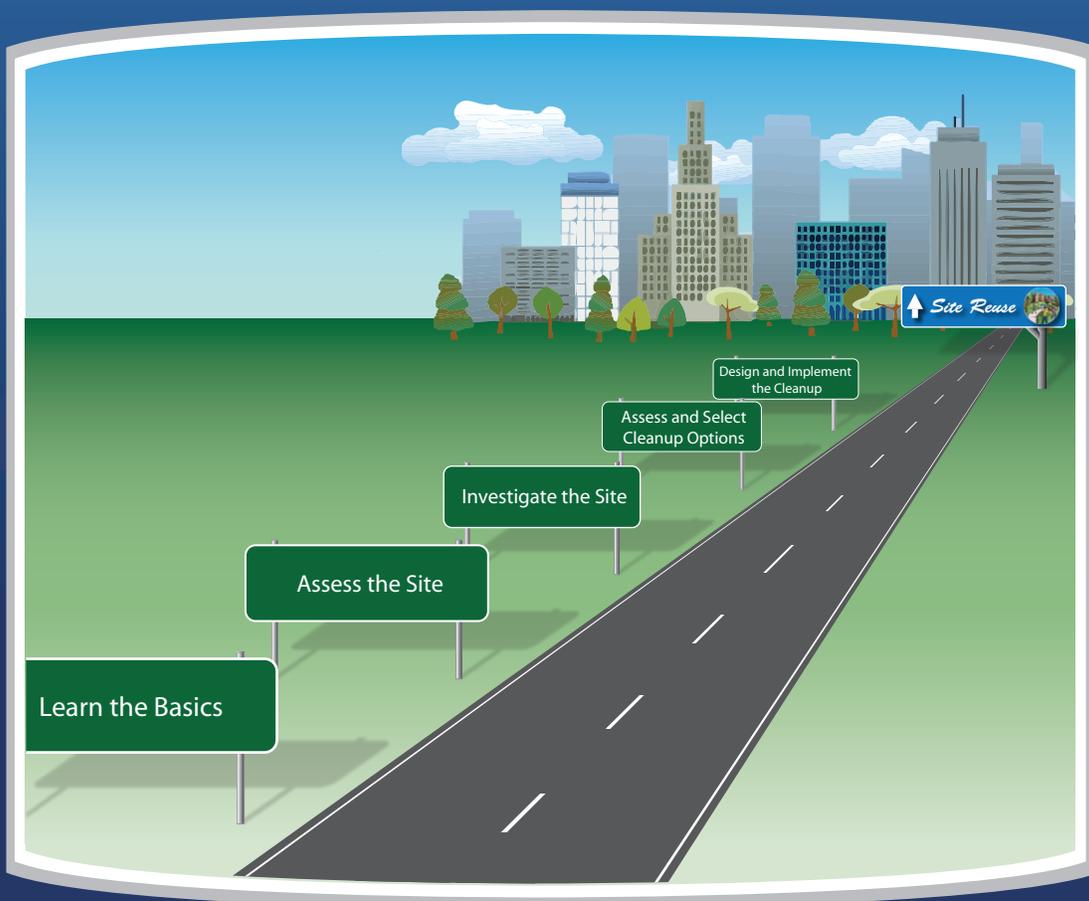
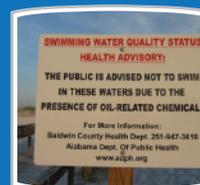
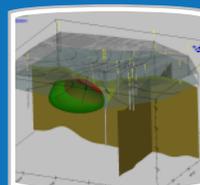
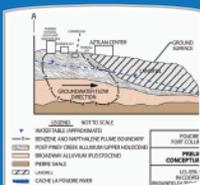
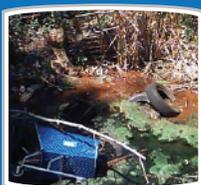


# Brownfields Road Map to Understanding Options for Site Investigation and Cleanup

## Fifth Edition



[www.brownfieldstsc.org/roadmap](http://www.brownfieldstsc.org/roadmap)





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## NOTICE

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This document can be downloaded from the EPA's Brownfields and Land Revitalization Technology Support Center at [www.brownfieldstsc.org/roadmap](http://www.brownfieldstsc.org/roadmap).

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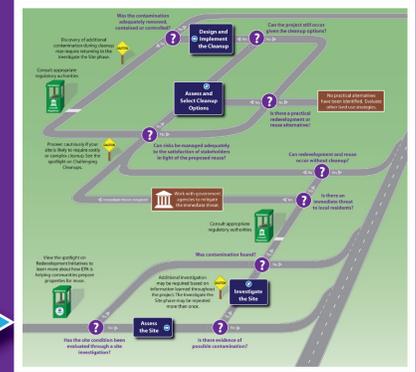
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C Acronyms and Glossary of Key Terms

# Introduction

Helping stakeholders understand options for site investigation and cleanup

## The Brownfields Road Map



The fifth edition features these updates:

- Details to assist stakeholders with planning their brownfields project
- Revised “road map” graphic
- General planning assistance for each phase of site investigation and cleanup
- “Spotlights” on 10 current issues and best management practices (BMPs)
- Online, searchable access to more than 300 technical resources and tools
- Online guide to contaminants and technologies typically associated with brownfields sites
- Expanded glossary of key terms and concepts

The *Brownfields Road Map to Understanding Options for Site Investigation and Cleanup, Fifth Edition*, provides a general outline of the steps in the investigation and cleanup of brownfields sites and introduces brownfields stakeholders to the range of technologies and resources available to them. The Road Map provides valuable information for stakeholders typically involved in or affected by redevelopment of brownfields sites, whether through public projects, private development or public-private partnerships.

The first edition of the Road Map, published in 1997, provided a broad overview of the EPA’s Brownfields Program and an outline of the steps involved in the cleanup of a brownfields site. Designed primarily for stakeholders who were unfamiliar with the elements of cleaning up a brownfields site, the Road Map built awareness of the advantages offered by innovative technologies. As the EPA’s Brownfields Program matured, the second (1999) and third (2001) editions were published to update information and resources associated with the program and innovative technologies. The fourth edition, published in 2005, provided additional resources and supplemental information about emerging best practices, processes and initiatives that influence the consideration and use of innovative technologies.

This edition incorporates a new approach to the Road Map through a streamlined publication and a companion website of technical resources and tools. Stakeholders can use the printed publication to learn about the general phases of the site investigation and cleanup process and gain an understanding of the considerations associated with typical brownfields sites. The Road Map website complements the publication by providing direct access to technical resources and tools that provide details about technology applications, methods and other site-specific concerns.



View the full contents of the Brownfields Road Map online at [www.brownfieldstsc.org/roadmap](http://www.brownfieldstsc.org/roadmap).

This edition of the Road Map will help:

- ***New and less experienced stakeholders.*** The Road Map will help these users learn about the EPA's Brownfields Program by introducing general concepts and methods for site investigation and cleanup.
- ***Decision-makers who are familiar with the Brownfields Program but are also interested in obtaining more detailed information.*** The Road Map provides these users with up-to-date information about the applicability of technologies and access to the latest resources that can assist them in making technology decisions. In addition, BMPs that have emerged in recent years are highlighted.
- ***Community members.*** The Road Map helps to encourage community members to participate in the decision-making process by providing information about the general site cleanup process, as well as guidelines and mechanisms to promote community involvement.
- ***Stakeholders who hire or oversee site cleanup professionals.*** The Road Map includes information to help stakeholders coordinate with many different cleanup practitioners, such as environmental professionals, cleanup contractors, technology vendors or staff of analytical laboratories. The Road Map provides these stakeholders with a detailed understanding of each phase in a typical brownfields site cleanup and presents information about the roles that environmental practitioners play in the process.
- ***Regulators.*** The Road Map will increase the understanding by regulatory personnel of site characterization and cleanup technologies and approaches. The Road Map also serves as a resource that regulators can use to provide site owners, service providers and other stakeholders with useful information about the Brownfields Program.
- ***Other potential brownfields stakeholders.*** The Road Map helps other stakeholders, such as financial institutions and insurance agencies, by providing information for their use in assessing and minimizing risks associated with brownfields redevelopment.

## Disclaimer

The Road Map is not an official guidance document. Rather, it draws on the EPA's experiences with brownfields sites, as well as Superfund sites, corrective action sites under the Resource Conservation and Recovery Act (RCRA), and underground storage tank (UST) sites. Specific conditions—such as the nature and extent of contamination, the proposed reuses of the property, the financial resources available, and the level of

support from neighboring communities—vary from site to site. Readers of the Road Map are encouraged to explore opportunities to use the BMPs described in the following pages in accordance with applicable regulatory program requirements.

This document provides general information and guidance regarding facilitating reuse of properties. It does not address all information, factors or considerations that may be relevant. This document is not legally binding. The word “should” and other similar terms used in this document are intended as general recommendations or suggestions that might be generally applicable or appropriate and should not be taken as providing legal, technical, financial or other advice regarding a specific situation or set of circumstances. This document may be revised at any time without public notice. Any references to private entities, products or services are strictly for informational purposes and do not constitute an endorsement of that entity, product or service.

This document describes and summarizes statutory provisions, regulatory requirements and policies. The document is not a substitute for these provisions, regulations or policies, nor is it a regulation itself. In the event of a conflict between the discussion in this document and any statute, regulation or policy, this document would not be controlling and cannot be relied on to contradict or argue against any EPA position taken administratively or in court. It does not impose legally binding requirements on the EPA or the regulated community and might not apply to a particular situation based on the specific circumstances. This document does not modify or supersede any existing EPA guidance document or affect the Agency’s enforcement discretion in any way.

#### How to Submit Comments

The EPA invites comments from members of the brownfields community to help ensure that any future versions of the Road Map meet their needs. Please submit comments to:

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Office of Superfund Remediation and Technology  
Innovation  
[pachon.carlos@epa.gov](mailto:pachon.carlos@epa.gov)  
(703) 603-9904

#### How to Obtain Additional Copies

A printed or hard copy version of this document can be obtained from the following source:

National Service Center for Environmental  
Publications  
U.S. Environmental Protection Agency  
P.O. Box 42419  
Cincinnati, OH 45242-0419  
(800) 490-9198 or (513) 489-8190  
Fax: (513) 489-8695

When you order the Road Map, please refer to document number EPA 542-R-12-001.

## About the EPA's Brownfields Program

Brownfields sites are defined as "real property, the expansion, redevelopment or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant or contaminant" (Comprehensive Environmental Response, Compensation, and Liability Act of 1980, as amended, §101(39)). The cleanup of brownfields sites improves and protects the environment and may result in many benefits for the local community.

The EPA established its Brownfields Economic Revitalization Initiative in 1995 to empower states, communities and other stakeholders in economic revitalization to work together to accomplish the redevelopment of brownfields sites. With enactment of the Small Business Liability Relief and Brownfields Revitalization Act in 2002, EPA assistance was expanded to provide greater support for brownfields cleanup and reuse. Many states and local jurisdictions also help communities adapt environmental cleanup programs to the special needs of brownfields sites.

### Summary of Brownfields Program Accomplishments as of January 2012

Thousands of properties have been assessed and hundreds of cleanups have been completed with the support of grants from the EPA's Brownfields Program.

| Measure                    | Cumulative Results |
|----------------------------|--------------------|
| Properties Assessed        | 18,204             |
| Cleanups Completed         | 702                |
| Acres Made Ready for Reuse | 33,444             |

Source: [www.epa.gov/brownfields/overview/bf-monthly-report.html](http://www.epa.gov/brownfields/overview/bf-monthly-report.html)

## Small Business Liability Relief and Brownfields Revitalization Act

Since 1995, the EPA's Brownfields Program has changed the way contaminated property is perceived, addressed and managed. Enactment of the Small Business Liability Relief and Brownfields Revitalization Act (Public Law 107-118; H.R. 2869) in January 2002 expanded the EPA's assistance by providing tools that the public and private sectors could use to promote sustainable brownfields cleanup and reuse.

The law modified the EPA's existing brownfields grants and technical assistance program by:

- Increasing the funding authority up to \$200 million per year
- Providing grants for assessments, revolving loan funds, direct cleanups and job training
- Expanding the entities, properties and activities eligible for brownfields grants, including sites such as mine-scarred lands
- Expanding applicability to sites with petroleum contamination such as abandoned gasoline stations
- Providing authority for brownfields training, research and technical assistance
- Allowing local government entities up to 10 percent of the grant funds to be used to monitor the health of exposed populations and enforce any institutional controls

The law changed and clarified Superfund liability:

- Provided liability protection for certain small-volume waste contributors and contributors of municipal solid waste
- Clarified Superfund liability for prospective purchasers, innocent landowners and contiguous property owners

The law created a strong, balanced relationship between the federal government and state and tribal programs:

- Authorized up to \$50 million per year for building and enhancing state and tribal response programs and expanded the activities eligible for funding
- Provided protection from Superfund liability at sites cleaned up under a state program
- Preserved the federal safety net by detailing the circumstances in which the EPA can revisit a cleanup
- Clarified the state role in adding sites to the Superfund National Priorities List (NPL)

Additional information on the Brownfields Law is available at [www.epa.gov/brownfields/laws/](http://www.epa.gov/brownfields/laws/).



Understanding the typical progression of the site investigation and cleanup process ensures that the proper groundwork is laid for future phases.

Site investigation and cleanup typically do not occur in the linear sequence outlined in the Road Map. At many sites, several activities may be undertaken concurrently, while others recur throughout the process. Similarly, many technologies that are used to characterize sites during the investigation phase may also be used during the cleanup phase.

The fifth edition of the Road Map is composed of a publication and a companion website. The publication presents the general phases involved in the investigation and cleanup of a brownfields site and introduces the reader to a range of considerations and activities. The website connects readers to the content of the publication online and provides direct access to many technical resources and tools.

### Overview of the Road Map Publication

The publication follows the process illustrated in the Brownfields Road Map graphic (see page 7). The first section, *Learn the Basics*, discusses important factors that set the stage for the investigation and cleanup of brownfields sites. The reader is introduced to concepts, strategies and methods that can be applied to efficiently and effectively prepare sites for reuse. Regulatory guidelines for the process also are introduced, and technologies are discussed within the overall framework of selecting site characterization and cleanup technologies. The remaining sections correspond to the general phases of site characterization and cleanup, from site assessment through implementation of cleanup remedies.

**Spotlights** – The Road Map “spotlights” focus the reader’s attention on key issues, processes and initiatives. They provide a quick look at topics relevant to brownfields projects and identify how readers can obtain additional information. Technical resources and tools for each spotlight are available from the companion website.

**Online Appendices** – Three appendices are provided at the Road Map Website.

*Appendix A, Guide to Contaminants and Technologies*, is an online guide to contaminants found at more than 30 types of brownfields sites and the range of technologies that may be appropriate for their characterization and cleanup.

*Appendix B, Brownfields and Technical Support Contacts*, provides information about state, tribal and EPA regional and technical points of contact.

