT&R approach, the number of layers included in the geosynthetic/composite cap will depend on RAOs, the site location, climatic conditions, evapotranspiration rates, soil layer water-holding capacity and drainage considerations.

Soil Layer. The soil layer serves as the final (top) layer of the cap. The soil is used in conjunction with vegetation to reduce erosion and infiltration of rainwater, enhance evapotranspiration and to protect the underlying layer(s) of the cap from water and wind erosion and dehydration. The typical thickness of the topsoil layer will range from 12 to 24 inches. The material used for the top soil layer will be selected on the basis of site-specific considerations. It should have good soil water-holding capacity, and be capable of supporting appropriate vegetation. Appropriate compaction will be necessary to provide structural stability within the overall cap design without adversely impacted the rooting of the vegetated cover.

Drainage Layer. A drainage layer consisting of high permeability materials may be installed immediate above the GC layer to allow drainage of infiltrating water and to prevent downward movement of water into the impacted soil. This layer will generally range from 6 inches to one foot in thickness and will consist of soil having a hydraulic conductivity of approximately 1×10^{-2} cm/sec.

Geosynthetic Clay Layer. The GC layer is composed of a manufactured product consisting two non-woven fabrics sandwiching a layer of bentonite which acts as a barrier to prevent significant infiltration through the cap. The low-permeability GC layer has a hydraulic conductivity on the order of 1×10^{-6} to 1×10^{-7} cm/sec.

8.4.5 RCRA Standard Cap

RCRA Subtitle C (subparts G, K and N) establishes the minimum requirements for cap systems designed and constructed for the containment of hazardous waste. Standard RCRA Subtitle C caps are designed to provide containment and hydraulic protection for a performance period of a minimum of 30 years. The surface barrier comprises five layers with a combined minimum thickness of 5.5 feet and a vegetated erosion-control surface. A RCRA standard cap typically includes the layers with the characteristics listed in Table 8.

8.5 IMPLEMENTATION CONSIDERATIONS

Prior to conducting field work, a series of project management and regulatory tasks should be completed. The general areas that require preparatory activities include:

- site access,
- permits,
- underground utilities,
- environmental and cultural protection,
- health and safety,
- waste management,
- staff and training,
- support and equipment, and
- notifications.

Table 8. Typical Requirements for RCRA Caps

LAYER[1]	REQUIREMENTS FOR SUBTITLE C CAP[2]	REQUIREMENTS FOR SUBTITLE D CAP[2]
Top Vegetation	Thickness varies from >6 inches dependent on site conditions.	Thickness varies from >6 inches dependent on site conditions.
Soil Layer	Minimum of 2 feet in thickness of graded soils at slope of 3 to 5%.	Thickness varies from >6 inches dependent on site conditions. Thickness of top vegetation and soil layers combined should be a minimum of 24 inches.
Drainage Layer[3]	Minimum of 1 foot in thickness and constructed of soil having a minimum hydraulic conductivity of $1x10^{-2}$ cm/sec or equivalent.	N/A
Impervious Layer[3]	Minimum of 2 feet in thickness of compacted natural or amended soils with a hydraulic conductivity of $1x10^{-7}$ cm/sec in contact with geomembrane.	Minimum of 18 inches in thickness of compacted natural or amended soils with a hydraulic conductivity of $1x10^{-5}$ cm/sec.
Leveling Layer	May vary in thickness from 6-18 inches to form a layer for construction of the overlying layers.	May vary in thickness from 6-18 inches to form a layer for construction of the overlying layers.

1 Layers in order from surface to increasing depth.
2 Final covers must be designed and constructed to have a permeability less than or equal to natural subsoils.
3 Varies in geo synthetic/composite cap.

Some municipalities have restrictions on the type of equipment that can be used within a specified distance from water mains, sewer lines, and utility lines. In addition, air districts may require a similar application that identifies the mitigation measures to reduce or eliminate air dispersal of contaminants.

8.5.1 Dust Control and Air Monitoring

Control of fugitive dust and emissions is required by local air districts and, if not identified as a project element in the remedy selection process, may be identified as a mitigation measure under the CEQA process. Therefore, a fugitive dust control and monitoring plan should be developed for the project. Dust control applies to any construction, demolition, excavation, and other earthmoving activities, including, but not limited to, land clearing, grubbing, scraping, travel on site, and travel on access roads to and from the site. Please refer to Section 7.5.1 for further discussion of the fugitive dust control and monitoring plan.

