Appendix E. DTSC Proven Technologies and Remedies Guidance (excerpts)

DEPARTMENT OF TOXIC SUBSTANCES CONTROL
CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

PROVEN TECHNOLOGIES AND REMEDIES GUIDANCE

REMEDIATION OF ORGANOCHLORINE PESTICIDES IN SOIL

FEBRUARY 26, 2010

CHAPTER 6
EVALUATION OF CLEANUP TECHNOLOGIES FOR OCP-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 OCPs in soil. This chapter provides the administrative record, technical basis, and evaluation necessary for streamlining the cleanup alternative evaluation. Also addressed are the site-specific evaluation and remedy selection processes for cleanup of OCP-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[1] and
- 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 OCP CONTAMINATION IN SOIL

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

The DTSC study included the following activities:

- review of literature relevant to sites with OCP soil contamination (see Appendix B for table summarizing the technologies applicable to OCPs in soil);
- identification of a representative number of DTSC sites with OCP-contaminated soils;
- review of the decision documents to determine which cleanup alternatives were routinely either screened out or selected for the remedy; and
- identification of the rationale for selection of remedy.

DTSC reviewed its EnviroStor database to identify sites with OCP-contaminated soils. The database evaluation identified 80 sites for which remedy selection or implementation occurred as of December 2008. Table 3 summarizes the types of sites included in the DTSC study.

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

Table 3. Cleanup Options Selected for Sites Evaluated by DTSC Study

DTSC SITE TYPE (NO. OF SITES)	ICS ONLY	OFF-SITE REUSE	CONSOLIDATION ON-SITE, IC	CAPPING IN PLACE, CONSOLIDATE & CAP, CAMU, IC	EXCAVATE & DISPOSE	IN SITU TREATMENT	THERMAL OR CHEMICAL TREATMENT WITH ON-SITE REUSE OR DISPOSAL
School Site (31*)	1	1	0	0	29	0	0
Military Facility (16*)	3	0	0	5	10	0	1
Voluntary Cleanup (20*)	1	1	2	4	7	4	2
State Response/ NPL (13*)	0	0	2	4	10	0	1

* Some sites selected multiple cleanup options (i.e., this number is not simply the sum of values listed in this row).
CAMU is corrective action management unit.
IC is institutional control.
NPL is National Priorities List.

DTSC reviewed the cleanup alternative decision documents for 80 sites identified in the database review. The review focused on the cleanup alternatives that were considered and the factors that led to selecting the cleanup alternative. The document review also considered the project type, site activities, types of OCPs 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 (Table 3);
- rationale for selection of the cleanup alternatives (described below); and
- rationale for rejection of the cleanup alternatives considered by the selection process (Table 4, Appendix B).

Based on the decision documents reviewed, the most frequently reported OCPs requiring a soil response action include DDT, DDE, chlordane, dieldrin, and toxaphene. The data indicate that excavation/disposal was the most frequently selected cleanup alternative and containment/capping was the next most frequently chosen cleanup alternative. The selection of the cleanup alternative as the preferred approach appears to be influenced by proven effectiveness, ability to meet the project timeframes, foreseeable future land use and volume of impacted area. Containment/capping was selected if a cap was compatible with the current and foreseeable future land use and the associated land-use restrictions were not an issue with interested parties.

The review of DTSC projects identified several projects for which *in situ* bioremediation was used to cleanup OCPs in shallow soils. Although insufficient performance data are available to identify *in situ* bioremediation as a proven technology, Tables B-2 and B-3 describe the technology and Appendix C provides case histories of DTSC projects that used *in situ* bioremediation.

Table 4 summarizes the frequency of the National Oil and Hazardous Substances Pollution Contingency Plan (NCP) criteria used to support rejection of a particular cleanup alternative for the 80 sites included in the DTSC study. A detailed summary of the primary rationale for selecting and rejecting a given technology is provided in Appendix B. The excavation/disposal alternative frequently was rejected based on cost. Containment/capping were most often rejected due to existing or planned land use, or because of the long-term operation and maintenance (O&M) requirements.