*Appendix C, Acronyms and Glossary of Key Terms*, defines acronyms and specialized terms used in discussing and describing brownfields cleanup efforts.

## Features of the Road Map Website

[www.brownfieldstsc.org/roadmap](http://www.brownfieldstsc.org/roadmap)

The companion website provides easy access to resources and tools. The website features:

- Technology resources organized by the general phases of the investigation and cleanup of brownfields sites
- Tools to help stakeholders find resources and publications with information that relates to their brownfields sites
- An interactive guide to contaminants and technologies
- A closer look at each of the spotlight topics, including links to related resources
- A list of acronyms and detailed glossary of terms
- Quick access to EPA, state and tribal brownfields and technical support contacts

### Guide to Contaminants and Technologies

Presents detailed information about contaminants found at brownfields sites and technologies used to investigate and treat them.

### Spotlights with Links to Additional Resources

Provides access to the spotlights presented in this publication and links to relevant resources. Resources can be previewed or downloaded from the companion website.

### Resources Grouped by Section and Searchable by Title

Enables users to find publications, resources and other online tools. Users can browse to find resources grouped by the sections of the Road Map or spotlight topic, or search by keyword.

The Brownfields Road Map illustrates the general steps involved in the investigation and cleanup of a brownfields site.

Actual steps may vary depending on site conditions and applicable state and federal regulations. Stakeholders should consult with appropriate regulatory agencies throughout the process and enlist qualified technical and legal services.

View an interactive, online map at [www.brownfieldstsc.org/roadmap](http://www.brownfieldstsc.org/roadmap) that contains links to information about the general phases and spotlight topics.

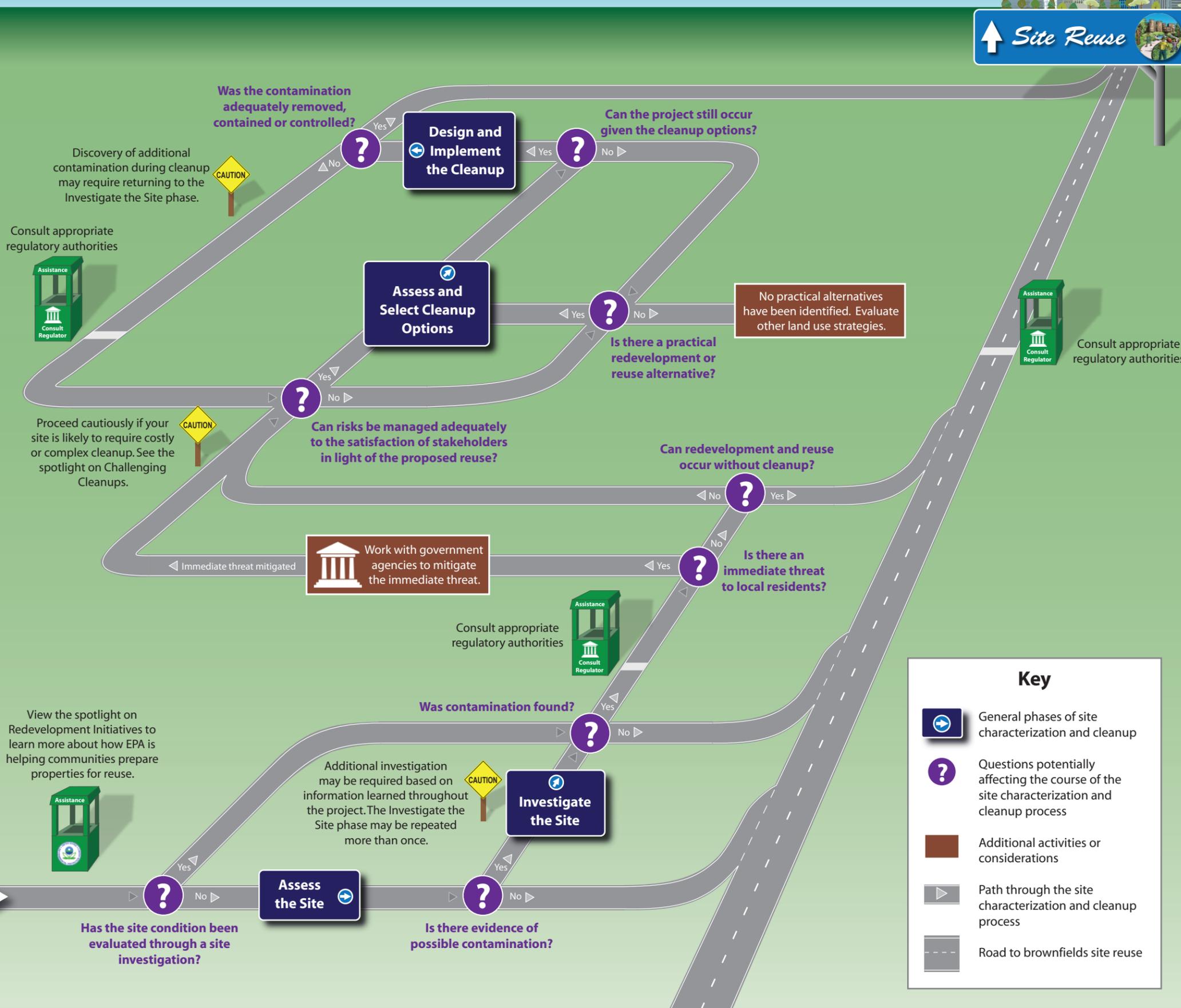
### Learn the Basics

Before you begin down the path outlined in the road map, it is important to get prepared. Preparation typically consists of the following activities:

- Setting reuse goals and planning
- Understanding regulations, regulatory guidelines and liability concerns
- Engaging the community
- Identifying funding
- Seeking professional support

**Begin Here**

# Brownfields Road Map



### Spotlights

The Road Map "spotlights" highlight key issues, processes and initiatives. Each spotlight provides a summary of topics relevant to brownfields projects and identifies related resources. The following spotlights are included in the Road Map:

#### Learn the Basics

1. Redevelopment Initiatives (p. 15)
2. Supporting Tribal Revitalization (p. 16)



#### Assess the Site

3. All Appropriate Inquiries (p. 18)
4. Project Life Cycle Conceptual Site Model (p. 22)



#### Investigate the Site

5. Data Quality (p. 25)
6. High-Resolution Site Characterization and In Situ Technologies (p. 29)
7. Vapor Intrusion (p. 30)



#### Assess and Select Cleanup Options

8. Challenging Cleanups (p. 35)
9. Understanding the Role of Institutional Controls (p. 36)



#### Design and Implement the Cleanup

10. Greener Cleanups (p. 40)





# Learn the Basics

- Setting reuse goals and planning
- Understanding regulations, regulatory guidelines and liability concerns
- Engaging the community
- Identifying funding
- Seeking professional support



Redevelopment Initiatives



Supporting Tribal Revitalization

**Begin Your Trip Here**

Begin here to learn about factors and considerations that affect cleanup at a brownfields site. These “basics” are integral to the cleanup process and the overall success of the brownfields project.

General concepts and terms related to the investigation and cleanup of brownfields sites are introduced here and reinforced throughout the publication.

## Brownfields Stakeholders

A stakeholder is typically considered an individual who is part of the decision-making process or can influence decisions. Stakeholders for brownfields projects may include:

- Federal, state and local agencies
- Local elected officials
- Local and regional community development agencies
- Developers
- Community members
- Tribes
- Property owners
- Academia
- Potentially responsible parties (PRP)
- Private industry
- Non-profit organizations

Brownfields projects may be initiated for a number of reasons. A landowner may want to sell a property to a prospective purchaser for development. A municipality may want to clean up a parcel or area that has become a public hazard or eyesore, create space for business development or build a park. A local comprehensive plan may call for infill development of a certain type in a brownfields area. In these cases, the brownfields process will be tailored to the specific end use envisioned for the property.

Preparing a brownfields site for reuse involves more than the investigation and cleanup of a property. The interests of many stakeholders must be integrated into the overall redevelopment process. Cleanup strategies vary from site to site, depending on factors such as intended end use, available funding, liability considerations, regulatory requirements, the type and extent of contamination present, and the technologies available for cleanup. At some sites, cleanup will be completed before the properties are transferred to new owners. At other sites, cleanup may take place simultaneously with construction and redevelopment.

Regardless of when and how cleanups are accomplished, a key challenge to brownfields projects is to clean up sites in accordance with reuse goals and appropriate laws and regulations. It is essential that stakeholders become familiar with factors that play a significant role in the success of a brownfields project, such as understanding applicable regulations, engaging members of the community, identifying funding and obtaining professional support.

## Setting Reuse Goals and Planning

From the outset, it is important to consider potential reuse goals. A reuse plan based on those goals (or lack thereof) will govern most brownfields projects, from identifying site investigation and cleanup standards, to obtaining competitive financing potentially critical to the ultimate affordability or profitability of the project. Keep in mind, however, that new information about contamination or cleanup needs may

require that reuse plans be altered. Be prepared to develop a flexible project plan that will evolve as information is collected, community input is received and decisions are made about the cleanup approach.

Establishing reuse goals for a brownfields project also helps the project team to define the decisions to be made throughout the project, which is fundamental to selecting appropriate technologies for site investigation and cleanup. When carefully selected, technologies enable those responsible for the brownfields project to collect the data necessary to support those decisions and accomplish the established goals.

If reuse goals are not known at the beginning of the project, the stakeholders should at a minimum make every attempt to identify the general type of desired development, whether industrial, commercial, residential or mixed-use. Absent that information, the most conservative assumptions should be applied at every stage of the brownfields project, a circumstance that could significantly increase the time and expense of the project, potentially up to the point of making the project infeasible.

## Understanding Regulations, Regulatory Guidelines and Liability Concerns

The redevelopment of brownfields sites may be subject to a variety of federal, state and local laws, regulations, policies and guidelines with respect to the characterization and cleanup of the site. These sites also may be governed by the standard practices of other government, nongovernment and private institutions.

The applicable laws, regulations, policies and guidelines will vary by site, depending on the regulatory authorities that have oversight authority for cleanup. Therefore, it is important to research this information at the outset and to work closely with the regulatory authorities throughout the cleanup process. For example, state or local regulatory authorities may oversee the cleanup of brownfields sites. These agencies should be consulted to determine what, if any, site-specific requirements, reviews, approvals or permits are applicable.

At the EPA, the Office of Site Remediation Enforcement (OSRE) supports cleanup and revitalization by issuing enforcement discretion guidance documents, model enforcement documents, responses to frequently asked questions, fact sheets and other documents. OSRE works with the EPA regional offices to provide guidance on relevant enforcement tools to potential

### State and Tribal Response Programs

Many states have established formal agreements with the EPA to facilitate assessment, cleanup and redevelopment of brownfields sites. The agreements, referred to as Voluntary Cleanup Programs (VCP), create a framework for states and the EPA to coordinate the oversight of the cleanup process. VCPs provide technical assistance, liability assurances and funding support to site owners and developers. Learn more at [www.epa.gov/compliance/cleanup/revitalization/state.html](http://www.epa.gov/compliance/cleanup/revitalization/state.html).

The EPA provides access to information about tribal brownfields programs at [www.epa.gov/brownfields/state\\_tribal/tribe\\_progs.htm](http://www.epa.gov/brownfields/state_tribal/tribe_progs.htm).

### Example of Regulatory Requirement

If the proposed end use calls for construction of a light industrial facility, it may be appropriate, depending on state and local regulatory requirements, to compare the relevant cleanup standards for industrial as well as commercial or residential reuse standards. If the more stringent standard required for commercial or residential reuse is used, additional cleanup and costs may be required initially, but doing so provides greater flexibility and avoids future delay(s) if the proposed reuse is likely to change.

The standards required will affect every aspect of the project, from its overall cost (which is generally greater as the standards become more conservative) to the selection of options for site investigation and cleanup.

### Key Resource for Regulatory and Liability Concerns

*The Revitalization Handbook*, updated and reissued in 2011 by EPA's OSRE, is designed for stakeholders involved in the assessment, cleanup and revitalization of contaminated sites. The handbook summarizes federal statutory provisions and EPA policy and guidance documents useful for managing liability risks associated with cleaning up sites, and describes tools that stakeholders can use to address liability concerns. The handbook, including recent updates, is available at [www.epa.gov/compliance/resources/publications/cleanup/brownfields/handbook/](http://www.epa.gov/compliance/resources/publications/cleanup/brownfields/handbook/).

developers and owners of contaminated land. These documents, along with current Superfund enforcement and brownfields policy and guidance documents, are available on the EPA's website at <http://cfpub.epa.gov/compliance/resources/policies/cleanup/superfund/>. The EPA also can be a valuable resource for brownfields stakeholders by providing regulatory and policy support to facilitate selection of technologies. See Appendix B, Brownfields and Technical Support Contacts, on the Brownfields Road Map website for contact information.

Many of the standard practices are designed to help brownfields redevelopment projects obtain financing from

public programs and private banks and institutions. Guidance and standards are issued by government and nongovernment organizations, such as ASTM International (formerly the American Society for Testing and Materials), the Federal Deposit Insurance Corporation (FDIC), state and local economic development authorities and private lenders.

Regulatory considerations at relevant phases of investigation and cleanup are identified in the following sections. Stakeholders are encouraged to regularly consult with appropriate regulatory agencies to ensure that requirements are properly addressed throughout the project.

### Engaging the Community

Encouraging active participation by members of the community who are most likely to be affected by site cleanup and reuse plans contributes to the success of the project. Engage the community to raise awareness, identify community concerns and

### Key Resource for Community Engagement

EPA's Brownfields Program is designed to promote the active participation of communities in each phase of the cleanup process so that revitalized land offers the greatest local benefit.

A detailed overview of opportunities to engage the community in a brownfields project, including the identification of public actions at each step, is depicted graphically at [www.epa.gov/oswer/engagementinitiative/brownfields.html](http://www.epa.gov/oswer/engagementinitiative/brownfields.html).

build support for cleanup efforts that will lead to redevelopment and revitalization of their community. To maximize chances for success, plan early for how the community stakeholders will be identified and encouraged to participate for the duration of the brownfields project, from the investigation phases throughout cleanup.

It is important that brownfields decision-makers encourage acceptance of reuse plans and cleanup alternatives by involving members of the community through multiple

outreach methods such as public meetings, newsletters, publications, websites and social networks. For an individual site, the community should be informed about how

the use of a proposed technology might affect redevelopment plans or the adjacent neighborhood. Consider how the people living in or near the site might be affected by cleanup activities and the intended reuse of the property; plan early and appropriately for how cleanup decisions and their potential impact will be shared with the community.

The EPA assists brownfields communities by directing its members to appropriate resources and providing opportunities to network and participate in sharing information. A number of websites, databases, newsletters and reports provide opportunities for brownfields stakeholders to network with other stakeholders to identify information about cleanup and technology options. Details about the EPA's community engagement efforts by the Office of Solid Waste and Emergency Response (OSWER) are available on the Community Engagement Initiative website at [www.epa.gov/oswer/engagementinitiative/](http://www.epa.gov/oswer/engagementinitiative/). Helpful tools and data focused on community engagement at UST sites are provided on the EPA's Office of Underground Storage Tanks (OUST) community engagement website at [www.epa.gov/oust/communityengagement/](http://www.epa.gov/oust/communityengagement/).

