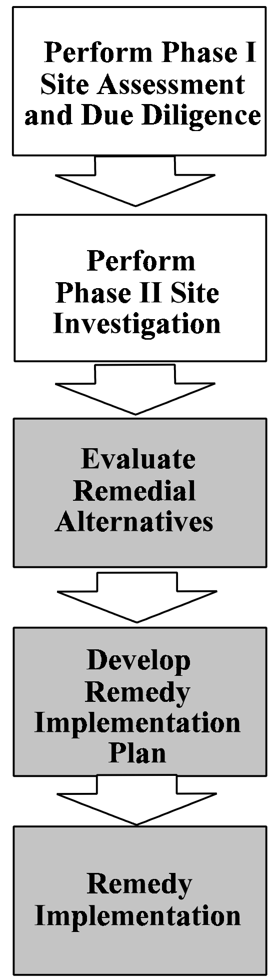
Chapter 5
Contaminant Management

Background

The purpose of this chapter is to help planners and decision-makers select an appropriate remedial alternative. This section contains information on developing a contaminant management plan and discusses various contaminant management options, from institutional controls and containment strategies, through cleanup technologies. Finally, this chapter provides an overview of post-construction issues that planners and decision-makers need to consider when selecting alternatives.



The principal factors that will influence the selection of a cleanup technology include:

- Types of contamination present;
- Cleanup and reuse goals;
- Length of time required to reach cleanup goals;
- Post-treatment care needed; and
- Budget.

The selection of appropriate remedy options often involves tradeoffs, particularly between time and cost. A companion document, *Cost Estimating Tools and Resources for Addressing Sites Under the Brownfields Initiative* (EPA/625/R-99/001 April 1999), provides information on cost factors and developing cost estimates. In general, the more intensive the cleanup approach, the more quickly the contamination will be mitigated and the more costly the effort. In the case of brownfields cleanup, both time and cost can be major concerns, considering the planner's desire to return the facility to reuse as quickly as possible. Thus, the planner may wish to explore a number of options and weigh carefully the costs and benefits of each.

Selection of remedial alternatives is also likely to involve the input of remediation professionals. The overview of technologies cited in this chapter provides the planner with a framework for seeking, interpreting, and evaluating professional input.

The intended use of the brownfields site will drive the level of cleanup needed to make the site safe for redevelopment and reuse. Brownfields sites are by definition not Superfund sites; that is, brownfields sites usually have lower levels of contamination present and, therefore, generally require less extensive cleanup efforts than Superfund sites. Nevertheless, all potential pathways of exposure, based on the intended reuse of the site, must be addressed in the site assessment and cleanup; if no pathways of exposure exist, less cleanup (or possibly none) may be required.

Some regional EPA and state offices have developed corrective action levels (CALs) for different chemicals, which may serve as guidelines or legal requirements for cleanups. It is important to understand that screening levels (discussed in "Performing a Phase II Site Assessment" above) are different from cleanup (or corrective action) levels. Screening levels indicate whether further site investigation is warranted for a particular contaminant. CALs indicate whether cleanup action is needed and how extensive it needs to be. Planners should check with their state environmental office for guidance and/or requirements for CALs.

Evaluate Remedial Alternatives

If the site investigation shows that there is an unacceptable level of contamination, the problem will have to be remedied. Exhibit 5-1 shows a flow chart of the remedial alternative evaluation process.

Establishing Remedial Goals

The first step in evaluating remedial alternatives is to articulate the remedial goals. Remedial goals relate very specifically to the intended use of the redeveloped site. A property to be used for a plastics factory may not need to be cleaned up to the same level as a site that will be used a school. Future land use holds the key to practical brownfields redevelopment plans. Knowledge of federal, state, local or tribal requirements helps to ensure realistic assumptions. Community surroundings, as seen through a visual inspection will help provide a context for future land uses, though many large brownfields redevelopment projects have provided the catalyst to overall neighborhood refurbishment. Available funding and timeframe for the project are also very significant factors in defining remedial goals.

Developing a List of Options

Developing a list of remedial options may begin with a literature search of existing technologies, many of which are listed in Exhibit D-1 of this document. Analysis of technical information on technology applicability requires a professional remediation specialist. However, general information is provided below for the community planner/developer in order to support informed interaction with the remediation professional.