8.5.2 Community Air Standards

Activities occurring near residential communities, schools, and other sensitive receptors (e.g., elderly or high use community areas) should specifically be considered in the dust control planning. Adequate protection of exposure to contaminants contained in the dust should be considered as part of the dust control measures.

If appropriate, community air monitoring should be conducted to ensure that the implementation of the remedy does not pose a potential treat to off-site receptors. Site-specific risk-based action levels should be calculated, in consultation with DTSC, and included in the community air monitoring plan.

8.5.3 Borrow Material Management

The design and implementation plan will need to provide for staging of borrow materials that are transported to the site for use in cap construction. Staging should be implemented so as to prevent the placement of clean material within contaminated areas unless provisions are included for use of an appropriate barrier. Generally, staging within contaminated areas with the use of a barrier will not be accepted except in cases where acceptable clean areas are not available.

8.5.4 Safety Standards

The design and implementation plan should address applicable Cal-OSHA health and safety requirements.

8.6 DESIGN AND IMPLEMENTATION PLAN

The engineered cap design and implementation plans will be presented in a design and implementation plan. The plan may be contained in the remedy selection document or as a stand-alone document. In general, plans for less complex projects will be included in the remedy selection document. The oversight agency should be consulted on specific submittal requirements. An annotated outline for the design and implementation plan is provided in Appendix E1.

8.7 COMPLETION REPORT

A completion report documenting the cap construction should be prepared. It should include as-built drawings as well as material testing results and should be stamped and signed by a professional engineer or professional geologist licensed in California with appropriate experience in hazardous substance site cleanup. An annotated outline for a completion report is provided in Appendix E3.

8.8 LONG-TERM STEWARDSHIP

Long-term stewardship applies to sites and properties where long-term management of contaminated environmental media is necessary to protect human health and the environment over time.

8.8.1 Institutional Controls

Institutional controls (ICs) such as Land Use Covenants (LUCs) will be required due to hazardous substances remaining on-site at concentrations which preclude unrestricted use of the property. Further discussion of ICs and LUCs is provided in Section 9.3.

8.8.2 Financial Assurance

Financial assurance will be required to assure that sufficient monies are available to implement any required corrective action activities and on-going O&M activities, conduct necessary five-year reviews and pay the regulatory oversight costs associated with those activities and IC implementation. Depending on the specific cap design employed, financial assurances may also need to include the costs of cap replacement. These on-going costs should be included in the cost calculation utilized in the remedy selection process. Financial assurance can be accomplished by several different mechanisms.

Life-cycle cost analysis (LCCA) is a useful tool for comparing the value of alternative cap structures and strategies. LCCA is an economic analysis method that compares the initial cost, future cost, and user delayed cost of different cap alternatives. Although not specific to caps, the *Life-Cycle Cost Analysis Primer* (U.S. Department of Transportation, 2002), the *Full Cost Accounting for Municipal Solid Waste Management: A Handbook* (EPA, 1997b), and *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA, 2000) describe the methods and techniques used in LCCA. Software programs such as RACER[12] can be used to create cost estimates for the LCCA methodology.

LCCA is an integral part of the decision making process for selecting the cap type and design. Present worth or value analysis is often used for comparing cost alternatives with varying durations.

8.8.3 Regulatory Oversight Agreement

A regulatory oversight agreement will be required because contaminants have been left in place that may pose a threat to human health and the environment if the cover is not maintained as designed. Examples include post-closure care permits and Operation and Maintenance (O&M) Agreements.

8.8.4 Operation and Maintenance

Any regulatory oversight agreement or enforceable mechanism should reference or include the approved O&M plan that outlines the procedures and requirements for on-going O&M of the cap. The purpose of the O&M plan is to ensure that the cap is maintained in good condition so that it remains protective of public health and the

[12] Mention of any trade names or commercial products does not constitute endorsement or recommendation of the Department of Toxic Substances Control.

environment. An sample document for an O&M plan is provided in Appendix E2. Selected elements of the O&M plan are highlighted below.

Inspections. The O&M Plan should provide for inspections of the cap to ensure that it is functioning as intended. These inspections should be conducted on a routine basis as well as after unplanned events (e.g., earthquake, on-site construction activities) that may have affected cap integrity.