## Identifying Funding

One of the most important factors to consider at the beginning of a brownfields project is funding. Simply put, the project cannot be initiated or undertaken until funding sources are identified and funds are secured. The success of a brownfields project is determined by the ability of the stakeholders to establish a funding package that covers the project costs from planning and assessment through cleanup and long-term monitoring. Most brownfields projects leverage funding from a variety of sources. Be mindful that securing funding can be a lengthy process.

The range of potential sources and the means of securing funds can appear overwhelming, but fortunately, many helpful resources and tools are available to guide stakeholders in exploring funding options.

Funding for the investigation and cleanup of brownfields sites is available from federal, state and public and private sources. Programs available at the federal level, such as the EPA, typically involve awarding grants and providing technical assistance to communities and stakeholders. Other federal programs, such as the U.S. Department of Housing and Urban Development, the U.S. Department of Agriculture, the U.S. Department of Transportation and the U.S. Department of Commerce, also

### Technical Assistance for Communities

The EPA's Technical Assistance to Brownfields Communities (TAB) program is a valuable community resource. Organized to provide geographically based assistance, the TAB program increases understanding of technical issues associated with brownfields sites and helps community members learn how to participate in cleanup and revitalization activities.

Details, including how to request technical assistance, are provided online at [www.epa.gov/brownfields/tools/](http://www.epa.gov/brownfields/tools/).

### EPA Brownfields Grants

The EPA offers funding for brownfields assessment, cleanup, revolving loan fund and environmental workforce development and job training grants. Learn more about the EPA's brownfields grants at [www.epa.gov/brownfields/grant\\_info](http://www.epa.gov/brownfields/grant_info).

Summaries of the types of grants are provided, including fact sheets, guidelines, resources, eligibility requirements, funding levels and tips for applying. Specific instructions and deadlines for applying for the EPA's brownfields grants are provided at [www.epa.gov/brownfields/applicat.htm](http://www.epa.gov/brownfields/applicat.htm).

### Key Resource for State Programs

Published in 2011 by the EPA's Office of Brownfields and Land Revitalization (OBLR), the *State Brownfields and Voluntary Response Programs: An Update from the States* provides helpful information about programs and tools available for brownfields projects through state programs. State-specific details are provided, including financial assistance tools, such as funding, tax incentives and environmental insurance; funding sources, amounts and whether the state program focuses on specific types of properties; liability relief provisions; and contact information.

The resource is available online at [www.epa.gov/brownfields/state\\_tribal/pubs.htm](http://www.epa.gov/brownfields/state_tribal/pubs.htm).

provide funding and technical assistance for brownfields projects. State programs are a valuable option as well, as states are increasingly offering flexible tools, financial assistance, tax incentives and other redevelopment support to promote cleanup and reuse of brownfields sites.

At the beginning of the project, explore federal, state and local programs to learn about the sources of funding available and the process for applying for and securing funding. Take advantage of the many helpful resources available on the EPA's Brownfields website ([www.epa.gov/brownfields/grant\\_info/](http://www.epa.gov/brownfields/grant_info/)) to learn about the EPA's grant programs, details about federal tax deductions

and to access state response programs, including points of contact and success stories.

### Seeking Professional Support

Most decision-makers for brownfields sites will require technical and legal assistance to fully understand the complexities of investigating and cleaning up contaminated sites. Depending on the complexity of a particular site, decision-makers may need the assistance of environmental practitioners with expertise in geosciences, chemistry, engineering, field sampling, redevelopment and other disciplines; cleanup contractors; technology vendors; and staff in analytical laboratories to perform many of the activities required to investigate and clean up the site. The inclusion of these professionals and other experts as members of a brownfields project team is recommended to ensure the successful completion of the brownfields project.

### Using Certified Professionals

Some states require the participation of certified or licensed professionals to help guide the site investigation and cleanup process.

Regulations applicable to brownfields projects in some states require the participation of certified or licensed environmental professionals to help guide the site investigation and cleanup process. For example, the EPA's final rule for All Appropriate Inquiries (AAI) requires that AAI investigations be performed or supervised by individuals who have specific certification or licensure, education or experience levels that meet the definition of

"Environmental Professional" provided in the AAI final rule. A request for proposal (RFP) is often used as the procurement mechanism to obtain the services of such professionals (individuals or a firm). The RFP requests potential service providers to submit a proposal that addresses the approach, qualifications and cost estimate for the services requested. The RFP can include specifications that encourage prospective bidders to think "outside the box" and consider innovative approaches. Selection criteria outlined in the RFP should include the demonstrated experience of the

individuals or firm in developing valid options for using streamlined strategies and innovative technologies at brownfields sites and in successfully implementing the selected options. Demonstrated experience can include resumes, project descriptions and letters of recommendation.

### **Seeing the Bigger Picture – Related EPA Initiatives**

As the EPA's Brownfields and Land Revitalization Program has matured over the years to address new challenges and evolving stakeholder needs, new programs and initiatives have been undertaken to better integrate efforts to clean up and reuse brownfields sites. See Spotlight 1, Redevelopment Initiatives: Connecting Cleanup and Reuse, and Spotlight 2, Supporting Tribal Revitalization, for a brief overview of several programs and initiatives that are designed to help the brownfields community integrate revitalization efforts, including principles such as sustainability, renewable energy and smart growth. In addition to setting policy and providing guidelines, these programs offer extensive resources to help brownfields stakeholders apply lessons learned from the experiences of other redevelopment projects.

### **Find Helpful Resources**



Visit the Brownfields Road Map website for resources to learn more about general concepts and factors for the cleanup of brownfields sites. The Learn the Basics resources provide more general information than the technology resources identified in the following chapters.

## Spotlight 1

## Redevelopment Initiatives: Connecting Cleanup and Reuse



Listed below are highlights of several EPA programs and initiatives focused on helping brownfields stakeholders learn how to more efficiently and collaboratively prepare contaminated properties for reuse.

| Initiative / Program  | Available Resources / Additional Details  |
|---|---|
| <p><b>Land Revitalization Program</b> – The Land Revitalization Program's mission is to restore land and other natural resources into sustainable community assets that maximize beneficial economic, ecological and social uses and ensure protection of human health and the environment. The Land Revitalization Program promotes sustainable approaches to remediation as the norm across all EPA contaminated land programs, recognizing cleanup and reuse as mutually supportive goals. The program emphasizes that the consideration of anticipated property reuse should be an integral part of cleanup decisions.</p>    | <p>Resources, policies and guidance, success stories and details about the program are available online at <a href="http://www.epa.gov/landrevitalization">www.epa.gov/landrevitalization</a>. Links to program-specific information, including details about grant and funding resources, are also provided.</p> |
| <p><b>Brownfields Area-Wide Planning Pilot Program</b> – This program supports community involvement in locally based efforts to plan for the assessment, cleanup and reuse of brownfields sites within a defined area. Through grants and technical assistance, the program promotes land revitalization on a larger scale than a single brownfields site (for example, revitalization of a neighborhood, block or corridor affected by a brownfields site) and promotes community engagement in the planning for brownfields revitalization efforts.</p>  | <p>Details about the pilot program, including pilot project fact sheets and information about applying for funding, are available at <a href="http://www.epa.gov/brownfields/areawide_grants.htm">www.epa.gov/brownfields/areawide_grants.htm</a>.</p>  |
| <p><b>Petroleum Brownfields Action Plan: Promoting Revitalization and Sustainability</b> – The EPA launched this program in 2008 to address the unique challenges associated with the cleanup and reuse of brownfields sites with petroleum contamination.</p>  | <p>Visit <a href="http://www.epa.gov/oust/petroleumbrownfields">www.epa.gov/oust/petroleumbrownfields</a> to access the action plan, progress reports, success stories, grants information and other resources.</p>   |
| <p><b>Smart Growth</b> – The EPA's Smart Growth program provides tools and resources to help people implement sustainable development strategies that promote healthy, attractive and economically strong communities. Integrating community, environmental and the economic considerations, applying smart growth principles to brownfields sites can lead to the selection of more valuable and sustainable reuse alternatives.</p>   | <p>To learn more about the EPA's Smart Growth program, visit <a href="http://www.epa.gov/smartgrowth/">www.epa.gov/smartgrowth/</a>. Resources, tools, technical assistance and examples of successful smart growth approaches are provided.</p>  |
| <p><b>Re-Powering America's Land</b> – Launched in 2008, this initiative encourages renewable energy development on current and formerly contaminated land and mine sites. Efforts focus on identifying the renewable energy potential of sites and providing useful resources for communities, developers, industry and state and local governments and others interested in reusing these sites for renewable energy development.</p>   | <p>Visit <a href="http://www.epa.gov/oswercpa/">www.epa.gov/oswercpa/</a> for information about funding sources, technical assistance, fact sheets, interactive mapping tools to identify sites with renewable energy potential, webinars and federal and state incentives.</p>                                   |
| <p><b>Superfund Redevelopment Initiative (SRI)</b> – Since 1999, SRI has helped communities return some of the nation's worst hazardous waste sites to safe and productive uses. In addition to cleaning up these Superfund sites and making them protective of human health and the environment, the Agency is working with communities and other partners to consider future use opportunities and integrate appropriate reuse options into the cleanup process. The EPA is also working with communities at sites that have already been cleaned up to ensure long-term stewardship of site remedies and to promote reuse.</p> | <p>Webinars, success stories, tools and resources, community support, demonstration project fact sheets, partnership information and complete details about the initiative are available online at <a href="http://www.epa.gov/superfund/programs/recycle/">www.epa.gov/superfund/programs/recycle/</a>.</p>      |



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_ri.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_ri.cfm).

## Spotlight 2

## Supporting Tribal Revitalization ↓

Federally recognized tribes in the United States develop their own environmental policy, establish standards and manage their environmental protection and natural resource management programs. Tribes can establish a brownfields program or a Tribal Response Program to address and reuse contaminated lands. The EPA provides technical and financial assistance to tribes for the restoration of contaminated tribal lands and the implementation of more effective approaches to attaining productive reuse of sites.

#### Financial and Technical Assistance Provided by the EPA

- *State and Tribal Response Program Grants* can be used to establish new or enhance existing environmental response programs.
- *Assessment, Revolving Loan Fund and Cleanup Grants (ARC Grants)* fund activities for sites contaminated by petroleum, hazardous substances, controlled substances or mine-scarred land.
- *Job Training Grants* fund opportunities for residents to take advantage of jobs created by the assessment and cleanup of brownfields sites.
- *Technical Assistance to Brownfield Communities (TAB) Grants* provide technical or training assistance to increase community understanding and participation in the brownfields remediation process.
- *Targeted Brownfields Assessments (TBA)* provide direct technical support for environmental assessment activities, which may be an option for sites that are not strong candidates for competitive grants.
- Limited funding also is available through Superfund cooperative agreements for program development and site assessment.

#### Tribal Highlights

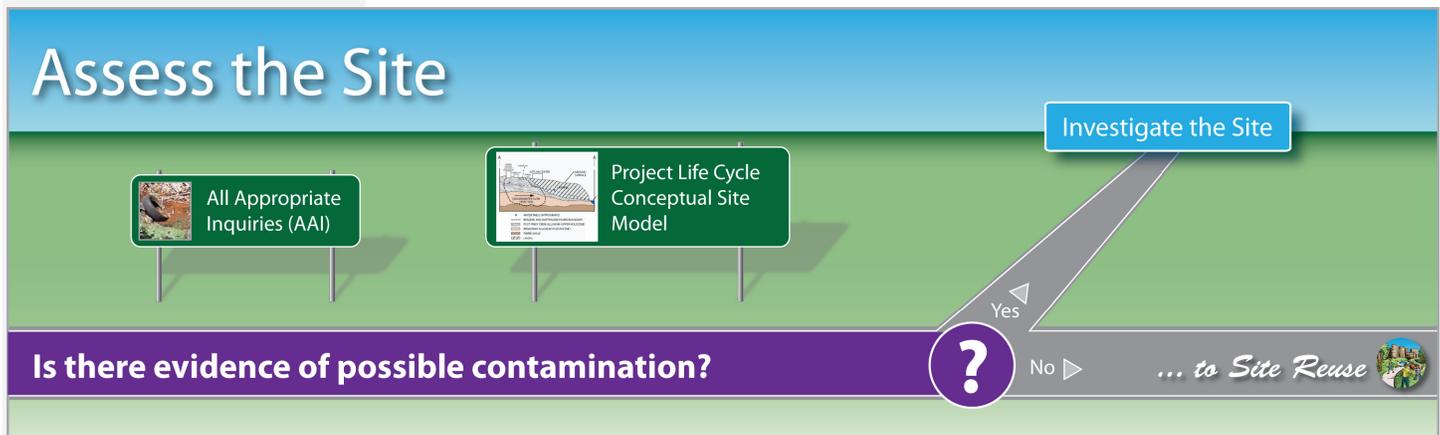
- The **Passamaquoddy Tribe** used funds from the Tribal Response Program to create an inventory of contaminated properties. The tribe also received assistance from the Maine Department of Environmental Protection's Brownfields Program to assess the Sipiyak Corner Store property, which included a vacant gas station. Discovery of contaminated soil resulted in the removal of USTs, and the site is now ready for reuse.
- The **Absentee Shawnee Tribe** has used funds from the EPA Brownfields Job Training grants to train more than 124 students on topics ranging from asbestos remediation to Hazardous Waste Operations and Emergency Response (HAZWOPER) health and safety training. Graduates of the training program have been employed by the Tribe's Office of Environmental Protection and other environmental firms and formed their own remediation company.

#### For More Information

Additional information about tribal grant funding guidance, tribal response program publications and tribal brownfields programs is available online at [www.epa.gov/brownfields/state\\_tribal](http://www.epa.gov/brownfields/state_tribal).



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_tr.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_tr.cfm).



The site assessment is a crucial step in the brownfields process because the need for any further environmental investigation and cleanup will depend on whether potential environmental concerns are identified.

### Collect and Assess Information about Your Brownfields Site

The purpose of this phase is to evaluate the potential for contamination at a particular site by collecting and reviewing existing information. A site assessment includes a review of site and government records, a site visit to visually inspect existing site conditions and identify any potential releases of hazardous substances, and interviews with people who have direct knowledge about historical uses of the site, past and current operational practices, and any potential for related environmental concerns.

#### ASTM International Phase I ESA

The site assessment is usually conducted consistent with ASTM International Phase I ESA practices, which are the generally accepted standard for evaluating a site for a potential release of hazardous substances or petroleum products into site structures, soil, groundwater, surface water, sediment and indoor air. Each instance when the available information suggests that a release of hazardous substances or petroleum products may have occurred is designated as a recognized environmental condition (REC). For more information about the ASTM International standard practice, visit [www.astm.org/Standards/E1527.htm](http://www.astm.org/Standards/E1527.htm).