Table 4. Cleanup Options Considered for the Sites Evaluated by DTSC Study

	Reason for Rejecting During Cleanup Alternative Analysis						
Technologies	Overall Protectiveness	Compliance with ARARs	Reduction of Toxicity, Mobility, Volume	Long-term Effectiveness	Short Term Effectiveness	Cost	Implementability
No Action	53	6	0	0	0	0	0
ICs Only	4	2	0	1	0	0	0
Excavation/Disposal	0	0	0	0	0	15	0
CAMU	0	0	0	3	0	0	0
Consolidation/Capping	0	13	0	4	0	8	0
Treatment (non-specific)	0	0	5	0	0	12	9

ARAR is applicable or relevant and appropriate requirement
CAMU is corrective action management unit
IC is institutional control

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 a screening evaluation, a more detailed and focused evaluation that considers the site characteristics must be conducted on the cleanup alternatives. The cleanup alternative screening evaluation presented in Section 6.1 and Appendix B may be used in lieu of a screening evaluation for sites using the PT&R approach (provided that the use of the PT&R screening evaluation is cited in the administrative record).

The next step in the PT&R approach is to determine which PT&R alternative is the most appropriate cleanup alternative. The alternatives evaluation may consist of a site-specific evaluation of the no action, excavation/ disposal, containment/capping alternatives, or a combination of these remedial options. Focusing on these PT&R alternatives is consistent with the NCP when:

- the number of alternatives evaluated for a site are reasonable;
- the number of alternatives evaluated are 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 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 associated with screening and evaluating those additional cleanup technologies being considered.

As illustrated in Figure 3, excavation/disposal has the potential to allow unrestricted use of the site. The containment/capping alternative, however, has long-term stewardship requirements which typically necessitate a regulatory oversight agreement. The focused alternatives evaluation may be prepared under State or federal guidelines, as summarized in Table 5.