Repairs and Maintenance. The cap should be maintained in a manner that ensures it is functioning as intended. Examples of cap maintenance include vegetation control, and repairs due to cover erosion, asphalt cracking, settlement, and subsidence. For asphalt and concrete caps, periodic sealing of the cap surface will be necessary. Repairs and maintenance of the cap should be performed according to the procedures and the timeframes specified in the O&M Plan.

Reporting, Recordkeeping, and Notifications. The O&M plan should outline the recordkeeping requirements for O&M activities and should provide for submittal of periodic inspection summary reports. The O&M plan should also identify the site activities or conditions that require notification of the regulatory agencies. The plan should also identify the timeframe and mechanism (e.g., verbal, written) for the required notifications.

8.8.5 Contingency Plan

Any regulatory oversight agreement or enforceable mechanism should reference or include a contingency plan that will be implemented in the event that an immediate response action is required to ensure protection of human health and the environment. The contingency plan may be a stand alone document or may be included as an element of the O&M plan.

8.8.6 Five-Year Review

Under CERCLA and State law, five-year reviews are required for a remedial action that results in hazardous substances remaining at the site. Any regulatory oversight agreement or enforceable mechanism, as well as the O&M plan, should include provisions for conducting five-year reviews. The purpose of the five-year review is to ensure that the remedy remains protective of human health and the environment, is functioning as designed, and is maintained appropriately by O&M activities. The review generally addresses the following questions:

- Is the remedy functioning as intended?
- Are the cleanup objectives, goals and criteria used at the time of cleanup alternative selection still valid?
- Have there been significant changes in the distribution or concentration of impacted soils at the site?

- Are modifications needed to make the O&M plan more effective?

The scope of the five-year review may be outlined in the O&M plan or in a separate workplan developed for a specific review. The review of the cap/cover portion of a remedy would typically consist of:

- Notifying the community that the review is being conducted;
- Inspecting the cap to document the condition of the cap; determine if necessary actions are required to maintain or improve cap integrity; and ensure the cap is meeting the intended performance objectives; and
- Preparing a report that details the findings of the review.

As applicable to a given site, other components of the remedy should also be addressed by the review.

Depending on site-specific considerations, the cap inspection and/or technical assessment may be conducted by DTSC staff and/or responsible party representatives. DTSC staff will review the report and make recommendations to: ensure that the remedy remains effective; identify milestones toward achieving or improving effectiveness; and provide a schedule to accomplish necessary tasks.

9.0 SITE CERTIFICATION

When the cleanup process is completed, DTSC will certify that the required cleanup has been completed and that no further cleanup is necessary, unless new information is obtained or site conditions change. DTSC will determine whether the residual concentrations of metals in soil are protective of public health and the environment based on the cleanup levels established in the regulatory decision document. The possible determinations are:

- adequate cleanup has been achieved (e.g., closure of a hazardous waste management unit);
- additional cleanup is necessary; and/or
- institutional controls (ICs*) are required to manage the remaining contamination.

9.1 CERTIFICATION OF ACTION

When a site cleanup is satisfactorily completed, DTSC issues a certification letter that the site has been cleaned up to levels required in the regulatory decision document. The certification letter is issued after any requirements for a Land Use Covenant (LUC*) or other ICs, and an Operation and Maintenance (O&M) Agreement/Plan (including establishment of a financial assurance mechanism) are met. These documents will state that DTSC has continuous oversight and the responsible party is required to maintain any measures necessary for on-going protection of public health and the environment.

9.2 OPERATION AND MAINTENANCE

Sites that have waste left in place when the PT&R alternative of containment/capping is selected will be required to have an O&M Plan (see Section 8.8.4). The mechanism under which O&M is conducted depends on the type of site.

9.3 INSTITUTIONAL CONTROLS FOR CONTAMINATION REMAINING IN PLACE

Where future land and water uses may not be compatible with residual metals contamination or where cleanup involves leaving metals-impacted soils in place, ICs are used to stop or reduce the exposure of human and environmental receptors. ICs are non-engineering mechanisms used to ensure that the intended future land use is consistent with site cleanup and engineering controls (e.g., caps) maintain their integrity and effectiveness. Examples of ICs for sites where contamination remains in place include LUCs, as well as public notice, signs, and fencing.