A site assessment—typically beginning with a Phase I Environmental Site Assessment (ESA)—is essentially a compilation and review of available information. Efforts conducted during a site assessment to evaluate the history of a site and determine whether contamination is present also can be used to comply with the requirements of an AAI investigation. Conducting an AAI investigation is one element required for obtaining liability protection. See Spotlight 3, All Appropriate Inquiries, for details on the requirements for performing an AAI investigation.

During the site assessment phase, it is important to consider the activities and requirements described in the subsequent chapters and determine how they may be affected by initial site assessment information. Because the information obtained in this phase will determine whether any future site investigation work must be done at the site, assessment activities should be thorough and tailored to meet site- and project-specific data objectives. The information collected during this initial phase of the brownfields project is extremely important for providing early indications of whether the property may need to be cleaned up to support its intended reuse and can provide a preliminary indication of the available cleanup technologies.

The information collected about the site is typically organized into a project life cycle conceptual site model (CSM). The CSM is a valuable planning tool and framework for designing site activities and facilitating communications of the project team and with stakeholders. See Spotlight 4, Project Life Cycle Conceptual Site Model, for details and access to examples of CSMs.

### Community Benefit

The CSM is useful for sharing information with community members about the environmental conditions of the site, goals for the cleanup, data to be collected and decisions to be made.

### Spotlight 3

## All Appropriate Inquiries ↓

All Appropriate Inquiries is the process of evaluating a property's history and environmental condition to determine whether any contamination may be present. AAI investigations are required to be performed for a future property owner to be considered an innocent landowner, contiguous property owner, or bona fide prospective purchaser under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), or Superfund.

### Conducting AAI Investigations

AAI investigations must be performed within a certain time frame and manner and by individuals with specific qualifications to be considered compliant with the AAI final rule, published at 40 Code of Federal Regulations (CFR) Part 312 (effective November 1, 2006). Specific requirements include the following:

- An AAI investigation must be performed or updated within 1 year prior to acquisition of the property.
- Specific activities required by the AAI final rule that must be performed or updated within 180 days before acquisition of the property include an onsite visual inspection, review of government records, interviews with previous and current site owners and searches for environmental cleanup liens.
- AAI investigations must be performed or supervised by individuals who have specific certification or licensure, education or experience levels that meet the specified definition of "Environmental Professional" provided in the AAI final rule.
- The findings of an AAI investigation must be documented in a written report. The report must include:
  - 1) An opinion as to whether the inquiry identified conditions indicative of releases or threatened releases of hazardous substances on, at, in or to the subject property,
  - 2) An identification of "significant" data gaps if they affect the ability of the environmental professional to identify conditions indicative of releases or threatened releases,
  - 3) Qualifications and signature of the environmental professionals, and
  - 4) An opinion regarding additional appropriate investigation, if the environmental professional has such an opinion.
- AAI requirements may be met using the ASTM E1527-05 Phase I Environmental Site Assessment Process or ASTM E2247-08 Phase I Environmental Site Assessment Process for Forestland or Rural Property.



### For More Information

Visit the EPA's All Appropriate Inquiries website at [www.epa.gov/brownfields/aa/](http://www.epa.gov/brownfields/aa/) for fact sheets about AAI, access to the EPA's published final rule on AAI (40 CFR Part 312), and other information.



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_aa.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_aa.cfm).

## Consider These Questions

### Goals and Planning

- » Has a redevelopment plan been prepared or a proposed end use identified?
- » Is a residential development planned?
- » If located in an industrial area, will the site remain industrial or be rezoned for commercial use?
- » If the site shows evidence of contamination, who and what will be affected?
- » Will users of the property be exposed directly to the site soil, soil vapor, sediment or surface water?
- » Who will conduct long-term monitoring and oversight, particularly if residual contamination is left in place?

### Oversight

- » Is the site located in an area targeted for redevelopment? If so, is the site being considered for cleanup under a federal or state Superfund cleanup initiative?
- » Will the site be entered into a VCP? If not, what agency (federal, state, local or tribal) is responsible for managing oversight of cleanup?
- » Are there other federal, state, local or tribal regulatory requirements for site assessment?
- » Are there other regulatory requirements for specific contaminants likely to be present on the site (for example, lead-based paint or asbestos)?

The needs and concerns of the community are also important considerations at this early step. For example, it may be beneficial to develop social and economic profiles and clearly identify what the community considers to be acceptable environmental risks. Discussions and planning for how to identify stakeholders and keep them engaged and actively participating throughout the entire project are important activities to be undertaken in conjunction with site assessment.

Technologies that detect possible contamination in indoor air may be applicable at this stage, as well as some real-time measurement technologies useful for assessing contamination in soil, groundwater, surface water or other environmental media. Examples of sampling and analysis technologies that may be applicable during this phase are presented in the online Guide to Contaminants and Technologies at the Brownfields Road Map website. However, the use of technologies is limited, since much of the work at this phase typically involves a search of paper and electronic records and interviews with current and previous site owners and workers.

## Conduct Your Site Assessment

Typical activities that may be conducted during the site assessment phase are indicated below. The list is intended as a general planning guide and is not a comprehensive listing of assessment activities required under state and federal regulations. Factors that should be considered are presented in the margin in the form of questions. For a better understanding of these requirements, such as the EPA's AAI regulations, consult the references identified and work with appropriate regulatory authorities.

- Establish the core technical team and take advantage of the team's expertise to evaluate the adequacy of existing site information and identify potential releases of hazardous substances or petroleum products.
  - Identify and secure experts in geosciences, chemistry, engineering, regulatory and field sampling.
  - As required, consider additional support from individuals experienced in risk assessment, biology, data management and quality assurance.
- Ensure that all brownfields stakeholders (such as regulators, community members, property owners and technical staff, such as chemists and engineers) are involved in the decision-making process.
- Identify future plans for reuse and redevelopment and goals of the site.
- Explore options for funding and technical assistance from the EPA.
  - Consider applying for a brownfields assessment grant.
  - Request technical assistance from the EPA's Targeted Brownfields Assessment (TBA) program.

- Assess the site through an ASTM International Phase I ESA or its equivalent and conduct AAI to determine whether contamination is likely present on site. In general, perform a records search, visit the site and interview individuals with knowledge of the site. The effort includes the following activities:
  - Search relevant environmental databases. Commercial firms can cost-effectively conduct database searches on a fee basis. The search will consist of a review of federal and state databases, including but not limited to: (1) the EPA’s Comprehensive Environmental Response, Compensation and Liability Information System (CERCLIS) of potentially contaminated sites, (2) RCRAInfo, a national program management and inventory system of hazardous waste handlers, (3) the National Pollutant Discharge Elimination System (NPDES) of permits issued for discharges into surface water and (4) state records of “emergency removal” actions (for example, the removal of leaking drums or the excavation of explosive waste).
  - Identify past owners and the uses of the property by conducting a title search and reviewing tax documents, city directories, sewer maps, topographic maps, aerial photographs and fire, police and health department documentation related to the property.
  - Analyze city government and other historical records to identify past use or disposal of hazardous or other waste materials at the site.
  - Interview property owners, occupants and others associated with the site, such as previous employees, residents and local planners.
  - Perform a walking inspection of the site and a visual evaluation of adjacent and other local properties.
  - Potentially collect samples to test for the presence of various contaminants — for example, lead-based paint, asbestos and radon in structures.
  - Plan additional investigations at the site and collect information as necessary to investigate any releases of hazardous substances identified during the site assessment and resolve any other uncertainties related to the site.
- Coordinate with the project team to begin development of the project life cycle CSM.
- Review the applicability of government oversight programs:
  - Determine whether there is a state VCP and consult with the appropriate federal, state, local and tribal regulatory agencies to include them in the decision-making process as early as possible.
  - Select the approach (such as redevelopment programs, federal regulatory programs, property transfer laws or a state brownfields program) that is required or available to facilitate the cleanup of the site.
  - Identify whether economic incentives, such as benefits from state brownfields programs or federal brownfields tax deductions, can be obtained.
  - Contact the EPA regional brownfields coordinator to identify and determine the availability of EPA support programs and federal financial incentives (see Appendix B, Brownfields and Technical Support Contacts).

### Consider These Questions

*(continued)*

#### The Community

- » What are the special needs and concerns of the community?
- » How can meaningful community involvement be solicited?
- » What environmental standards should be considered to ensure that community stakeholders are satisfied with the outcome of the cleanup?

#### Site Conditions

- » What is known about the site?
- » What records exist that indicate potential contamination and past use of the property and adjacent properties?
- » What information is needed to identify the types and extent or the absence of contamination?
- » Has a previous Phase I ESA been conducted?
- » Have other environmental actions occurred (such as notices of violation)?

#### Funding

- » Who will pay for the site investigation and cleanup?
- » Are private, state, city or other federal agency funds available?

- Decide how to encourage and incorporate community participation:
  - Identify regulatory requirements for public involvement.
  - Assess community interest in the project.
  - Identify community-based organizations.
  - Review any community plans for redevelopment.
- Examine factors that may impede redevelopment and reuse.
- Identify environmental or other site conditions that the community would likely find unacceptable in light of the proposed reuse.
- Begin identifying potential sources for funding site investigation and cleanup activities at the site, if necessary.

### Find Helpful Resources



Visit the Brownfields Road Map website to identify and review resources and tools that provide details about technology applications, methods and other site-specific concerns.

### Plan Your Next Step

The next course of action is determined by the results of the site assessment and what has been learned about the site. Several possible outcomes and subsequent courses of action are explained below.

| Result of Site Assessment  | Course of Action   |
|--|--|
| No evidence of contamination is found and there is no evidence of possible contamination. Stakeholder concerns have been addressed adequately. | Confirm results with appropriate regulatory officials before proceeding with redevelopment activities.   |
| Evidence of contamination is found that poses a significant potential risk to human health or the environment.                                 | Contact the appropriate federal, state, local, or tribal government agencies responsible for hazardous waste. Based on feedback of the government agency, identify the cleanup levels required for redevelopment, and proceed to the Investigate the Site phase. |
| Contamination possibly exists, as indicated by the presence of RECs.   | Proceed to the Investigate the Site phase.   |
| Contamination definitely exists, but no site investigation has been conducted.   | Proceed to the Investigate the Site phase.   |
| Contamination definitely exists and a site investigation has been performed.   | Proceed to the Investigate the Site phase if additional investigation is warranted; otherwise, proceed to the Assess and Select Cleanup Options phase.   |

Spotlight 4

**Project Life Cycle  
Conceptual Site Model**

A Conceptual Site Model is a graphical and written summary of what is known or hypothesized about environmental contamination at a brownfields site. An effective CSM is easy to understand and helps technical teams, communities and stakeholders communicate with each other and learn about the nature, extent, exposure and risk associated with contamination. CSMs typically include graphical data and written content, and may also include information such as site features, geologic and hydrogeologic data, contaminant types, transport and exposure pathways and potential receptors.

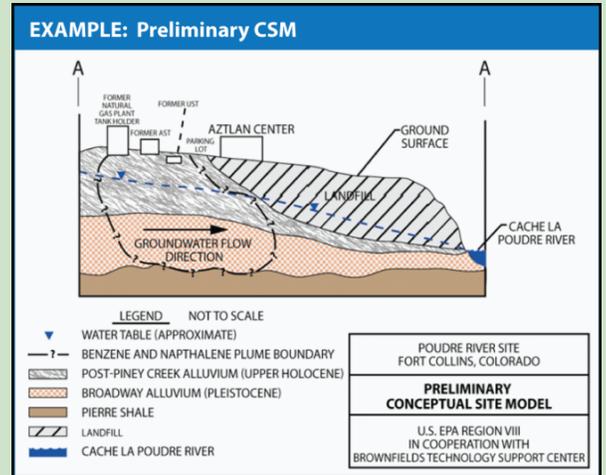
**Benefits of CSM Use**

CSMs are an important tool for the assessment and cleanup of brownfields sites because they can assist stakeholders to:

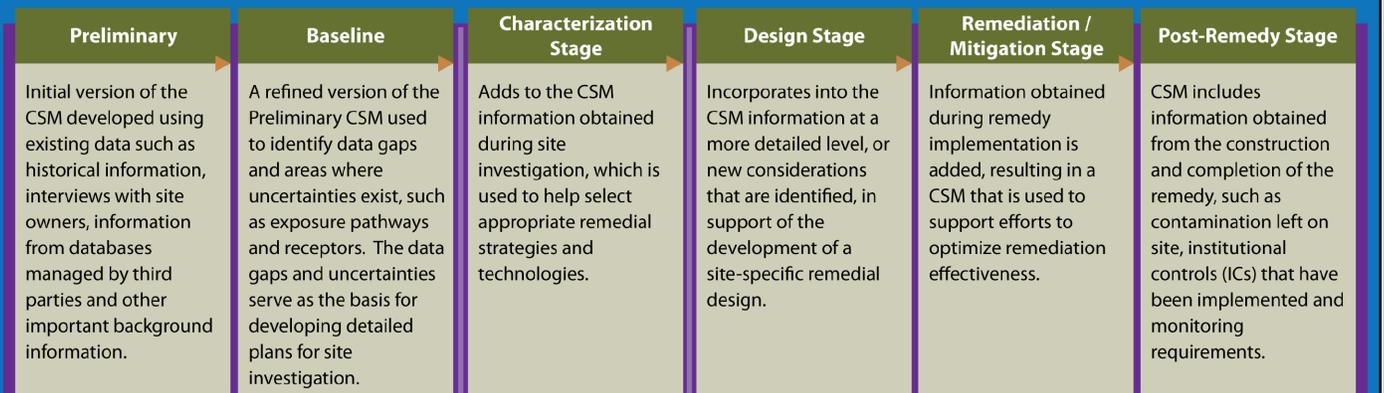
- More fully understand site conditions and features
- Synthesize information from multiple sources
- Identify which information is unknown or uncertain about the site
- Define a plan for collecting additional information
- Obtain stakeholder agreement on site conditions and related project investigation, design and cleanup plans

**Phases of the Project Life Cycle CSM**

There are six phases of a life cycle CSM. It is important to understand that a life cycle CSM does not require the creation of six individual CSMs, but rather the development of one CSM that evolves through all stages of site redevelopment. As additional information about the site is known, the CSM becomes a powerful tool to support technical and communication needs.