Figure 3. Summary of PT&R Cleanup Alternatives for OCPs in Soil

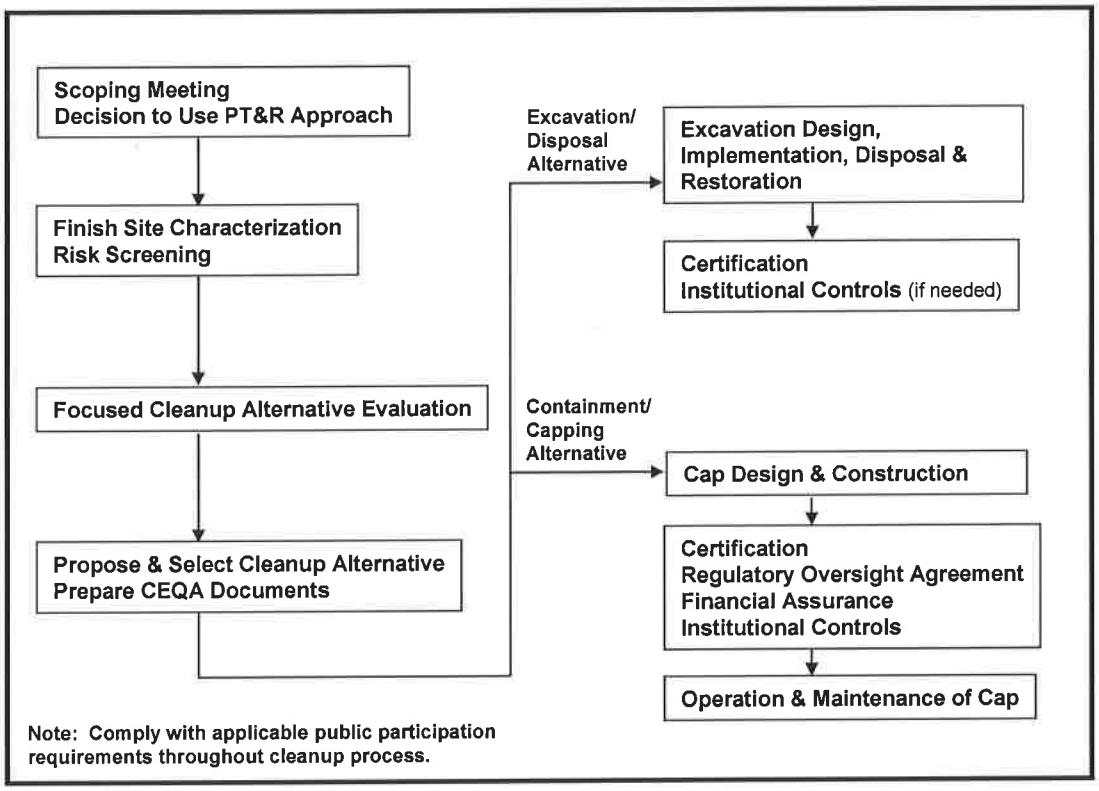

Table 5. State and Federal Guidelines for Focused Alternatives Evaluation

Law	Process	Description	Suggested Reference(s)
HSAA	Remedial Action Plan (RAP)[1]	Process for developing, screening, and detailed evaluation of alternative remedial actions for sites. Response action selection document under HSC §25356.1.	DTSC, 1995
	Removal Action Workplan (RAW)[1]	Prepared when a proposed, non-emergency removal action or a remedial action is projected to cost less than $2,000,000. Response action selection document under HSC §25356.1.	DTSC, 1993, 1998
CERCLA	Feasibility Study (FS)[1,2]	Process for the development, screening, and detailed evaluation of alternative remedial actions for sites.	USEPA, 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.	USEPA, 1993
RCRA or HWCL	Corrective Measures Study (CMS)[1]	Mechanism used by the corrective action process to identify, develop, and evaluate potential remedial alternatives.	USEPA, 1991a, 1994, 1997a
HSAA, HWCL, RCRA, CERCLA	Interim Measures[1] (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.	

1 See Appendix D for link to example or sample document.
2 A feasibility study is not required for RAW process. However, the RAW should evaluate the effectiveness, implementability, and cost of various alternatives.
CERCLA – Comprehensive Environmental Response, Compensation, and Liability Act
HSAA – Hazardous Substance Account Act
HWCL – Hazardous Waste Control Law
RCRA – Resource Conservation and Recovery Act

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

- identification of applicable federal/State/local requirements (referred to as applicable or relevant and appropriate requirements [ARARs] under some cleanup processes)
- establishment of site-specific RAOs
- evaluation of the PT&R cleanup alternatives and the no action alternative against the applicable NCP criteria[2]:

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

[2] Only the effectiveness, implementability, and cost criteria apply to the DTSC RAW process. For hazardous waste sites, the RCRA-balancing criteria can be used instead of the NCP criteria.

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

Additional criteria may also be considered in the remedial alternative evaluation process for a given site. For example, an evaluation of the sustainability of each remedial alternative could be used to identify potential environmental stressors (e.g., resource depletion, physical disturbances) and their associated impacts. The *Interim Advisory for Green Remediation* (DTSC, 2009) provides additional discussion regarding sustainability as a criterion in the remedy selection process.

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 CEQA documents are usually prepared concurrently with the remedy selection documents, if not sooner (see Section 6.4). Once approved by DTSC, the draft remedy selection and 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); and
- responses to any public comments pertaining to the decision to use the PT&R approach.

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., a cap). 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 alternatives.

6.4 CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

Remediation of OCPs in soil must meet all applicable local, State and federal requirements, including the CEQA. CEQA (Pub. Resources Code, sec. 21000 et seq.). 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. For further information, DTSC's CEQA-related polices and procedures are available at www.dtsc.ca.gov.