Remedial alternatives fall under three categories, institutional controls, containment technologies, and cleanup technologies. In many cases, the final remedial strategy will involve aspects of all three approaches.

Institutional Controls

Institutional controls are mechanisms that help control the current and future use of, and access to, a site. They are established, in the case of brownfields, to protect people from possible contamination. Institutional controls can range from a security fence prohibiting access to certain portions of the site to deed restrictions imposed on the future use of the facility. If the overall management approach does not include the complete cleanup of the facility (i.e., the complete removal or destruction of onsite contamination), a deed restriction will likely be required that clearly states that hazardous waste is being left in place within the site boundaries. Many state brownfields programs include institutional controls.

Containment Technologies

The purpose of containment is to reduce the potential for offsite migration of contaminants and possible subsequent exposure to people and the environment. Containment technologies include engineered barriers such as caps and liners for landfills, slurry walls, and hydraulic containment.

Evaluate Remedial Alternatives

Compile and Assess Possible Remedial Alternatives for the Brownfields Site

Establish Remedial Goals

Determine an appropriate and feasible remedy level and compile preliminary list of potential contaminant management strategies, based on:

- Federal, state, local, or tribal requirements
- Community surroundings
- Available funding
- Timeframe

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Develop List of Options

Compile list of potential remedial alternatives by:

- Conducting literature search of existing technologies
- Analyzing technical information on technology applicability

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Initial Screening of Options

Narrow the list of potential remedial alternatives by:

- Networking with other brownfields stakeholders
- Identifying the data needed to support evaluation of options
- Evaluating the options by assessing toxicity levels, exposure pathways, risk, future land use, and financial considerations
- Analyzing the applicability of an option to the contamination.

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Select Best Remedial Option

Select appropriate remedial option by:

- Integrating management alternatives with reuse alternatives to identify potential constraints on reuse, considering time schedules, cost, and risk factors
- Balancing risk minimization with redevelopment goals, future uses, and community needs
- Communicating information about the proposed option to brownfields stakeholders

Exhibit 5-1. Flow Chart of the Remedial Alternative Evaluation Process

Often, soils contaminated with metals can be solidified by mixing them with cement-like materials, and the resulting stabilized material can be stored on site in a landfill. Like institutional controls, containment technologies do not remove

the contamination, but rather mitigate potential risk by limiting access to it.

For example, if contamination is found underneath the floor slab at a facility, leaving the contaminated materials in place and repairing any damage to the floor slab may be justified. The likelihood that such an approach will be acceptable to regulators depends on whether potential risk can be mitigated and managed effectively over the long term. In determining whether containment is feasible, planners should consider:

- *Depth to groundwater*. Planners should be prepared to prove to regulators that groundwater levels will not rise and contact contaminated soils.
- *Soil types*. If contaminants are left in place, native soils will be an important consideration. Sandy or gravelly soils are highly porous, which enable contaminants to migrate easily. Clay and fine silty soils provide a much better barrier.
- *Surface water control*. Planners should be prepared to prove to regulators that stormwater cannot infiltrate the floor slab and flush the contaminants downward.
- *Volatilization of organic contaminants*. Regulators are likely to require that air monitors be placed inside the building to monitor the level of organics that may be escaping upward through the floor and drains.

Cleanup Technologies

Cleanup technologies may be required to remove or destroy onsite contamination if regulators are unwilling to accept the levels of contamination present or if the types of contamination are not conducive to the use of institutional controls or containment technologies. Cleanup technologies fall broadly into two categories--ex situ and in situ, as described below.

- *Ex Situ*. An ex situ technology treats contaminated materials after they have been removed and transported to another location. After treatment, if the remaining materials, or residuals, meet cleanup goals, they can be returned to the site. If the residuals do not yet meet cleanup goals, they can be subjected to further treatment, contained on site, or moved to another location for storage or further treatment. A cost-effective approach to cleaning up a brownfields site may be the partial treatment of contaminated soils or groundwater, followed by containment, storage, or further treatment off site.