**Project Life Cycle CSM Phases**



Assess the Site

Investigate the Site

Assess and Select Cleanup Options

Design and Implement the Cleanup

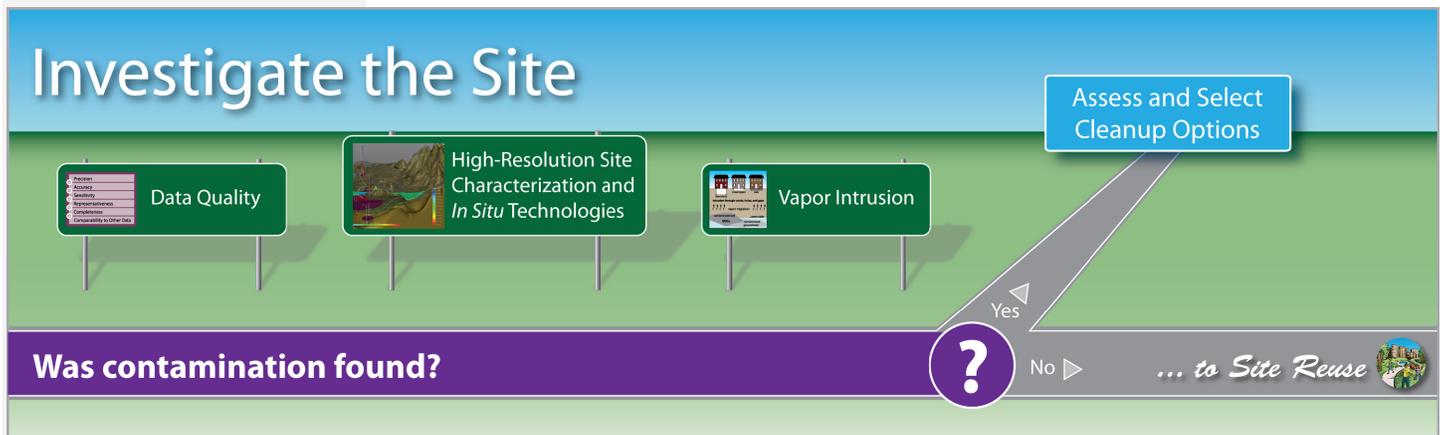
**Road Map Steps:** The six life cycle CSM phases relate to the general steps involved in the investigation and cleanup of a brownfields site.

**For More Information**

More details, including tools to assist in developing and using a CSM, and examples of CSMs, are available on the Triad Resource Center website ([www.triadcentral.org/tech/dsp\\_sub.cfm?id=13](http://www.triadcentral.org/tech/dsp_sub.cfm?id=13)).



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_csm.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_csm.cfm).



Information collected during the site investigation phase supports future decisions about potential cleanup options and reuse alternatives.

### Confirm Contamination and Identify its Source, Nature and Extent

Activities conducted during the site investigation phase are focused on confirming whether any contamination exists at a site, locating the source of contamination, characterizing its nature and extent and identifying possible threats to the environment or to any people living or working nearby. For brownfields sites, the results of a site investigation are used to identify and quantify the risks associated with potential contamination and to develop effective cleanup plans. The results may also be used to set specific goals for the cleanup and assess anticipated cleanup costs, which will help stakeholders evaluate the economic viability of the project.

#### ASTM International Phase II ESA

Environmental site assessments are conducted to evaluate existing environmental problems from past operations and potential environmental problems from current or proposed operations at a site. The primary objective of conducting a Phase II ESA is to confirm and evaluate the RECs identified in the Phase I ESA.

For more information about the ASTM International standard practice, visit [www.astm.org/Standards/E1903.htm](http://www.astm.org/Standards/E1903.htm)

A site investigation, also referred to as a Phase II ESA, is designed based on the results of the Phase I ESA discussed in the preceding chapter. The Phase II ESA includes the analysis of samples of building materials and environmental media, such as soil and soil gas, groundwater, surface water, sediment and indoor air. For sites where contamination is confirmed, additional site investigation efforts are used to delineate the nature and extent, source locations and significance of contamination for the purpose of supporting subsequent cleanup and reuse decisions. Contaminant migration pathways through media (for example, soil, groundwater and air) are also examined in relation to potential receptors (for example, humans, animals and plants). A baseline risk assessment to quantify risk to human health and or the environment may be conducted.

Examples of investigation technologies that may be useful during this phase are presented in the online Guide to Contaminants and Technologies available at the Brownfields Road Map website.

Many technologies are available to assist those involved in brownfields cleanup to be more effective in their efforts. In addition, BMPs for site investigation and cleanup have emerged in the last few years. These BMPs incorporate systematic project planning, dynamic work strategies and the use of real-time measurement

technologies to accelerate and improve the cleanup process by reducing costs, improving decision certainty, and expediting site redevelopment. For example, effective systematic planning of the investigation can result in lower overall project costs, while dynamic work strategies can reduce or eliminate the need for multiple mobilizations to a site to complete investigations.

Real-time measurement technologies provide information about contamination at the site that the project team can analyze while in the field. Used collaboratively with off-site laboratory analysis, the real-time data and field-based analytical methods can provide a more precise picture of the conditions at the site (for example, the extent of contamination and migration pathways). See Spotlight 5, Data Quality: The Key to Making Robust Site Decisions, for details about the benefits of using real-time measurement tools and methods. A thorough site investigation will improve understanding about the true conditions of the site, which reduces uncertainty and improves stakeholder confidence in the decisions made.

Provided below is an overview of using BMPs to investigate a brownfields site and the benefits of their use.

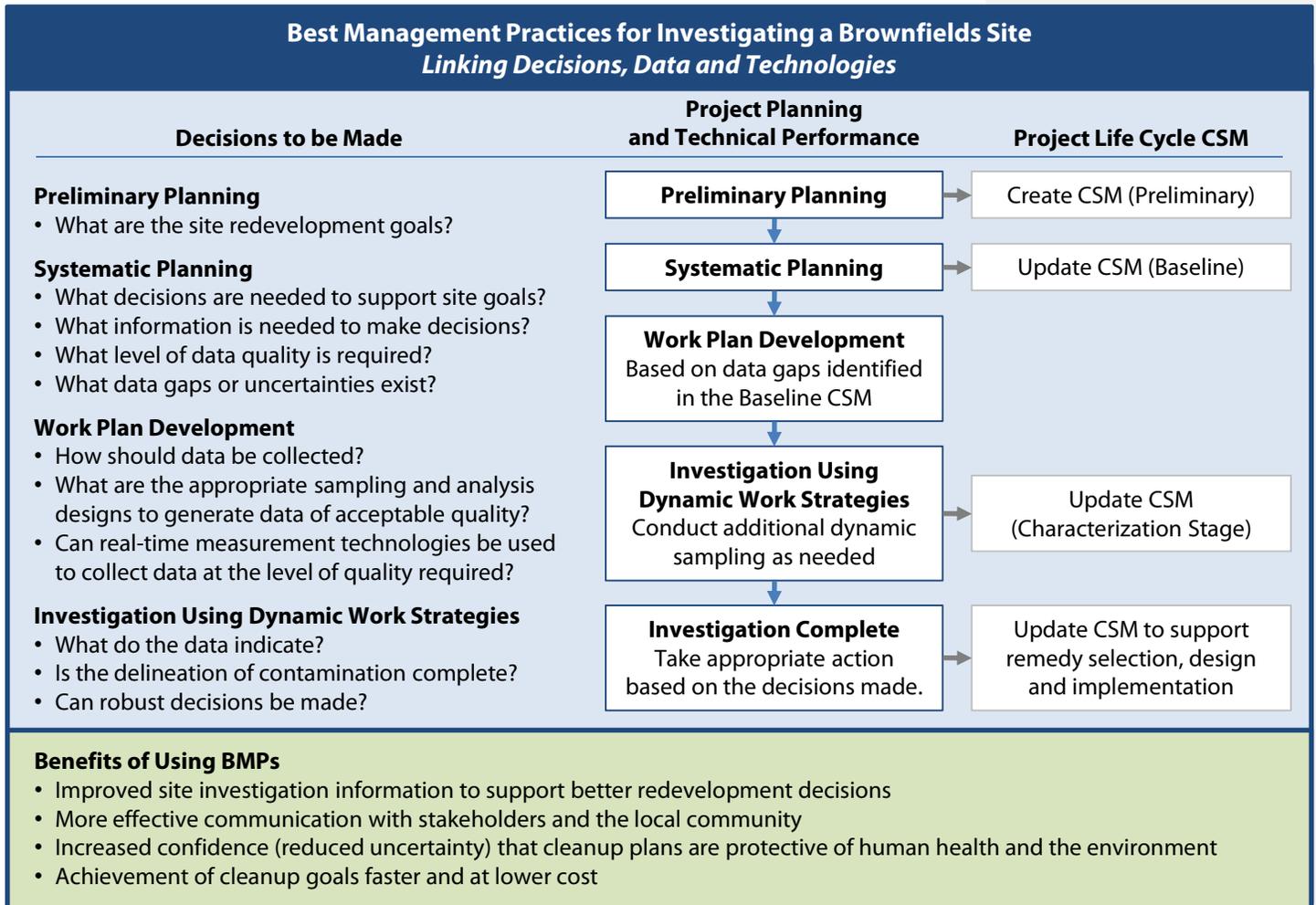
**Types of Uncertainty**  
Using BMPs helps to reduce a variety of uncertainties associated with brownfields projects.

**Analytical Uncertainty**  
Methods, Quantity, Quality, Validation, Appropriate Use

**Sampling Uncertainty**  
Media, Methods, Location, Distribution, Depth, Purpose

**Site Decision Uncertainty**  
Risk, Action Levels, Remedy, Stakeholders, Acceptability

**Resource Uncertainty**  
Funding, Schedule, Personnel, Logistics, Weather



## Spotlight 5

## Data Quality: The Key to Making Robust Site Decisions

Successful brownfields projects rely on environmental data that accurately represent actual site conditions. These data must be of defensible quality and provide sufficient detail to support robust decision-making so that a brownfields project can proceed in a manner acceptable to all stakeholders and in accordance with government regulatory and oversight programs (for example, EPA quality assurance and state voluntary cleanup programs). Thus, data quality should be considered during each redevelopment step, from determining the extent of contamination and assessing risks to implementing the best cleanup approach.

### Planning for Data Quality

Planning efforts for a brownfields project should address factors that affect data quality, such as sampling design, sampling methods, analytical methods and quality assurance/quality control (QA/QC) protocols. To ensure that defensible quality data are collected, initial planning activities for brownfields projects should include:

- Clarifying project and data quality objectives (DQO)
- Identifying decisions and relevant supporting data that will be necessary to support project completion
- Developing a CSM to understand site conditions and identify key site data gaps
- Achieving consensus from project stakeholders on strategies and methods for data collection, evaluation and use

### Using Field-based Methods to Reduce Site Uncertainty

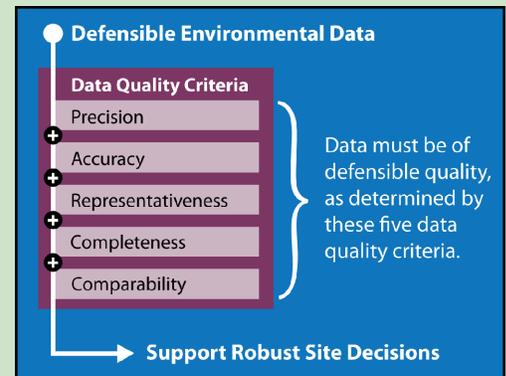
Understanding the true conditions of the brownfields site reduces site uncertainty—which is the key to making successful decisions. Increased decision confidence among site owners, buyers and surrounding communities decreases the likelihood of errors and omissions that could negatively affect the site later. However, the cost of reducing uncertainty can vary considerably based on the contaminants of concern and the technologies and methods used to generate data.

Using real-time direct sensing tools and field-based analytical methods may be a cost-effective way to reduce site uncertainty. They increase sampling density and precision by enabling lower per-measurement costs than sole reliance on conventional sampling and laboratory analysis methods. These tools and methods can also increase the quality and value of conventionally derived data by ensuring that samples are collected from the appropriate locations, thereby increasing the representativeness of those samples. Project teams can use data collected with field-based methods to make timely decisions rather than waiting weeks to months for laboratory results and formal project report generation.

For each brownfields project, steps should be taken to confirm that the field-based methods to be used on the project site will provide adequate data quality to support decision-making. In addition, results from field-based sensing and analytical methods should be confirmed using appropriate laboratory analytical methods.

### For More Information

Information about data quality is available at [www.triadcentral.org/reg](http://www.triadcentral.org/reg), including an overview of key concepts and considerations for using real-time measurement systems. Additional resources are provided by the Interstate Technology and Regulatory Council (ITRC) Incremental Sampling Methodology Team ([www.itrcweb.org/teampublic\\_ISM.asp](http://www.itrcweb.org/teampublic_ISM.asp)) and the ITRC Sampling, Characterization and Monitoring Team ([www.itrcweb.org/teampublic\\_SCM.asp](http://www.itrcweb.org/teampublic_SCM.asp)).



### Field-based Methods Can Be Very Powerful



Reduce uncertainty and improve understanding of site conditions with greater sampling density

Offer lower per-measurement costs than conventional sampling and laboratory analysis



Support real-time decision making rather than waiting for laboratory results and formal reports

Increase decision confidence of stakeholders

Real-time is within a time frame that allows the project team to react to the information while in the field.



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_dq.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_dq.cfm).

## Conduct Your Site Investigation

The following activities are typically conducted during the site investigation phase. Intended as a general planning guide, the list is not a comprehensive inventory of all site investigation activities required under state and federal regulations. Factors to be considered while planning the site investigation are presented in the margin in the form of questions.

- Contact the EPA regional brownfields coordinator to explore the potential for the project to qualify for a brownfields assessment grant and options for technical assistance through the EPA's TBA program.
- If a Phase II ESA is warranted, consider funding sources (such as state brownfields programs and federal tax deductions) for site investigation and cleanup activities:
  - Contact your state's brownfields program representative and the EPA regional brownfields coordinator to identify the availability of state and EPA support programs and federal financial incentives.
- In collaboration with stakeholders, use the results of the Phase I ESA to update the project life cycle CSM. Identify critical data gaps as the basis for the design of a Phase II ESA.
- Continue to work with regulatory agencies during the site investigation design and data collection phases to ensure that regulatory requirements are being properly addressed:
  - Identify and consult with the appropriate federal, state, local and tribal agencies to include their input as early as possible in the project.
- Invite community members to participate in discussions about the project goals and objectives and in decisions about the site investigation design.
- Identify the proper mix of real-time measurement technologies and conventional methods (such as off-site laboratory analysis) to investigate the site and meet the required level of data quality.
- Research and ensure that proposed real-time measurement technologies and the off-site laboratory can accurately detect all contaminants of interest to a concentration that is lower than or comparable to the screening level concentrations defined by the regulatory guidance and the agencies overseeing the project.
- Conduct a Phase II ESA to define the environmental conditions associated with the identified RECs at the site:
  - Identify potentially viable site sampling and testing methods to confirm geological and hydrogeological site conditions. For example, consider consulting with a geophysical survey service provider to evaluate approaches for cost-effectively addressing data gaps.
  - Confirm and refine as necessary the human health and ecological pathways for exposure to site contaminants.