APPENDIX B

SUPPORTING DOCUMENTATION FOR DTSC TECHNOLOGY SCREENING

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Table B-1 Cleanup Options Selected and Characteristics of Sites Evaluated by DTSC Study

DTSC Site Type (No. of Sites)	Cleanup Option Selected (Number of Sites)							
	IC Only	Consolidate & IC	Excavate & Off-site Reuse	Capping & IC	CAMU & IC	Excavation & Off-site Disposal	Thermal / Chemical Treatment & Disposal/ Reuse	In situ Bioremediation
Schools Properties (31)	1	0	1	0	0	29	0	0
Military Facility (16*)	3	0	0	2	3	10	1	0
Voluntary Cleanup (20*)	1	2	1	4	0	7	2	4
State Response/ NPL (13*)	0	2	0	4	0	10	1	0

Total number of sites represented: 80

Cubic Yards of Impacted Soil (No. of Sites)	Cleanup Option Selected (Number of Sites)							
	IC Only	Consolidate & IC	Excavate & Off-site Reuse	Capping & IC	CAMU & IC	Excavation & Off-site Disposal	Thermal / Chemical Treatment & Disposal/ Reuse	In situ Bioremediation
≤ 100 (4)	0	0	0	0	1	3	0	0
>100, ≤ 1000 (23*)	0	0	0	0	1	23	1	0
>1000, ≤ 10,000 (23*)	0	0	0	3	0	18	1	1
> 10,000 (20*)	0	4	2	7	2	10	2	1

Total number of sites represented: 70 (volume of impacted soil not available for all 80 sites)

Maximum Depth of Impacted Soil (No. of Sites)	Cleanup Option Selected (Number of Sites)							
	IC Only	Consolidate & IC	Excavate & Off-site Reuse	Capping & IC	CAMU & IC	Excavation & Off-site Disposal	Thermal / Chemical Treatment & Disposal/ Reuse	In situ Bioremediation
≤2 feet (23*)	2	2	1	2	1	13	0	3
>2, ≤5 feet (18*)	0	1	1	2	0	14	0	1
>5, ≤10 feet (12*)	0	1	0	1	2	13	2	0
> 10 feet (5*)	0	0	0	2	0	3	2	0

Total number of sites represented: 58 (maximum depth of impact not available for all 80 sites)

Table B-1 (Continued)

OCPs Present	Cleanup Option Selected (Number of Sites)							
	IC Only	Consolidate & IC	Excavate & Off-site Reuse	Capping & IC	CAMU & IC	Excavation & Off-site Disposal	Thermal / Chemical Treatment & Disposal/ Reuse	In situ Bioremediation
DDD/DDE/DDT	3	4	2	9	1	37	4	3
Chlordane	3	0	1	2	2	37	2	2
Dieldrin	0	1	0	5	2	32	2	2
Toxaphene	1	2	1	3	0	10	3	2
Other	0	1	0	2	2	16	2	1

Total number of sites represented: 80

Other Contaminants Present	Cleanup Option Selected (Number of Sites)							
	IC Only	Consolidate & IC	Excavate & Off-site Reuse	Capping & IC	CAMU & IC	Excavation & Off-site Disposal	Thermal / Chemical Treatment & Disposal/ Reuse	In situ Bioremediation
Metals	4	2	2	3	1	39	1	1
VOCs	0	0	1	2	1	11	1	0
SVOCs, PAHs, PCBs, dioxins	2	2	1	3	1	12	2	0
TPH, BTEX	1	1	0	1	0	10	0	1
Other pesticides	0	0	0	0	0	1	1	0
None reported	0	2	0	4	2	9	2	3

Total number of sites represented: 73 (information on other contaminants not available for all 80 sites)

Notes:
*Some sites selected multiple cleanup options. Hence, this number is not simply the sum of values listed in this row.