- *In Situ*. In situ technologies treat contamination in place and are often innovative technologies. Examples of in situ technologies include bioremediation, soil flushing, oxygen-releasing compounds, air sparging, and treatment walls. In some cases, in situ technologies are feasible, cost-effective choices for the types of contamination that are likely at brownfields sites. Planners, however, do need to be aware that cleanup with in situ technologies is likely to take longer than with ex situ technologies. Several innovative technologies are available to address soils and groundwater contaminated with organics, such as solvents and some PAHs, which are common problems at brownfields sites.

Maintenance requirements associated with in situ technologies depend on the technology used and vary widely in both effort and cost. For example, containment technologies such as caps and liners will require regular maintenance, such as maintaining the vegetative cover and performing periodic inspections to ensure the long-term integrity of the cover system. Groundwater treatment systems will require varying levels of post-cleanup care and verification testing. If an in situ system is in use at the site, it will require regular operations support and periodic maintenance to ensure that the system is operating as designed.

Table D-1 in Appendix D presents a comprehensive list of various cleanup technologies that may be appropriate, based on their capital and operating costs, for use at brownfields sites. In addition to more conventional technologies, a number of innovative technology options are listed.

Screening and Selection of Best Remedial Option

When screening management approaches at brownfields sites, planners and decision-makers should consider the following:

- Cleanup approaches can be formulated for specific contaminant types; however, different contaminant types are likely to be found together at brownfields sites, and some contaminants can interfere with certain cleanup techniques directed at other contaminant types.

- The large site areas typical of some brownfields can be a great asset during cleanup because they facilitate the use of land-based cleanup techniques such as landfilling, landfarming, solidification, and composting.

- Consolidating similar contaminant materials at one location and implementing a single, large-volume cleanup approach is often more effective than using several similar approaches in different areas of the site. At iron and steel sites for example, metals contamination from the blast furnace, the ironmaking area, and the finishing shops can be consolidated and cleaned up using solidification/stabilization techniques, with the residual placed in an appropriately designed landfill with an engineered cap. Planners should investigate the likelihood that such consolidation may require prior regulatory approval.

- Some mixed contamination may require multicomponent treatment trains for cleanup. A cost-effective solution might be to combine consolidation and treatment technologies with containment where appropriate. For example, soil washing techniques can be used to treat a mixed soil matrix contaminated with metals compounds (which may need further stabilization) and PAHs; the soil can then be placed in a landfill. Any remaining contaminated soils may be subjected to chemical dehalogenation to destroy the polycyclic aromatic hydrocarbon (PAH) contamination.

- Groundwater contamination may contain multiple constituents, including solvents, metals, and PAHs. If this is the case, no in situ technologies can address all contaminants; instead, groundwater must be extracted and treated. The treatment train is likely to be comprised of a chemical precipitation unit to remove the metals compounds and an air stripper to remove the organic contaminants.

Selection of the best remedial option results from integrating management alternatives with reuse alternatives to identify potential constraints on reuse. Time schedules, cost, and risk factors must be considered. Risk minimization is balanced against redevelopment goals, future uses, and community needs. The process of weighing alternatives rarely results in a plan without compromises in one or several directions.

Develop Remedy Implementation Plan

The remedy implementation plan, as developed by a professional environmental engineer, describes the approach that will be used to contain and clean up contamination. In developing this plan, planners and decision-makers should incorporate stakeholder concerns and consider a range of possible options, with the intent of identifying the most cost-effective approaches for cleaning up the site, considering time and cost concerns. The remedy implementation plan should include the following elements:

- A clear delineation of environmental concerns at the site. Areas should be discussed separately if the management approach for one area is different than that for other areas of the site. Clear documentation of existing conditions at the site and a summarized assessment of the nature and scope of contamination should be included.
- A recommended management approach for each environmental concern that takes into account expected land reuse plans and the adequacy of the technology selected.
- A cost estimate that reflects both expected capital and operating/maintenance costs.
- Post-construction maintenance requirements for the recommended approach.
- A discussion of the assumptions made to support the recommended management approach, as well as the limitations of the approach.