For sites requiring ICs, California Code of Regulations, title 22, section 67391.1 requires the property owner to enter into a LUC to ensure that DTSC will have authority to implement, monitor, and enforce the protective restrictions. LUCs allow on-going use of the property as long as the cleanup remedy is not compromised by current or future development. LUC Agreements are intended to protect public health and the

environment by preventing inappropriate land use, increasing the probability that the public will have information about residual contamination, ensuring that long-term mitigation measures are carried out by protecting the engineering controls and remedy, and ensuring that subsequent owners assume responsibility for preventing exposure to contamination.

California Code of Regulations, title 22, section 67391.1 requires that a LUC imposing appropriate limitations on land use shall be executed and recorded with the local county recorder's office when hazardous materials, hazardous wastes or constituents, or hazardous substances will remain at the property at levels which are not suitable for unrestricted use of the land. It requires DTSC to clearly set forth and define land use limitations or covenants in a cleanup decision document prior to approving or concurring in any facility closure, corrective action, remedial or removal action, or other response actions. Further information regarding LUCs is available on the DTSC Internet site.

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GLOSSARY

ARARs. Section 121(d) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) requires that on-site remedial actions attain or waive federal environmental “applicable or relevant and appropriate requirements” (ARARs), or more stringent State environmental ARARs, upon completion of the remedial action. The 1990 National Oil and Hazardous Substances Pollution Contingency Plan (NCP) also requires compliance with ARARs during remedial actions and during removal actions to the extent practicable.

Background. Metals concentrations that represent only pristine or natural conditions often are referred to as “background” concentrations. In some instances, non-specific off-site sources may also have contributed to the “background” concentration. For the purposes of this guidance document, the general term “background” will be used to refer to soil that has not been affected by site-related releases.

Brownfields. Brownfields are properties that are contaminated, or thought to be contaminated, and are underutilized due to perceived remediation costs and liability concerns. When agricultural and green spaces are developed for residential, commercial or industrial uses, infrastructure such as roads and sewers must be developed. That redundant infrastructure wastes scarce tax dollars and adds to the burden on California's environment. Redeveloping frequently urban brownfields properties optimizes the use of existing infrastructure and protects our resources.

CAMU. Corrective Action Management Units, or "CAMUs,"' are special units authorized under the federal and state hazardous waste management laws to facilitate treatment, storage, and disposal of hazardous wastes managed for implementing cleanup, and to remove the disincentives to cleanup that the application of hazardous waste management requirements can sometimes impose.

Capping. Impacted soils are isolated by placement of a barrier to prevent exposure and/or reduce surface water infiltration.

Capillary fringe. Zone of soil immediately above the water table that acts like a sponge taking up water from the underlying water table and retaining this water under suction. The soil pores act like capillary tubes with the smaller the soil pore (space between mineral grains), the greater is the rise of water within the soil pore. At the base of the capillary fringe most if not all of the soil pores are completely filled with water. At the top of the capillary fringe, only the smallest soil pores are filled with water.

CERCLA. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), commonly known as Superfund, was enacted by Congress on December 11, 1980, and amended in 1986, by the Superfund Amendments and

Reauthorization Act (SARA). This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA established prohibitions and requirements concerning closed and abandoned hazardous waste sites, provided for liability of persons responsible for releases of hazardous waste at these sites; and established a trust fund to provide for cleanup when no responsible party could be identified.

CEQA. The California Environmental Quality Act was signed into law in 1970 (Public Resources Code, §21000 et seq). CEQA requires public agencies to disclose and consider the environmental implications of their decisions, and to eliminate or reduce the significant environmental impacts of their decisions whenever it is feasible to do so.

Chemical fixation. The term *chemical fixation* implies transformation of toxic contaminants to new, nontoxic forms. Chemical fixation typically requires mechanical mixing or blending of reagents with the contaminated mass. These reagents effect destruction, alteration, or chemical bonding of the contaminant(s).

Chemicals of potential concern. Chemicals of potential concern (COPCs) are the metals that exceed screening levels and are carried forward into the risk assessment.

Chemical oxidation state. Refers to the positive or negative charge associated with a metal or metal ion. The chemical oxidation state affects how the metal moves in the soil and may affect the toxicity of the metal. A higher oxidation state means that the metal has a relative higher positive charge (less electrons around the nucleus) than lower oxidation states. Each metal has certain oxidation states typically occur in nature. For example, chromium usually occurs in a trivalent oxidation state (Cr^{+3}, Cr(III)) or in a hexavalent oxidation state (Cr^{+6}, Cr(VI)).