## Consider These Questions

### Goals and Planning

- » Can the need for cleanup be assessed accurately from the site assessment or from a previous site investigation?
- » Who or what could be affected by the contamination or cleanup efforts?
- » What happens if contamination poses a "significant threat" to local residents?
- » What happens if the contamination is originating from an adjacent property or other off-site source?
- » What happens if sampling indicates that contamination is originating from a naturally occurring source?

### Oversight

- » Will the site be entered into a state VCP? If so, will the investigation plan be reviewed through the VCP? If not, are there applicable federal, state, local and tribal regulatory requirements?
- » What agency will oversee the investigation? Does the agency have suitable standards or guidelines for the proposed reuse?

### The Community

- » What issues has the community raised that may affect the site investigation?
- » How will the results of the site investigation be shared with the community?

**Consider These Questions***(continued)***Site Conditions**

- » What are the potential exposure pathways?
- » Are the infrastructure systems (roads, buildings, sewers, public water systems and other facilities) contaminated? Could they be affected by efforts to clean up contamination?
- » Is the site likely to be a “challenging cleanup”? See Spotlight 8 on page 35.

**Options**

- » Has the team explored the full range of technologies that can produce data of the quality required?
- » What real-time technologies are available to facilitate site investigation and support data collection efforts?
- » Can the technologies selected limit the number of mobilizations to the site?
- » Will the site investigation involve iterative steps to address data gaps that arise during the project?

- Delineate the nature, extent, source and significance of any contamination confirmed to be present.
- During the field investigation, evaluate results with other stakeholders to achieve consensus that the associated data needs at each identified release have been addressed.
- If applicable, evaluate whether and how the infrastructure systems (for example, roads, sewers and structures) are affected by contamination.
- Update the Baseline CSM with data and observations obtained during the site investigation. Use the Characterization CSM to identify and evaluate potential cleanup options.
- Assess the risks posed to human health and the environment. Depending on the planned end use of the property, other potential exposure pathways or sensitive receptors may also require evaluation. Consider the human exposure pathways of direct contact, ingestion, or inhalation of soil and dust, water and indoor air.
- Depending on state regulatory requirements, perform a risk assessment to identify site-specific cleanup levels when contaminant concentrations confirmed at the site exceed regulatory screening levels.
- Evaluate confirmed site contamination in all affected environmental media in terms of overall cleanup costs, including initial actions and long-term operation and maintenance. Include potential cleanup options and constraints that may affect redevelopment requirements, such as project schedules, costs and potential for achieving the desired reuse.
- Share the updated CSM with members of the community to promote understanding of the site conditions.

**Find Helpful Resources**

Visit the Brownfields Road Map website to identify and review resources and tools that provide details about technology applications, methods and other site-specific concerns.

## Plan Your Next Steps

The next course of action is determined by the results of the site investigation. Several possible outcomes and subsequent courses of action are explained below.

| <b>Result of the Site Investigation</b>  | <b>Course of Action</b>   |
|--|---|
| No contamination is found.   | Consult with appropriate regulatory officials before you proceed with redevelopment activities.   |
| Contamination is found, but does not pose a significant risk to human health or the environment.   | Consult with appropriate regulatory officials before you proceed with redevelopment activities.   |
| Cleanup of the contamination found probably will require a small expenditure of funds and time.  | Proceed to the Assess and Select Cleanup Options phase.   |
| Cleanup of the contamination probably will require a significant expenditure of funds and time. Residual contamination is determined not to pose a risk to local residents or the environment. | Determine whether redevelopment continues to be practicable as planned, or whether the redevelopment plan can be altered to fit the circumstances; if so, proceed to the Assess and Select Cleanup Options phase. |
| Contamination is found that poses a risk to local residents or the environment.  | Contact the appropriate federal, state, local or tribal government agencies responsible for hazardous waste. Compliance with other programs, such as the EPA's RCRA and Superfund programs, may be required.      |

## Spotlight 6

## High-Resolution Site Characterization and *In Situ* Technologies Promote Effective Cleanups

**High-resolution site characterization (HRSC) strategies and techniques define contaminant distributions in environmental media with greater certainty.**

The advent of innovative site characterization technologies and strategies and the development of more effective treatment methods may provide brownfields stakeholders with new options for faster and more effective site cleanup.

New approaches to site cleanup, based on the use of *in situ* treatment technologies, promote more targeted or “surgical” options for cleanup by enabling a better understanding of subsurface features, contaminant distribution, volume, mass and behavior over time.

### Benefits of *In Situ* Treatment

Treatment using *in situ* methods reduces the time required to clean up a site, decreases the amount of residual contamination left at sites and minimizes the need for long-term operations and maintenance. Together, these benefits directly serve the interests of brownfields stakeholders by:

- Expediting site redevelopment and reuse
- Reducing the requirement for engineering controls (EC) and ICs
- Lowering or eliminating long-term expenditures related to environmental protection measures

*In situ* treatments also provide the added value of supporting the goals of greener cleanups. For example, *in situ* treatments reduce the amount of treatment materials and waste generation and handling.

### Why High-Resolution Site Characterization?

Design and implementation of *in situ* remedies requires an accurate understanding of the nature and extent of subsurface contamination, which can most efficiently and reliably be defined using HRSC strategies and technologies. In addition, HRSC data can be used to support the initial evaluation and selection of *in situ* treatment technologies.

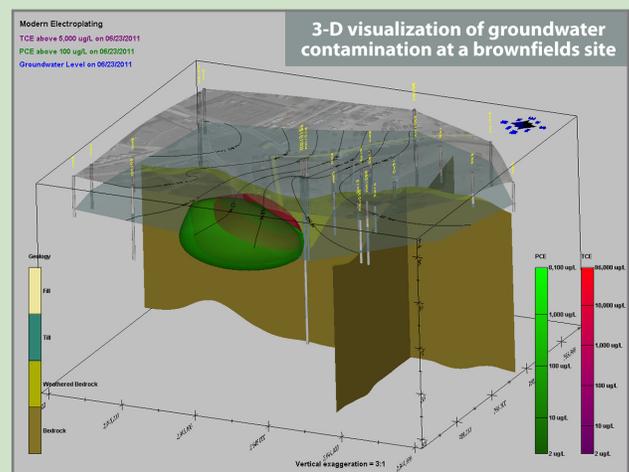
HRSC supports more effective use of *in situ* remedies by:

- Characterizing subsurface conditions critical to successful remedy design at a scale that conventional investigation methods are unable to attain
- Providing greater confidence that a site is fully characterized by increasing data density
- Enabling more accurate estimation of contaminant mass and volume through tighter source identification and delineation
- Improving the cost and performance of remedy monitoring by minimizing monitoring network needs.

As a targeted strategy or as an overall BMP, HRSC can be applied to sites of any size under any regulatory program.

### For More Information

HRSC is a new EPA initiative, and a formal definition for HRSC strategies and technologies has not yet been finalized. The general concept and benefits of HRSC are being explained and communicated through a variety of EPA efforts. Technical resources and other information about HRSC are available at [www.brownfieldstsc.org/topics.cfm](http://www.brownfieldstsc.org/topics.cfm).



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_hr.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_hr.cfm).

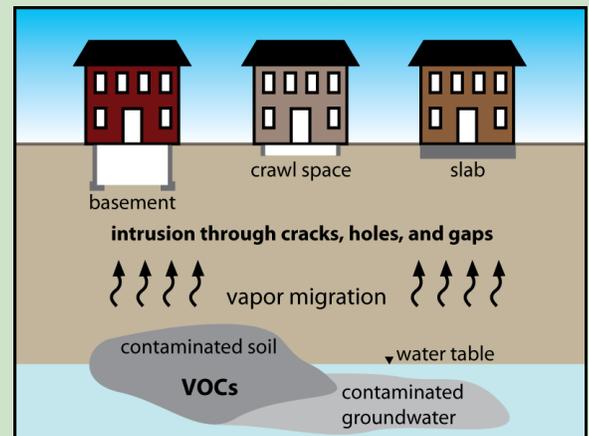
## Spotlight 7

## Vapor Intrusion

Vapor Intrusion (VI) occurs when toxic vapors enter structures, become concentrated and contaminate the indoor air. The vapors, which come from chemicals in contaminated soil or groundwater, migrate through foundation cracks, fractures in basement floors or walls, crawl spaces and small gaps around pipes and utility lines. VI poses potential chronic and acute health risks to anyone who breathes the air inside the affected buildings.

Many contaminants can cause VI, including chemicals that readily evaporate (volatile) and those that evaporate more slowly (semivolatile). Vapor-causing contaminants are commonly referred to as volatile organic compounds (VOCs). Examples of VOCs include gasoline, degreasers, dry-cleaning solvents, naphthalene and some pesticides.

VI should be evaluated for all brownfields projects with possible VOC contamination in the subsurface of the property or in the subsurface of nearby property. Because contaminated vapors can migrate laterally in the soil and groundwater, the source does not need to be on the property to create a VI risk. Even green spaces or properties with no history of industrial activity may be affected by VI if located near a contaminated property. Typical brownfields sites with VI concerns include former gas stations, dry cleaners, landfills, automobile repair shops and former manufacturing and chemical processing plants.



### Considerations for Brownfields Projects

- Evaluating the potential for VI should begin early in the site assessment and investigation phases. Often, the only way VI concerns can be solved is to adequately evaluate them before cleanup begins. Solutions may be easier to implement and are generally less expensive if VI concerns are evaluated before construction is complete.
- The movement of volatile vapors can be difficult to quantify and initial environmental site assessments may not accurately identify VI concerns. If a potential VI risk exists, appropriate sampling should be conducted during the site investigation to evaluate potential exposure pathways.
- VI concerns should be incorporated into the project life cycle CSM to help define data quality objectives and identify considerations for the cleanup design.
- Strategies to reduce or eliminate indoor air contaminant risks include:
  - Remediating or controlling the sources of contamination in the subsurface
  - Increasing natural building ventilation
  - Ventilating the affected buildings with properly operated heating, ventilation and air conditioning systems
  - Restricting the use of the facilities of concern
  - Changing the location or altering the design of future buildings
- Operations, maintenance and monitoring of mitigation systems are generally necessary.
- Some states have specific VI guidance; environmental agencies should be consulted to ensure that up-to-date and appropriate guidance is followed.

### For More Information

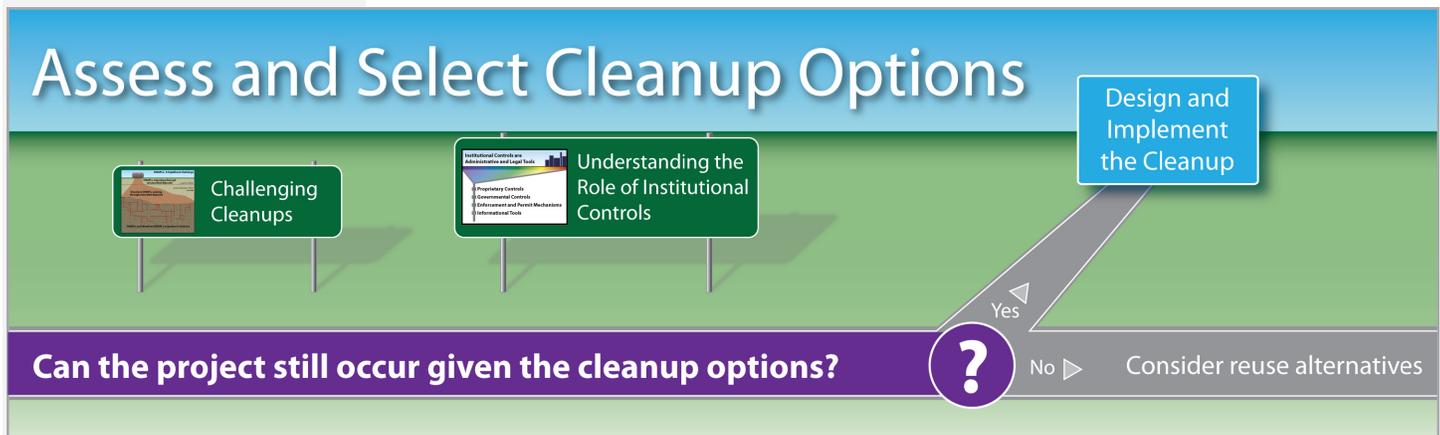
In 2008, the EPA's Brownfields and Land Revitalization Technology Support Center published *Brownfields Technology Primer: Vapor Intrusion Considerations for Redevelopment*. This primer contains detailed information about assessing and mitigating VI concerns that will help stakeholders communicate with technical experts and contractors.



The EPA's VI website, [www.epa.gov/oswer/vaporintrusion/](http://www.epa.gov/oswer/vaporintrusion/), provides basic information and policy, guidance and technical documents. VI resources also are provided on the CLU-IN website at [www.clu-in.org/issues/default.focus/sec/Vapor Intrusion/](http://www.clu-in.org/issues/default.focus/sec/Vapor+Intrusion/).



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_vi.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_vi.cfm).



The purpose of evaluating various cleanup alternatives is to identify technologies with the capability to meet specific cleanup and reuse objectives.

## Evaluate Applicable Cleanup Alternatives for Your Site

Data collected during the site assessment and investigation phases are critical for moving to this phase of a brownfields project. The project team and stakeholders use the data and information known about a property to review and evaluate cleanup options applicable to specific site conditions and consistent with cleanup and reuse goals. Continuing to use the BMPs discussed in the previous sections ensures that stakeholders can contribute meaningfully to the decision-making process because they understand the site conditions and potential risks.

Sharing details about the options under consideration and inviting comment from those in the community likely to be affected by the cleanup and reuse is an important activity and contributes significantly to long-term community acceptance and support of the selected cleanup alternative and the overall reuse goals. Encouraging community involvement in these decisions ensures that the approaches taken to address environmental impacts remain consistent with stakeholders' goals and objectives.

After discussion and efforts to reach consensus among the various stakeholders, decisions are made about the selection of cleanup alternatives, including the use of technologies with the capability to meet specific cleanup and redevelopment objectives. For brownfields sites, it also is important to

frame these discussions and decisions around budget considerations and work schedule constraints so that the project remains financially viable.

Institutional controls are another important consideration during this phase. Examples of these legal and administrative tools include easements, covenants, zoning restrictions and posting advisories to increase community awareness of the environmental conditions and cleanup activities at the site. See Spotlight 9, Understanding the Role of Institutional Controls at Brownfields Sites, for more information about institutional controls.

### Identifying the Best Options for Challenging Cleanups

The cleanup of some brownfields sites may be complicated by site conditions and the specific contamination found on or near the property. See Spotlight 8, Challenging Cleanups, for a more detailed discussion.

## Selecting the Cleanup Options for Your Site

The following list identifies activities that are typically conducted during the evaluation and selection of cleanup options. The list is intended as a general planning guide and is not a comprehensive inventory of all activities to be undertaken during this phase.

Factors to be considered are presented in the margins in the form of questions.