Planners and decision-makers can use the framework developed during the initial site evaluation (see the section on "Site Assessment") and the controls and technologies described below to compare the effectiveness of the least costly approaches for meeting the required management goals established in the Data Quality Objectives. These goals should be established at levels that are consistent with the expected reuse plans. Exhibit 5-2 shows the remedy implementation plan development process.

A remedy implementation plan should involve stakeholders in the community in the development of the plan. Some examples of various stakeholders are:

- Industry;
- City, county, state and federal governments;
- Community groups, residents and leaders;
- Developers and other private businesses;
- Banks and lenders;
- Environmental groups;
- Educational institutes;
- Community development organizations;
- Environmental justice advocates;
- Communities of color and low-income; and
- Environmental regulatory agencies.

Community-based organizations represent a wide range of issues, from environmental concerns to housing issues to economic development. These groups can often be helpful in educating planners and decision-makers in the community about local brownfields sites, which can contribute to successful brownfields site assessment and cleanup activities. In addition, state voluntary cleanup programs require that local communities be adequately informed about brownfields cleanup activities. Planners can contact the local Chamber of Commerce, local philanthropic organizations, local service organizations, and neighborhood committees for community input. Representatives from EPA regional offices and state and local environmental groups may be able to supply relevant information and identify other appropriate community organizations. Involving the local community in brownfields projects is a key component in the success of such projects.

Remedy Implementation

Many of the management technologies that leave contamination onsite, either in containment systems or because of the long periods required to reach management goals, will require long-term maintenance and possibly operation. If waste is left onsite, regulators will likely require long-term monitoring of applicable media (e.g., soil, water, and/or air) to ensure that the management approach selected is continuing to function as planned (e.g., residual contamination, if any, remains at acceptable levels and is not migrating). If long-term monitoring is required (e.g., by the state) periodic sampling, analysis, and reporting requirements will also be involved. Planners and decision-makers should be aware of these requirements and provide for them in cleanup budgets. Post-construction sampling, analysis, and reporting costs can be substantial and therefore need to be addressed in cleanup budgets.

Develop Remedy Implementation Plan

Coordinate with Stakeholders to Design a Remedy Implementation Plan

Review Records

Ensure compliance with applicable Federal, state, and tribal regulatory guidelines by:

- Consulting with appropriate state, local, and tribal regulatory agencies and including them in the decisionmaking process as early as possible
- Contacting the EPA regional Brownfields coordinator to identify and determine the availability of EPA support Programs
- Identifying all environmental requirements that must be met

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Develop Plan

Develop plan incorporating the selected remedial alternative. Include the following considerations:

- Schedule for completion of project
- Available funds
- Developers, financiers, construction firms, and local community concerns
- Procedures for community participation, such as community advisory boards
- Contingency plans for possible discovery of additional contaminants
- Implementation of selected management option

Exhibit 5-2. Flow Chart of the Remedy Implementation Plan Development Process

Exhibit 5-3. Cleanup Technologies for Pulp and Paper Brownfields Sites

Applicable Technology	Technology Description	Examples of Applicable Process Areas	Contaminants Treated by This Technology
Containment Technologies			
Capping	Relatively impermeable material used to cover buried waste materials to minimize rainfall infiltration and resultant contaminant migration.	De-inking, digestion of recycle paper	Metals.
Sheet Piling	Steel or iron sheets are driven into the ground to form a subsurface barrier. Used primarily for shallow aquifers.		Not contaminant -specific.
Grout Curtain	Grout curtains are injected into subsurface soils and bedrock. forming an impermeable barrier.		Not contaminant -specific.
Slurry Walls	Vertically excavated trench filled with a slurry of bentonite, soil, and water to contain or divert contaminated groundwater and landfill leachate.		Not contaminant -specific.
Ex Situ Technologies			
Excavation/ Offsite Disposal	Removes contaminated material to an EPA approved landfill.	Maintenance and process areas, USTs.	Not contaminant-specific.
Composting	Controlled microbiological process that converts biodegradable hazardous materials in soils to innocuous, stabilized byproducts.	Maintenance.	SVOCs, VOCs.
Chemical Oxidation/ Reduction	Reduction/oxidation (Redox) reactions chemically convert hazardous contaminants to nonhazardous or less toxic compounds that are more stable, less mobile, or inert. Common oxidizing agents are ozone, hydrogen peroxide, hypochlorite, chlorine, and chlorine dioxide.	Metals.	