BTEX – benzene, toluene, ethylbenzene, xylenes
CAMU – corrective action management unit
DDD – dichlorodiphenyldichloroethane
DDE – dichlorodiphenyldichloroethylene
DDT – dichlorodiphenyltrichloroethane
IC – institutional control
NPL – National Priorities List
OCP – organochlorine pesticide
PAHs – polynuclear aromatic hydrocarbons
PCBs – polychlorinated biphenyls
SVOCs – semivolatile organic compounds
TPH – total petroleum hydrocarbons
VOCs – volatile organic compounds

Table B-2 Technologies Applicable at Sites with OCPs in Soil

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
Ex Situ Technologies				
Isolation (Excavation & disposal, consolidation & capping)	Impacted soil is isolated beneath an engineered cap or within an engineered disposal unit (e.g., landfill, CAMU).	• Applicable to a wide variety of soils and immobile contaminants.	• Long-term maintenance. • Land-use restrictions. • May not be protective if groundwater is shallow.	
Incineration	High temperatures (870-1,200 °C) are used to combust (in the presence of oxygen) organic constituents in hazardous wastes.	• Able to treat high concentrations of organic compounds.	• Limited number of commercial incinerators. • Cost to transport soil to off-site incinerator. • High cost and energy usage. • Feed size and materials handling issues can impact applicability or cost. • Off gases and combustion residuals generally require treatment. • May not meet destruction/ removal efficiency requirements.	2
Gas Phase Chemical Reduction (GPCR)	Hydrogen reacts with chlorinated organic compounds at high temperatures (≥850°C) and low pressure. By-products include methane, hydrogen chloride, and small amounts of low molecular weight hydrocarbons (e.g., benzene).	• Capable of treating high concentrations of DDT and hexachlorobenzene.	• High power requirements. • Requires pre-treatment by thermal desorption. • Solid residues require disposal. • Used liquor requires treatment and disposal. • Some uncertainty as to whether emissions contain dioxins/furans.	1, 3
Pyrolysis	Induces chemical decomposition of organic materials via heat in absence of oxygen. Operates under pressure at temperature of 430°C (800°F). Organic materials transformed into gases, small quantities of liquid and solid residue.	• Can be used to treat pesticides.	• Requires drying of the soil prior to treatment to achieve low soil moisture content (<1%). • Specific feed size and materials handling requirements that impact applicability or cost at specific sites. • High moisture content increases treatment costs.	2, 3

Table B-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
Ex Situ Technologies (Continued)				
Mechanochemical Dehalogenation (MCD™)	Mechanical energy (ball mill) is used to promote reductive dehalogenation of OCPs. Contaminants react with a base metal and hydrogen donor to generate reduced organics and metal salts. Produces nonhazardous by-products. Multistep process involving excavation, soil drying (<2% moisture), treatment of gaseous emissions, soil screening, and the MCD™ process.	• Able to treat high concentrations of aldrin, dieldrin, DDT/DDD/DDE, lindane. • Soils with low clay content. • Amenable to small-scale applications.	• Limited experience and vendors. • Experience to-date suggests that soil composition (especially clays) affects process performance. • Capture and treatment of residuals (volatilized contaminants captured, dust, and other condensates) may be difficult, especially when the soil contains high levels of fines and moisture. • Multi-step process.	1, 2, 3
Anaerobic Bioremediation	Promotes degradation of toxaphene in soil by native anaerobic organisms through biostimulation with biological amendments (e.g., blood meal, phosphates). Homogenized soil is transferred to a lined cell and covered with water and a plastic sheet to promote anaerobic conditions.	• Relatively low toxaphene concentrations. • Soil texture appropriate for incorporating amendments. • Presence of active toxaphene-degrading bacteria.	• Requires bench-scale test to determine applicability and to estimate treatment duration. • Space requirements for treatment cells. • May require odor mitigation. • Treatment time can range from five weeks to two years. • Not appropriate for extremely cold climates. • Does not achieve more than 90 percent contaminant reduction. Leaves residual concentrations of toxaphene and camphenes. • Debris potentially contaminated with toxaphene will require testing to determine appropriate disposal.	1, 3