CHHSLs. 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. Developed by the Office of Environmental Health Hazard Assessment (OEHHA), CHHSLs include concentrations of metals in soil that the Cal/EPA considers to be below thresholds of concern for risks to human health. The CHHSLs pertain to the direct exposure of humans to contaminants in soil via incidental soil ingestion, dermal contact, and inhalation of dust in outdoor air. The thresholds of concern used to develop the CHHSLs are an excess of lifetime cancer risk of one-in-a-million (10^{-6}) and a hazard quotient of 1.0 for noncancer health effects.

Cleanup goal. Concentration value against which the success or completeness of a cleanup effort is evaluated.

Colloids. Small particles (less than ten microns in diameter) suspended in liquid phase of soil.

Complex. Unit in which a central metal ion is bonded by a number of associated atoms or molecules in a defined geometric pattern. The associated atoms or molecules are termed ligands.

Conceptual site model (CSM). Tool to help organize and communicate information about the site characteristics. It provides a summary of how and where contaminants are expected to move, and who might be exposed to chemicals and how it explains what a problem is and why a response is needed.

Corrective Measures Study. The corrective measures study is the mechanism for the development, screening, and detailed evaluation of alternative corrective actions.

Detection frequency. The percentage of total samples of in which the metal was detected.

Exposure point concentration. The exposure point concentration (EPC) is a conservative estimate of the average chemical concentration in the soil.

Feasibility Study. The feasibility study is the mechanism for the development, screening, and detailed evaluation of alternative remedial actions.

HSAA. Hazardous Substances Account Act, Health and Safety Code, division 20, chapter 6.8.

HWCL. Hazardous Waste Control Law, Health and Safety Code, division 20, chapter 6.5.

Institutional control. Institutional controls (ICs) are actions, such as legal controls, that help minimize the potential for human exposure to contamination by ensuring appropriate land or resource use.

Interim measures. Interim measures as short-term actions to control on-going risks while site characterization is underway or before a final remedy is selected.

Ligand. An atom, molecule, group, or ion that is bound to a central atom of a molecule, forming a complex.

Land Disposal Restrictions. The Land Disposal Restriction (LDR) program found in federal and state regulations requires waste handlers to treat hazardous waste or meet specified levels for hazardous constituents before disposing of the waste on the land. To ensure proper treatment, the regulations establish a treatment standard for each type of hazardous waste. The regulations list these treatment standards and ensure that hazardous waste cannot be placed on the land until the waste meets specific treatment standards to reduce the mobility or toxicity of the hazardous constituents in the waste.

Land Use Covenant. Written instruments and agreements restricting land uses, easements, servitudes, and land use restrictions. Recorded land use restrictions (or covenants) are provisions set forth in a document which can specify requirements on real property and affect the title, which is the evidence of ownership, to property. Land use covenants are recorded at the county recorder's office so that they will be found during a title search of the property deed.

Metals. Metals are defined as any element that has a characteristic luster, is usually in solid form, is malleable and ductile, and is usually a good conductor of heat and electricity. These elements are referred to by various terms, including alkali metals, alkaline earth metals, transition metals, trace metals, heavy metals, micronutrients, and toxic metals. For the purposes of this document, metalloids (e.g., arsenic, antimony, selenium) are also considered metals because these elements exhibit both metallic and non-metallic properties.

Metal retention capacity. When a contaminant is released to soil, chemical reactions with soil particles will cause the metal to be retained in the vicinity of the release. If the release continues for longer time periods or consists of large amounts of metal, the ability of the soil to react with the metal will be overwhelmed and the metal will migrate further away from the source.