- Establish cleanup objectives that consider the end use and use applicable standards, published state or federal guidelines, risk-based corrective actions (RBCA), or site-specific risk assessment results.
- Communicate information about the proposed cleanup option to brownfields stakeholders, including members of the affected community. Solicit the input of the community in the site cleanup selection process and actively engage community members in decision-making.
- Review general information about cleanup technologies and approaches to become familiar with those that may be applicable to the contaminants and geologic and hydrogeologic conditions present at the site. Focus on identifying cleanup options that have a proven track record for sites with similar contaminants and conditions:
  - Use the resources available on the Brownfields Road Map website to identify technologies.
  - See Appendix A, Guide to Contaminants and Technologies, at the Brownfields Road Map website for examples of technologies that are appropriate for specific types of contaminants.
  - Search existing literature that further describes the technology alternatives.
  - Analyze detailed technical information about the applicability of technology alternatives.
- Enlist the help of a professional environmental practitioner with experience in applying these technologies at similar sites.
- Assess the need for using ICs as part of the cleanup approach.
- Narrow the list of potential cleanup options that are most appropriate and compatible for addressing site contamination and proposed reuse:
  - Network with other brownfields stakeholders and environmental practitioners to leverage their expertise.
  - Determine whether sufficient data are available to support identification and evaluation of cleanup alternatives.
  - Analyze in more detail the applicability of technologies to the contamination and conditions identified at a site.
  - Evaluate the options against a number of key factors, including their effectiveness, implementability and cost.
  - Consider the benefits that some cleanup options may offer; for example, less disruption to the community, potential reduction of liability and long-term sustainability.

### Consider These Questions

#### Goals and Planning

- » Is there a consensus that site characterization uncertainties have been sufficiently reduced?
- » How is the appropriate and feasible level of cleanup identified?

#### Oversight

- » Are there federal, state, local or tribal cleanup requirements?
- » Are there prescribed standards for the cleanup?
- » Is there a state environmental insurance program?

#### The Community

- » How can the community participate in the review and selection of options?
- » What environmental standards should be considered to ensure that community stakeholders are satisfied with the outcome and process of the cleanup?
- » Are cleanup options acceptable in light of community concerns?
- » Are cleanup options compatible with regional or local planning goals and requirements?

#### Site Conditions

- » Should risk-based approaches be considered for addressing exposure?
- » Will the cleanup facilitate or hinder the planned redevelopment?
- » Is there a need for ICs after cleanup? If so, will ICs facilitate or hinder development?

**Consider These Questions***(continued)***Options**

- » Are the options acceptable in light of community concerns about protection and reuse of the site?
- » Are the cleanup options compatible with regional or local planning goals and requirements?
- » What are the short- and long-term effects of the cleanup technologies under consideration?
- » What options are available to monitor the performance of cleanup technologies?
- » Are proposed ICs appropriate in light of community concerns?
- » What plans, including financial assurances, are being made to ensure that ICs remain functional as long as contamination is present?
- » Does the proposed cleanup approach place burdens on future land owners or occupants?

**Funding**

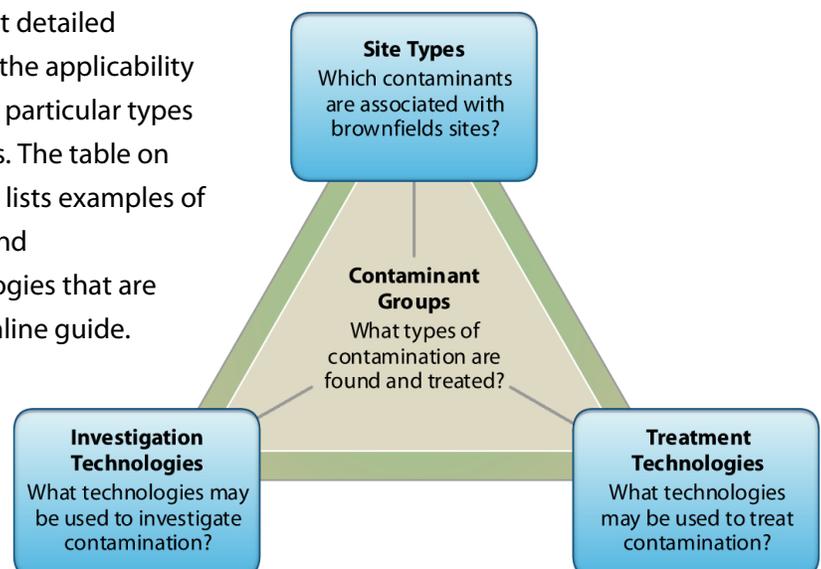
- » How long will cleanup take?
- » What will cleanup cost?
- » Will schedule constraints or the estimated cost adversely affect the project's viability?
- » Who will pay for long-term costs to maintain the cleanup, including any ICs?

- Determine the effects of various technology alternatives on redevelopment objectives.
- Continue to collaborate with regulatory agency stakeholders to ensure that regulatory requirements are properly addressed:
  - Confirm that the agencies concur that site characterization uncertainties have been sufficiently reduced to allow the process of remedy selection and design to begin.
  - Obtain agency input regarding the range of cleanup options under consideration and input regarding any additional options.
- Contact the EPA regional brownfields coordinator to explore the potential for the project to qualify for a brownfields cleanup grant or TBA support.
- Integrate cleanup alternatives with reuse alternatives to identify potential constraints on reuse and time schedules and to assess cost and risk factors.
- To provide a measure of certainty and stability to the project, investigate environmental insurance policies, such as protection against cost overruns, undiscovered contamination and third-party litigation, and integrate their cost into the project financial package.
- Select an acceptable remedy that not only achieves cleanup goals and addresses the risk of contamination, but also best meets the objectives for redevelopment and reuse of the property and is compatible and sustainable with the needs of the community.

**Find Helpful Resources**

Visit the Brownfields Road Map website to identify and review resources and tools that provide details about technology applications, methods and other site-specific concerns.

A wide variety of chemical contaminants may be present at brownfields sites. Use the online Guide to Contaminants and Technologies, available at the Brownfields Road Map website, to get detailed information about the applicability of technologies for particular types of brownfields sites. The table on the following page lists examples of brownfields sites and treatment technologies that are described in the online guide.



**Examples of Brownfields Site Types and Treatment Technologies**

| Site Activities and Operations*  | Treatment Technologies (Media)  |
|--|---|
| <ul style="list-style-type: none"> <li>• Agricultural</li> <li>• Battery recycling and disposal</li> <li>• Chemical and dye manufacturing</li> <li>• Chlor-alkali manufacturing</li> <li>• Cosmetics manufacturing</li> <li>• Drum recycling</li> <li>• Dry cleaning</li> <li>• Gasoline stations</li> <li>• Glass manufacturing</li> <li>• Hospitals</li> <li>• Incinerators</li> <li>• Landfills, municipal and industrial</li> <li>• Leather manufacturing</li> <li>• Machine shops and metal fabrication</li> <li>• Manufactured gas plants and coal gasification</li> <li>• Marine maintenance</li> <li>• Metal plating and finishing</li> <li>• Metal recycling and automobile salvage</li> <li>• Mining and mine-scarred lands</li> <li>• Painting and automobile body repair</li> <li>• Pesticide manufacturing and use</li> <li>• Petroleum refining and reuse</li> <li>• Pharmaceutical manufacturing</li> <li>• Photographic film manufacturing and development</li> <li>• Plastic manufacturing</li> <li>• Printing and ink manufacturing</li> <li>• Railroad yards</li> <li>• Research and educational institutions</li> <li>• Semiconductor manufacturing</li> <li>• Smelter operations</li> <li>• Underground storage tanks</li> <li>• Vehicle maintenance</li> <li>• Wood preservation</li> <li>• Wood pulp and paper manufacturing</li> </ul> | <ul style="list-style-type: none"> <li>• Air Sparging (G)</li> <li>• Bioremediation (G/S)</li> <li>• Chemical Treatment (G/S)</li> <li>• Electrokinetics (G/S)</li> <li>• Flushing (G/S)</li> <li>• Incineration (S)</li> <li>• In-Well Air Stripping (G)</li> <li>• Mechanical Soil Aeration (S)</li> <li>• Multi Phase Extraction (G/S)</li> <li>• Nanoremediation (G/S)</li> <li>• Open Burn/Open Detonation (S)</li> <li>• Permeable Reactive Barrier (G)</li> <li>• Physical Separation (S)</li> <li>• Phytoremediation (G/S)</li> <li>• Pump and Treat (G)</li> <li>• Soil Amendments (S)</li> <li>• Soil Vapor Extraction (S)</li> <li>• Soil Washing (G/S)</li> <li>• Solidification/Stabilization (S)</li> <li>• Solvent Extraction (S)</li> <li>• Thermal Desorption (S)</li> <li>• Thermal Treatment (in situ) (G/S)</li> <li>• Vitrification (S)</li> </ul> <p>G - Groundwater, leachate and surface water<br/>S - Soils, sediments and sludges</p> |
| <p>* Depending on the type of site, level of contamination and risks posed, these sites may be subject to other laws and regulations other than state VCPs, and it may not be appropriate to manage them through the brownfields programs. Check with EPA or the state on a site-specific basis to ensure assessment and cleanup are conducted in accordance with the applicable statutory and regulatory authorities.</p>   |   |



Use the online Guide to Contaminants and Technologies to obtain more details about the applicability of technologies at brownfields sites.

**Plan Your Next Step**

After cleanup options have been selected for your site, consider the following options:

| Result of the Review of Cleanup Options   | Course of Action  |
|---|---|
| The proposed cleanup option appears feasible.   | Proceed to the Design and Implement the Cleanup phase.  |
| No cleanup option appears feasible in light of the proposed redevelopment and land reuse needs (such as project milestones, cost and intended reuse). | Determine whether revising the redevelopment plan remains a practicable option; if so, proceed to the Design and Implement Cleanup phase. Compliance with other programs, such as the EPA's RCRA and Superfund programs, may be required. |

## Spotlight 8

## Challenging Cleanups

The cleanup of some brownfields sites can be challenging because the property is contaminated with chemicals that are highly mobile, hard to find or difficult to treat. Contaminants may be hard to clean up because:

- They are difficult to capture or separate
- They are located in hard-to-reach areas (for example, fractured bedrock)
- They do not degrade naturally in the environment

Combinations of these factors present a variety of challenges during site characterization and cleanup, which can result in additional costs and time throughout a brownfields project.

### Types of Brownfields Sites with Challenging Cleanups

Many brownfields sites — including former gas stations, electronics manufacturing facilities, auto service centers, dry cleaning facilities, electroplating plants, wood preservation sites and manufactured gas plants — have been affected by contaminants that are challenging to investigate and clean up. Some of the common contaminants found at these types of brownfields sites include dense non-aqueous phase liquids (DNAPLs), polychlorinated biphenyls (PCBs), dioxins/furans, 1, 4-dioxane, methyl tertiary butyl ether (MTBE), perchlorate and arsenic.

### Assessment Considerations and Cleanup Options

Site assessment and cleanup should be designed with strategies and technologies that address the unique nature of the contaminants of concern. A solid understanding of contaminant behavior in the environment is critical to designing and implementing effective assessment and cleanup. For example, contaminants that are hazardous at very low concentrations may require costly, time-intensive laboratory analysis to detect, as compared with contaminants at higher concentrations, which might be well-suited for assessment using cost-effective screening technologies.

### For More Information

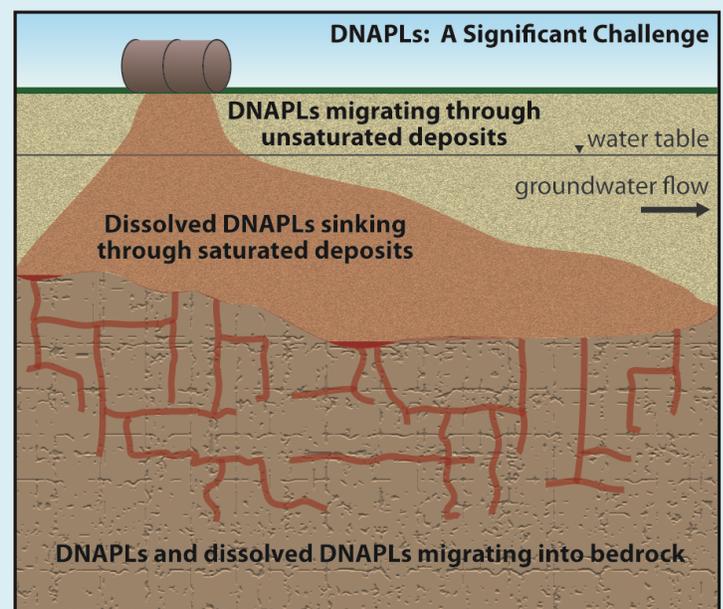
The EPA provides reports and other informational materials about various contaminants on the Contaminant Focus section of the EPA's Contaminated Site Clean-Up Information (CLU-IN) website at [www.cluin.org/contaminantfocus](http://www.cluin.org/contaminantfocus).

### EXAMPLE: A Closer Look at DNAPLs

Two factors make DNAPLs a contaminant that is difficult to clean up: (1) they do not easily dissolve in water (they are only slightly soluble) and (2) they are heavier than water. Being denser than water, DNAPLs tend to sink through groundwater and permeate into fine-grained soil units such as silt and clay. DNAPLs also can migrate in multiple directions through fractures in bedrock. Because of these properties, it can be difficult to predict DNAPL migration pathways. Subsequently, DNAPLs in bedrock and fine-grained soils can act as continuing sources of contamination, which may cause long-term impacts to groundwater and pose a significant challenge to site cleanup.

Used alone, traditional pump-and-treat systems may require years to decades to clean up the groundwater. In these cases, it is important to consider more effective alternatives, either individually or in combination ("treatment train" or "combined remedy"). Examples of such treatments include:

- Using microorganisms to break down the contamination (bioremediation)
- Extracting DNAPL compounds from soil in vapor form with a vacuum system and treating the gas to remove the contaminants (soil vapor extraction [SVE])
- Applying chemicals to the contamination to break down the DNAPLs into nonhazardous compounds such as water and carbon dioxide (in situ chemical oxidation injection)



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_cc.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_cc.cfm).

## Spotlight 9

## Understanding the Role of Institutional Controls at Brownfields Sites

Institutional controls are a broad spectrum of administrative and legal tools used to help minimize the potential for exposure to residual contamination and to protect physical cleanup measures at contaminated sites. ICs work by limiting land or resource use or by providing information that helps modify or guide human behavior at a site. ICs normally supplement ECs and are typically used in conjunction with the overall cleanup remedy to support reuse. Long-term considerations associated with IC use, such as impacts on reuse and funding requirements, must be carefully weighed against the costs and benefits of permanent removal of contamination.

### Types of ICs

- *Proprietary controls* involve private agreements that impose restrictions on, or otherwise affect the use of, a property. Common examples of proprietary controls are covenants, deed restrictions and easements.
- *Governmental controls*, such as zoning, building codes, groundwater use regulations and commercial fishing bans, restrict land or resource use by the authority of a government entity.
- *Enforcement and permit tools with IC components* typically involve administrative orders, consent decrees and permits to limit certain activities at a site or require a specific activity, such as monitoring and reporting.
- *Informational devices*, such as signs, markers and community outreach activities, provide notification and may communicate risks about residual contamination that may remain on a site after a cleanup remedy has been undertaken.