Table B-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
Ex Situ Technologies (Continued)				
Xenorem™	Uses an enhanced composting technology consisting of organic amendments and aerobic and anaerobic treatment cycles. Complex, multi-step process involving soil excavation, screening, mixing, and amendment followed by cyclical amendment and mixing.	• Relatively low concentrations of chlordane, DDT, dieldrin, and toxaphene.	• Requires bench-scale studies to determine length of anaerobic phase. • Limited experience with method. • In one application, unable to meet cleanup standards for OCPs after a year of treatment. • Organic amendment applications last about 14 weeks. • Amendments can increase final soil volume by up to 40%.	1, 3
In Situ or Ex Situ Technologies				
GeoMelt™	Uses heat to destroy persistent organic compounds or permanently immobilize them into a vitrified end product. Typically requires excavation, pretreatment, mixing, feeding, melting, and vitrification. Commercially available as both fixed and transportable units.	• Low to high concentrations of dieldrin, chlordane, heptachlor, DDT, and hexachlorobenzene. • Relatively low moisture content soils.	• High power usage. • By-products include solid residues, scrubbing liquors, carbon filters, and gas emissions. • Vitrified waste-filled refractory container disposed at an appropriate landfill.	1, 3
DARAMEND®	Three-step bioremediation technology that promotes degradation of toxaphene and DDT through amendment-enhanced treatment and sequential anoxic and oxic conditions. Reagents include DARAMEND® organic amendment, zero valent iron, and water. Uses land farming practices in two-foot treatment layer. On-going maintenance and number of treatment cycles will vary by site and soil type.	• Relatively low concentrations of DDT and toxaphene. • Soil texture appropriate for incorporating amendments and periodic tilling.	• Typically requires bench-scale or pilot-scale studies • May be technically or economically infeasible at high contaminant concentrations. • For ex situ applications, space requirements for treatment cells. • May require screening to remove debris from soil. • Management of soil moisture content to facilitate biological activity while minimizing leachate production. • High humic content may slow down cleanup via increased organic adsorption and oxygen demand.	1, 3

Table B-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
In Situ Technologies				
Bioremediation	Nutrients and proprietary soil amendments are used to stimulate existing or added bacteria in the soil to metabolize OCPs into salt, carbon dioxide and water. On-going maintenance and number of treatment cycles will vary by site and soil type.	• Applicable to most soils and low to moderate concentrations of some OCPs. • Soil texture appropriate for incorporating amendments and periodic tilling. • Presence of appropriate indigenous bacteria.	• Similar to DARAMEND® • Cool temperatures may inhibit biodegradation rates.	4
Chemical Oxidation	Oxidants are used to chemically convert OCPs to non-hazardous or less toxic. Rate and extent of OCP degradation are dictated by its chemical properties and susceptibility to oxidative degradation. Matching the oxidant and *in situ* delivery system to contaminants and site conditions is key to successful implementation and achieving performance goals.	• Potentially capable of achieving high treatment efficiencies. • More commonly applied to groundwater contamination.	• OCPs are considered reluctant to recalcitrant compounds for treatment via chemical oxidation. • Intermediate reaction products for OCPs not fully understood. • Health and safety concerns with handling strong oxidants, generation of off-gas, heat, dust, and creating flammable conditions. • May not be cost effective if large oxidant quantities are required. • Mobilization of contaminants and oxidation byproducts to groundwater may be a concern for some sites. • Oxidant delivery problems due to reactive transport and soil heterogeneity. • Short persistence of some oxidants due to fast reaction rates. • Natural oxidant demand may be high for some soils (e.g., high organic matter content, high reduced minerals, carbonates, free radical scavengers).	5, 6

Table B-2 (Continued)

TECHNOLOGY	DESCRIPTION	APPLICABILITY	LIMITATIONS / CONSTRAINTS	REF.
In Situ Technologies				
Isolation by Capping	Impacted soils are isolated by placement of a low permeability barrier to surface water infiltration.	• Applicable to most soils and OCPs. • Frequently used to address impacted soils in industrial areas.	• Long-term maintenance. • Land-use restrictions. • May not be protective if groundwater is shallow.	