National Contingency Plan. The National Oil and Hazardous Substances Pollution Contingency Plan, more commonly called the National Contingency Plan or NCP, is the federal government's blueprint for responding to both oil spills and hazardous substance releases. The NCP is the result of our country's efforts to develop a national response capability and promote overall coordination among the hierarchy of responders and contingency plans. Since its first version published in 1968, Congress has revised the NCP to include a framework for responding to hazardous substance spills. [40 Code of Federal Regulations sections 300.1 - 300.920]

Non-time-critical removal action. Non-time-critical removal actions, as defined by CERCLA, are removal actions that the lead Agency determines, based on the site evaluation, that a removal action is appropriate, and a planning period of at least six months is available before on-site activities must begin. Further, because non-time-critical removal actions can address priority risks, they provide an important method of moving sites more quickly through the Superfund process. Thus, conducting non-time-critical removal actions advances the goals of the Superfund Accelerated Cleanup Model (SACM) to include substantial, prioritized risk reduction in shorter time frames and to communicate program accomplishments to the public more effectively.

Operable unit. An OU is a geographical area designated for the purpose of analyzing and implementing remedial actions. OUs are defined on the basis of similar features and characteristics (e.g., physical and geographic properties and

characteristics developed in previous investigations) and for ease of site management and administration.

Preliminary Endangerment Assessment. Under DTSC (2004), the Preliminary Endangerment Assessment (PEA) includes activities performed to determine whether current or past waste management practices have resulted in the release or threatened release of hazardous substances or materials which pose a threat to public health or the environment.

RCRA. The Resource Conservation and Recovery Act (RCRA), an amendment to the Solid Waste Disposal Act, was enacted in 1976 to address the huge volumes of municipal and industrial solid waste generated nationwide. Under RCRA, EPA has the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous wastes. [Title 40 of the Code of Federal Regulations (CFR), Parts 239 through 282]

Remedial Action Plan. Under the HSAA, the RAP is the remedy selection document for a remedial action for which the capital costs of implementation are projected to cost $1,000,000 or more.

Removal Action Workplan. Under the HSAA, the RAW is the remedy selection document for a nonemergency removal action (or a remedial action if cost is less than $1 million) at a hazardous substance release site. Typically, short-term actions designed to stabilize or cleanup a site posing an immediate threat to human health or the environment.

Risk assessment. A risk assessment is an analysis that uses information about toxic substances at a site to estimate a theoretical level of risk for people who might be exposed to these substances.

Risk screening. Process of the identification of metal COPCs that need to be cleaned up on the site based on potential risk to human health. Screening involves a comparison of site media concentrations with risk-based values (e.g., CHHSLs).

Screening level. Concentration value used to evaluate whether a metal poses a risk to human health and should be identified as a COPC.

Site characterization. Process of determining the type, quantity, and location of contaminant releases at a site. Also includes assessment of site characteristics that affect how and where the contaminant may be moved and the how human health and the environment are or may be affected.

Soils. Loose material on the surface and in the subsurface of the earth consisting of solids (i.e., mineral grains, organic matter), water, and air.

Soil Washing. Water-based process for scrubbing soils to remove contaminants by dissolving/ suspending in wash solution or concentration into smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing.

Solidification/Stabilization. Use of chemical or physical processes to treat wastes. Solidification technologies encapsulate waste to form a solid material. Stabilization technologies reduce the hazard potential by converting waste to less soluble, mobile, or toxic forms.

Soluble/solubility/solubilization. Tendency of a metal to dissolve in the soil solution or groundwater. Process of causing a metal to dissolve.

Time-critical removal action. Where a release or threatened release poses an imminent or substantial risk to health or environment, an emergency or time-critical removal may be employed to prevent a release of contaminants or minimize its risk. For these types of removal actions, evaluation and reporting requirements are kept to a minimum to expedite the response.

Treatability study. Treatability studies are investigations conducted to provide sufficient data to allow treatment alternatives to be fully developed and evaluated during cleanup option evaluation and to support the design of the selected alternative(s). Treatability studies may also be used to reduce cost and performance uncertainties for treatment alternatives to acceptable levels so that a cleanup option can be selected.

Upper confidence limit (UCL). The upper confidence limit (UCL) is a statistical term that can be calculated using soil data collected from a statistically designed sampling program. The method for calculating the UCL will depend on the data distribution. Soil samples collected from a statistically designed program are taken to be representative of the actual environmental conditions onsite (i.e., samples collected are a subset of the actual site conditions, but represent the whole site). The 95 percent confidence interval (or error) is the region about the arithmetic sample mean that is likely to contain the underlying population mean (representing the whole site itself) with a probability of 95 percent.

Volatile/Volatilization. Tendency of a metal to change into a vapor. Process of causing a metal become a vapor.