### Long-Term Considerations

- Identify the long-term costs and administrative implications of maintaining and enforcing ICs.
- Evaluate the potential use of ICs early in the cleanup process to plan appropriately for implementation, maintenance and enforcement challenges.
- Consider and compare the costs of leaving contamination in place while maintaining ICs to the costs associated with treating or removing contamination.

### For More Information

The EPA's interim final guidance, "Institutional Controls: A Guide to Planning, Implementing, Maintaining, and Enforcing Institutional Controls at Contaminated Sites," was published in the *Federal Register* in 2010 to request public comment. In 2009, the EPA released a fact sheet that provides general information about the costs of ECs and ICs at brownfields sites. The fact sheet, which includes an example of the use of ICs as part of a site cleanup, is available online at [www.epa.gov/brownfields/tools/lts\\_cost\\_fs.pdf](http://www.epa.gov/brownfields/tools/lts_cost_fs.pdf). Another EPA fact sheet, "Addressing Long-Term Stewardship: Highlights from the Field," provides three examples that highlight long-term considerations for maintaining and enforcing ICs. It can be viewed online at [www.epa.gov/brownfields/tools/lts\\_fs\\_04\\_2008.pdf](http://www.epa.gov/brownfields/tools/lts_fs_04_2008.pdf).

### Institutional Controls are Administrative and Legal Tools

#### Types of ICs

- Proprietary Controls
- Governmental Controls
- Enforcement and Permit Mechanisms
- Informational Tools

#### Objectives of ICs

Minimize potential exposure to contamination  
Restrict land use activities that might compromise cleanup efforts



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_ic.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_ic.cfm).



The final phase of preparing a brownfields property for reuse is designing and implementing the cleanup. During this phase, the discovery of additional contamination may require further site investigation or reassessment of available cleanup options.

Maintaining stakeholder participation during cleanup promotes long-term community acceptance and support of the planned reuse of the brownfields site.

## Develop and Carry Out Your Detailed Cleanup Plans

During the cleanup design and implementation phase, the property is prepared for redevelopment and reuse by carrying out the selected cleanup options, as described in the preceding chapters. The design of the cleanup plan and implementation of the chosen remedies involves close coordination with all other redevelopment efforts in the immediate vicinity of the site.

Building on the comprehensive understanding of site conditions that has evolved during the project, real-time technologies and dynamic work strategies can be used to monitor and assess the results of cleanup activities. As in the site investigation phase, these field-based methods can be used to evaluate progress toward the achievement of the cleanup goals. Precise monitoring data help to minimize uncertainty and form the basis for long-term monitoring strategies, including the use of institutional controls.

In some cases, implementing the cleanup may lead to the discovery of additional contamination or may reveal other complicating factors that require the project team to conduct further site investigation and characterization. Additional site investigation results may demonstrate that no practical alternatives exist for cleaning up the site to meet the reuse goals of the project; if so, the site owner may need to consider modifying the proposed land reuse plan or identifying other land use alternatives. See Spotlight 8, Challenging Cleanups, for details about sites affected by contaminants that are difficult to investigate and clean up.

## Design and Implement Your Cleanup

Typical activities that may be conducted during this phase are outlined below, along with factors to consider. The list is intended as a general planning guide and is not a comprehensive inventory of all activities to be undertaken during cleanup of a

brownfields site. Factors to be considered are presented in the margin in the form of questions.

- Review all applicable federal, state, local and tribal regulations and regulatory guidelines to identify all specific requirements, including guidelines for state VCPs.
- Continue to engage regulatory stakeholders to ensure that regulatory requirements are being properly addressed:
  - Confirm that the agency concurs with the design of the selected remedy.
  - Obtain agency input and concurrence on remedy assessment metrics and alternative exit strategies.
- Contact the state brownfields program and the EPA regional brownfields coordinator to identify and determine the availability of state and EPA support programs.
- Develop conceptual plans for cleanup and subsequent monitoring that incorporate technology options and consider the effect of any cleanup activities on the proposed reuse of the property and the schedule for project design or construction:
  - Develop or review the schedule for completion of the project.
  - Obtain a final amount for the grant funding available for project development.
  - Coordinate renovation and construction of infrastructure with cleanup activities.
  - Coordinate activities with developers, financiers, construction firms and members of the local community.
- Establish contingency plans to address the discovery of additional contamination during cleanup, including tools such as environmental insurance policies.
- Continue to maintain stakeholder consensus and active community participation during cleanup:
  - Conduct public outreach meetings on a regular basis.
  - Provide updates about the progress of cleanup activity.
  - Share successes when important cleanup milestones are achieved.
  - Inform the community about changes in activity that could affect reuse plans.
- Implement, document and monitor the performance of the cleanup using the accepted assessment metrics.
- Work with the state VCP, if applicable, and county or local officials to facilitate the placement and implementation of institutional controls.

## Consider These Questions

### Goals and Planning

- » How will the cleanup be monitored and assessed?
- » Will long-term monitoring be required?
- » Have alternative land use strategies been developed?

### Oversight

- » Are there federal, state, local and tribal requirements for the design, installation and monitoring of cleanup activities?

### The Community

- » How will the community participate in this phase?
- » Are there examples of effective community engagement?

### Site Specifics

- » Can redevelopment and cleanup activities be performed concurrently?
- » Will ICs facilitate or hinder redevelopment? In the future?

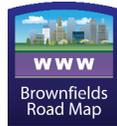
### Options

- » How will the cleanup design affect long-term liabilities or future use of the site?
- » What can be done to protect the community and other property during cleanup?

### Funding

- » What are the tradeoffs between cost and meeting project deadlines?
- » How will long-term monitoring be funded and managed?

## Find Helpful Resources



Visit the Brownfields Road Map website to identify and review resources and tools that provide details about technology applications, methods and other site-specific concerns.

## Plan Your Next Steps

After the cleanup is completed, consider the following courses of action:

| Result of Cleanup   | Course of Action   |
|---|--|
| Contamination has been adequately removed, contained or controlled.                           | Consult with the appropriate regulatory officials before you proceed with redevelopment activities.  |
| Additional contamination has been discovered.   | Consult with appropriate regulatory officials to determine how to proceed with cleanup activities. You may need to return to the Investigate a Site phase to conduct additional sampling to delineate the extent and nature of the contamination and assess the impact of additional characterization and cleanup costs on the overall viability of the project. |
| Long-term site monitoring and operation and maintenance (O&M) of the site remedy is required. | Return to the Investigate a Site phase to evaluate options, including cost considerations, for long-term monitoring and O&M, and as necessary collect after-performance samples for monitoring cleanup.  |

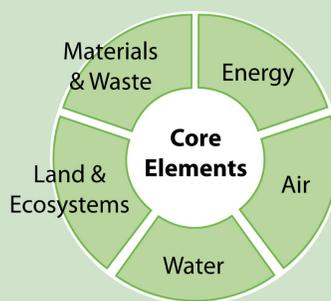
## Spotlight 10

## Greener Cleanups

Cleanup actions, while protective of the environment, also have their own “environmental footprint”—they use energy, water and materials. To reduce this footprint, cleanups can be performed in a “greener” manner by considering the environmental effects of remedy implementation and incorporating options to minimize the impact of cleanup actions. Principles of greener cleanup can be applied throughout the site cleanup process, although it can be advantageous to consider these options early to reduce the overall footprint of the project. The manner in which these technologies or approaches are implemented can produce greener cleanups. Greener cleanup BMPs can reduce environmental impacts while maintaining cleanup objectives and ensuring that the remedy is protective of human health and the environment.

### Core Elements of Greener Cleanups

- Reduce total *energy* use by improving energy efficiency and increasing use of energy from renewable resources.
- Reduce *air* emissions of greenhouse gases and criteria pollutants such as ozone, nitrogen dioxide and sulfur dioxide.
- Protect *water* resources and reduce water use.
- Reduce *waste* and improve *materials* management.
- Safeguard the *land and ecosystem* during site cleanup.



### Examples of Greener Cleanup BMPs to Consider for Brownfields Projects

- Buy local equipment and materials to minimize transportation costs.
- Use energy-efficient machinery or vehicles that use alternative energy.
- Provide an on-site collection and storage area for compostable materials for use on site or by the local community.
- Use uncontaminated wastewater or treated water for tasks such as wash water, irrigation, dust control and other uses.
- Consider renewable energy generation source development as a land reuse option.
- Reuse salvaged building materials in redevelopment construction.
- Explore production of energy on site to operate remedial systems.
- Perform a renewable energy assessment to identify how renewable resources could provide future energy needs.
- Incorporate low impact development (LID) techniques that view stormwater as a resource rather than a waste source.

### Examples of Sites Implementing Greener Cleanups

- Nitrate-contaminated groundwater at the Apache Powder site in Arizona was treated by recirculating it through a gravity-driven, constructed wetland system using a pump powered by solar energy.
- At the Grove Landfill site in Texas, salvaged site materials such as concrete and wood were reused on site for erosion control, mulch and fill, and a tractor powered by vegetable oil was used to remove on-site debris.

### Government Support of Greener Cleanups

The U.S. government encourages the consideration of environmental footprint reduction at many levels ranging from Presidential Executive Orders to Agency policies. Through *The Principles for Greener Cleanups*, issued by EPA’s OSWER, the EPA advances efforts to perform site investigation and cleanup in a manner that reduces the environmental footprint while maintaining primary cleanup objectives. In addition, each of the EPA’s 10 regional offices has its own “clean and green” policy encouraging the integration of green remediation practices into the cleanup process within their states and territories.

### Footprint Assessment Tools

A variety of tools, such as software models and calculators, are available to evaluate the environmental footprint of remediation processes. The Green Remediation Focus Footprint Assessment website ([www.cluin.org/greenremediation/subtab\\_b3.cfm](http://www.cluin.org/greenremediation/subtab_b3.cfm)) provides a summary of available tools, which includes the greener cleanup core elements addressed by the tool, the form in which the tool is available (web-based, decision software or decision matrix) and provides a link to additional information.

### For More Information

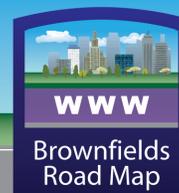
The Green Remediation Focus section of the EPA’s CLU-IN website at [www.cluin.org/greenremediation](http://www.cluin.org/greenremediation) provides information on integrating green remediation into cleanups and case studies that describe green remediation implementation.



Resources for this spotlight are available at [www.brownfieldstsc.org/roadmap/spotlight\\_gc.cfm](http://www.brownfieldstsc.org/roadmap/spotlight_gc.cfm).

# Appendices

[www.brownfieldstsc.org/roadmap](http://www.brownfieldstsc.org/roadmap)



View the appendices online at the Brownfields Road Map website

Home - Guide to Contaminants and Technologies

## Guide to Contaminants and Technologies

Use this guide to gain a better understanding of the range of technologies that may be appropriate for investigating and remediating contaminants found at typical brownfields sites.

The information is organized by Site Types, Investigation Technologies, and Treatment Technologies, which is cross-referenced by Contaminant Groups. Stakeholders can navigate among various site types, technologies, and contaminants to find information that is relevant to their site.

The information in this guide was obtained from various EPA sources, and is intended to provide general information about brownfields sites. It is not intended to be all inclusive, and detailed information about individual contaminants is not provided (for example, cleanup levels for contaminants). Contaminants and activities associated with common brownfields site types may not be relevant for every site. In addition, investigation and treatment technologies may not be appropriate in all situations. Stakeholders are encouraged to consult EPA or state officials, qualified professionals, and other sources of information when they proceed with redevelopment related investigation and remediation activities.

| Site Types  | Investigation Technologies                                  | Treatment Technologies                                | Contaminant Groups  |
|---|---|---|---|
| Which contaminants are associated with typical brownfields sites? | What technologies may be used to investigate contamination? | What technologies may be used to treat contamination? | What types of contamination are found at brownfields sites? |

## Appendix A – Guide to Contaminants and Technologies

The guide contains detailed information about the types of contaminants typically found at brownfields sites and the range of technologies that may be appropriate for assessing and remediating them. The guide will help stakeholders answer the following questions:

- Which contaminants are associated with brownfields sites?
- What technologies may be used to investigate contamination?
- What technologies may be used to treat contamination?

Information about site types, investigation technologies and treatment technologies is cross-referenced by contaminant group. Stakeholders can look up details about 7 general contaminant groups and more than 30 types of brownfields sites, explore technology options for investigating contamination and review many treatment technologies.

Home - Brownfields and Technical Support Contacts

## Brownfields and Technical Support Contacts

Brownfields stakeholders may contact individuals at state and EPA national and regional levels who are available to assist cleanup and redevelopment efforts at brownfields sites. The individuals are a valuable resource for brownfields stakeholders by providing support and guidance on applicable laws, regulations, and policies, and technical assistance associated with the selection of technologies.

State Brownfields Program Contacts

EPA Regional Brownfields Coordinators

EPA Regional Land Revitalization Coordinators

EPA Targeted Brownfields Assessments

EPA Technical Assistance to Brownfields Communities (TAB) Providers

Tribal Brownfields Programs

Argonne  
US Army Corps of Engineers  
The Brownfields and Land Revitalization Technology Support Center  
1-877-838-7229 (toll free)

EPA Contact  
Carlos Pachon  
Office of Superfund Remediation and Technology Innovation  
pachon.carlos@epa.gov  
703-603-9904

## Appendix B – Brownfields and Technical Support Contacts

The Brownfields and Technical Support Contacts page includes links to up-to-date information for individuals at state, tribal and EPA national and regional levels who are available to assist cleanup and redevelopment efforts at brownfields sites. The individuals are a valuable resource for brownfields stakeholders by providing support and guidance on applicable laws, regulations and policies and technical assistance associated with the selection of technologies.

Home - Acronyms and Glossary

## Acronyms

µg/L Micrograms per Liter

## Glossary

Jump to: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

**I** Top

**1, 4-Dioxane** 1,4-Dioxane is a man-made liquid that has many industrial applications, including use as a solvent for detergents, paints, lacquers; in the preparation of adhesives, inks, and coatings; and in processing petrochemicals, paper, pesticides, electronic components, and plastics. Common synonyms include dioxane, dioxan, p-dioxane, diethylene dioxide, diethylene oxide, diethylene ether, or glycol ethylene ether. 1,4-Dioxane is highly mobile and has not been shown to readily biodegrade in the environment.

**A** Top

**Adsorption** Adsorption is the adhesion of molecules of gas, liquid, or dissolved solids to a surface. The term also refers to a method of treating wastes in which activated carbon is used to remove organic compounds from wastewater. See also: *Carbon Adsorption*

## Appendix C – Acronyms and Glossary of Key Terms

A list of acronyms and a detailed glossary of specialized terms used in discussing and describing brownfields cleanup efforts is available on the Brownfields Road Map website.