Notes:
CAMU corrective action management unit
DDD dichlorodiphenyldichloroethane
DDE dichlorodiphenyldichloroethylene
DDT dichlorodiphenyltrichloroethane
OCP organochlorine pesticide

REFERENCES

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Table B-3 Evaluation of Technologies Applicable to Sites With OCPs in Soil Against NCP Analysis Criteria

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARS	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST[1]
Institutional Controls	**Manages potential exposure by restricting access and future land use.**	May not comply with ARARs.	Uncertain because does not remove contamination.	Not a treatment alternative.	Does not create risks during implementation.	Easily implemented.	Typically the lowest cost alternative.
Excavation and Off-site Disposal	Protectiveness achieved by OCP removal from site.	Requires compliance with applicable state and federal transportation and disposal requirements.	High long-term effectiveness for site. Protectiveness at disposal site dependent on off-site management choices.	Disposal reduces mobility. Reduction in toxicity and volume depends on off-site management choices.	Requires standard precautions necessary for protection of human health and environment during excavation, transport, and disposal. Requires dust control.	Easy to implement if facility available with adequate capacity for waste type is located within a reasonable distance from site. Uses standard construction equipment and labor.	Usually reasonable for small to medium volumes of soil. May be **cost** prohibitive for large volumes.
Containment by Capping	Protectiveness is achieved by barriers that prevent dermal contact and/or ingestion. Protectiveness of groundwater depends on depth to water, OCP mobility, cap design.	Requires compliance with applicable state and federal waste disposal requirements. **On-site containment requires institutional controls.**	Long-term protection ensured through continued cap maintenance and institutional controls. Long term effectiveness for ecological/ human health risks and groundwater are contingent on cap design.	Not a treatment alternative. However, some OCPs may degrade over time without specific treatment.	Requires standard precautions for protection of human health and environment. Requires dust control if soil is excavated and consolidate beneath cap.	Commercially available. Demonstrated technology. Necessary materials easily attainable. Uses standard construction equipment and labor. Technically and administratively feasible.	May be **cost** prohibitive though generally less expensive than most forms of treatment.
Vitrification ▪ GeoMelt™	Protectiveness achieved by destroying OCPs or by immobilizing OCPs in a solid block of glass-like material.	Treatment may require location- or action-specific ARARs. Generation of off-gas may trigger chemical-specific ARARs.	Limited data on long-term effectiveness of immobilized OCPs. High long-term effectiveness if able to destroy OCP.	Reduces toxicity and mobility by destroying or immobilizing OCPs. Generally decreases volume.	Presents potential short-term risks from air release during excavation for ex situ treatments and on-site treatment units.	Requires **multiple treatment steps** and pilot testing. In situ methods still in demonstration phase. Limited commercial availability. Requires substantial energy source.	Typically higher **cost** than other cleanup alternatives.

Table B-3 (Continued)