Exhibit 5-3. Continued

Applicable Technology	Technology Description	Examples of Applicable Process Areas	Contaminants Treated by This Technology
Soil Washing	A water-based process for scrubbing excavated soils to remove contaminants. Removes contaminants by dissolving or suspending them in the wash solution, or by concentrating them into a smaller volume of soil through particle size separation, gravity separation, and attrition scrubbing.	Wastes from maintenance	SVOCs. Metals.
Thermal Desorption	Low temperatures (200°F to 900°F) used to remove organic contaminants from soils and sludges. Off gases are collected and treated. Can be performed on site or off site.	Power generation and maintenance operations, UST.	VOCs. PCBs. PAHs.
Incineration	High temperatures (1400°F to to 2,200ºF) are used to volatilize and combust hazardous wastes.	Maintenance operations, USTs, and bleaching.	VOCs, PCBs, dioxins.
UV Oxidation	Destruction process that oxidizes constituents in water using strong oxidizers and irradiation with UV light.	Maintenance operations, USTs.	VOCs.
Pyrolysis	A thermal treatment technology that induces chemical decomposition of organic materials in the absence of oxygen. Collected vapors, small amounts of liquid, and a solid residue result.		
Precipitation	Conversion of soluble heavy metal salts to insoluble salts that precipitate. Often used as a pretreatment for other treatment technologies where the presence of metals would interfere with the treatment processes.	Wastes from recycling and de-inking operations.	Metals.
Liquid Phase	Groundwater is pumped through a series of vessels containing		Low levels of Carbon metals, VOCs

Exhibit 5-3. Continued

Applicable Technology	Technology Description	Examples of Applicable Process Areas	Contaminants Treated by This Technology
Adsorption	activated carbon, to which dissolved contaminants adsorb.		SVOCs.
Air Stripping	Contaminants are partitioned from groundwater by greatly increasing the surface area of the contaminated water exposed to air.	Maintenance operations, USTs.	VOCs.
In Situ Technologies			
Natural	Natural subsurface processes such as dilution, volatilization, biodegradation, adsorption, and chemical reactions with subsurface media can reduce contaminant concentrations to acceptable levels.	Maintenance	VOCs. Attenuation
Soil Vapor Extraction	A vacuum is applied to the soil to induce controlled air flow and remove contaminants from the unsaturated (vadose) zone of the soil. The gas leaving the soil may be treated to recover or destroy the contaminants.	Maintenance	VOCs.
Soil Flushing	Extraction of contaminants from the soil with water or other aqueous solutions. Accomplished by passing the extraction fluid through in-place soils using injection or infiltration processes. Extraction fluids must be recovered with extraction wells from the underlying aquifer and recycled when possible.		Metals.
Solidification/	Reduces the mobility of hazardous substances and contaminants through chemical and physical means.		Metals. Stabilization
Air Sparging	In situ technology in which air is injected under pressure below the water table to increase groundwater oxygen concentrations and enhance natural biological degradation.	Maintenance UST,	VOCs.

(Continued)

Exhibit 5-3. Continued

Applicable Technology	Technology Description	Examples of Applicable Process Areas	Contaminants Treated by This Technology
Passive Treatment Walls	A permeable reaction wall is installed inground, across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall.	Appropriately selected location for wall.	Metals. VOCs .
Chemical Oxidation	Destruction process that oxidizes constituents in groundwater by the addition of strong oxidizers.	Maintenance operations, UST, acid pickling, cokemaking, casting, finishing operations.	VOCs.
Bioventing	Stimulates the natural in-situ biodegradation of volatile organics in soil by providing oxygen to existing soil	Maintenance operations, UST, acid pickling, cokemaking, casting, finishing operations.	VOCs. microorganisms.
Biodegradation	Indigenous or introduced microorganisms degrade organic contaminants found in soil and groundwater.	Maintenance operations, UST, acid pickling, cokemaking, casting,	VOCs