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARS	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST[1]
Thermal Destruction or Treatment ▪ Incineration ▪ GPCR ▪ Pyrolysis	Protectiveness is achieved by inducing temperature and chemical conditions that destroy, transform, or decompose OCPs to less toxic byproducts.	Requires compliance with applicable state and federal requirements for waste excavation, transportation, treatment, storage, disposal and air quality.	Thermal treatments offer a long-term solution by destroying OCPs or transforming OCPs to less toxic byproducts.	Contaminant toxicity, volume and mobility is reduced through destruction, or transformation of OCPs to non-hazards by-products (gaseous, solid residues, liquors).	Potential short-term risks from air release during excavation for ex situ treatments and on-site treatment units. Potential short-term risks from handling and transporting waste for off-site treatments. Relatively short timeframe to achieve cleanup levels.	**May require treatability studies. Some treatments have commercially available treatment units for on-site use. Construction and/or permit requirements for onsite treatment units may be difficult. Limited off-site incineration capacity.**	Relatively higher cost than other types of treatment.
Mechanochemical Dehalogenation	Protectiveness is achieved by reductive dechlorination of OCPs using mechanical energy, a catalyst, and a hydrogen donor to produce non-hazardous by-products.	Requires compliance with applicable state and federal hazardous waste treatment, storage, and disposal requirements. Excavation, construction, and operation of on-site treatment units may require compliance with location-specific ARARs. Emission controls may be needed to ensure compliance with air quality standards.	Limited data on effectiveness of process.	Permanently transforms OCPs to less toxic by-products.	Presents potential short-term risks from air release during excavation for ex situ treatments and on-site treatment units. Relatively short timeframe to achieve cleanups.	Requires **multiple treatment steps** and bench scale testing. Limited commercial availability.	Typically higher **costs** than other cleanup alternatives.

Table B-3 (Continued)

TECHNOLOGY	NCP CRITERIA						
	OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT	COMPLIANCE WITH ARARS	LONG-TERM EFFECTIVENESS	REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT	SHORT-TERM EFFECTIVENESS	IMPLEMENTABILITY	COST[1]
Biological Treatment	Protectiveness is achieved by microbial transformation of OCPs to less toxic by-products under controlled or managed environmental conditions.	Requires compliance with applicable state and federal hazardous waste treatment, storage, and disposal requirements. Excavation, construction, and operation of on-site treatment units may require compliance with location-specific ARARs. Emission controls may be needed to ensure compliance with air quality standards.	Permanently destroys target OCPs. Reduces contaminant levels. Duration of treatment determines final contaminant levels. Reduces overall toxicity between pre- and post-treatment.	Reduces toxicity, mobility, and volume of soil contaminated with OCPs through treatment.	Manage fugitive dust emissions during soil excavation or landfarming activities. Requires measures for protection of human health during excavation, handling, and treatment. **Cleanup times** vary based on whether in situ or ex situ treatment is used and the ability to maintain optimal environmental conditions. Ex situ treatment times are faster. In situ treatment times vary with on ability to control environmental conditions conducive to OCP degradation.	Treatment techniques are established and require moderate effort to implement. Commercial additives and treatment units available. **Assess applicability through bench and treatability studies.** Ex situ methods may have multi-stage process and require treatment unit. In situ methods use landfarming techniques.	Costs vary based on applied technology and duration of treatment. In situ treatments generally cost less than ex situ treatments.
In Situ Chemical Oxidation	Protectiveness achieved by transforming OCPs to less toxic by-products and achieving target cleanup levels. Potential for mobilization to groundwater.	Requires compliance with applicable state and federal requirements for treatment process.	Permanently destroys OCPs, if successful. Uncertain effectiveness for some OCPs.	If successful, reduces toxicity, mobility, and volume of soil contaminated with OCPs. Uncertainty in type and persistence of reaction intermediates.	Requires precautions for protection of human health and environment during treatment process (e.g., reagent handling). Cleanup times vary based on oxidant effectiveness and control of environmental conditions that affect reaction.	Assess applicability through bench scale and treatability studies. May require permit for treatment process. Ability to achieve geochemical conditions needed for treatment.	Costs vary depending on volume and type of reactant needed.

Table B-3 (Continued)

Notes:

Bold indicates major reason(s) rejected during alternatives analysis for sites evaluated by DTSC study (see Table 3 of main text of this guidance).

ARAR – applicable or relevant and appropriate requirement
GPCR – gas phase chemical reduction
NCP – National Contingency Plan
OCP – organochlorine pesticide

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