CHAPTER 9
Implementation of Cleanup Level Selection

9.1 Introduction to Selecting Cleanup Levels at EPA Removal and Remedial Residential Lead Sites

Due to significant site-specific variability, EPA's Superfund program does not set a national cleanup standard for lead in residential soil. Once EPA has determined that a removal or remedial action at a site is warranted under CERCLA, the Superfund program uses a consistent risk-based process by which residential soil lead removal and remedial cleanup levels are based on utilizing the IEUBK model with a target BLL (see CHAPTER 8).

At sites where lead in soil is a contaminant of concern, EPA Regions will determine whether actions to reduce lead exposure may be warranted under CERCLA. Once the determination has been made to address the lead contamination under CERCLA at a site, Regions should consider taking early actions to mitigate site risks by addressing the immediate risk posed to the current population, followed by longer-term actions to achieve site-wide protectiveness. Regions should also consider whether removal authority is appropriate at the site if current or potential elevated blood lead concentrations for children at specific residences, or elevated soil lead levels at or above the RML[110], may warrant a time critical removal.

When elevated BLLs are the basis for concern at either a home or site, occupational contributions of lead, elevated lead levels in drinking water, lead from nearby air emissions, and LBP dust in the homes should be assessed in addition to contaminated soil. These sources of lead can be significant and, in some cases, may be a greater contributor to elevated BLLs than contaminated soil. The IEUBK model can help determine if contributions by these other sources are significant. When this happens, consultation with regional risk assessors and public health officials (such as those at ATSDR and state/local health departments who can lead individual interviews and investigations) is recommended to better understand potential health impacts and identify alternative (non-CERCLA) resources to reduce exposure. While CERCLA may address many of the exposure pathways, there may be situations where other authorities should be considered.

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[110] https://www.epa.gov/risk/regional-removal-management-levels-chemicals-rmls.

Please note that unless all removal/remedial responses achieve unlimited use/unrestricted exposure (UU/UE) status, protectiveness is often achieved through some level of ICs as a component of the remedy (see Chapter 10 for more information).

The following sections describe some of the different strategies available should a CERCLA response action be warranted.

9.2 Applying Removal Management Levels (RMLs) and Establishing Preliminary Remediation Goals (PRGs)

9.2.1 Applying Removal Management Levels (RMLs) at Sites

The Emergency Response and Removal Program (Removal Program) has addressed lead contamination in the outdoor environment for decades and believes a consistent, scientifically defensible, and attainable lead contamination level could help streamline lead cleanups and provide clarity amongst EPA's suite of cleanup programs (*i.e.*, removal, remedial, and RCRA). The Removal Program encourages Regions, where appropriate, to use site-specific considerations, modeling (IEUBK), and analytical testing (IVBA assays) when developing their removal actions involving lead in soils. As lead contamination is ubiquitous in the United States, the Removal Program is sensitive to focusing EPA's limited resources on lead contamination that poses substantial danger to public health.

RMLs were developed to help the Agency identify sites where a removal action under CERCLA may be warranted. Although not necessarily protective for long-term exposures, RMLs are risk-based values commonly used to help define areas, contaminants, and conditions that may warrant a removal action at a site. RMLs do not account for site-specific information. Furthermore, RMLs are not *de facto* cleanup standards and sites where contaminant concentrations fall below RMLs are not necessarily "clean" and could warrant further action under the Remedial Program.

9.2.2 Establishing Preliminary Remediation Goals (PRGs) at Remedial Sites

CERCLA's remediation goal is to achieve protectiveness either through actions such as, but not limited to, excavation of lead-contaminated soil to meet protective media levels or the use of ICs/ECs to prevent exposure. The CERCLA remedial cleanup process includes developing PRGs as described in the preamble of the NCP as: "The preliminary remediation goals are concentrations of contaminants for each exposure route that are believed to provide adequate protection of human health and the environment based on preliminary site information" (55 FR 8712, March 8, 1990). In general, PRGs are based on risk or ARARs and TBC criteria.

As noted in the NCP:

> (i) *Establish a remedial action objective specifying contaminants and media concern, potential exposure pathways, and remediation goals. Initially, preliminary remediation goals (PRGs) are developed based on readily available information such as chemical-specific ARARs or other chemical information. Preliminary remediation goals should be modified as necessary, as more information becomes available during the RI/FS. Final remediation goals will be determined when the remedy is selected. Remediation goals shall establish acceptable exposure levels that are protective of human health and the environment (See 40 CFR 300.430(e)(2)(i)).*

A key concept is that a PRG is the average concentration of a chemical in an exposure area that will yield the specified "target risk" in an individual who is exposed at random within the exposure area (U.S. EPA 1991). For lead sites, the PRG is the average or arithmetic mean value. Site-specific factors such as current and reasonably anticipated future land use need to be considered to develop a protective level. Thus, if an exposure area has an average above the PRG, some level of response action may be warranted. (In some cases, the value set may be an NTE value.) However, in general, it may not be necessary to remediate all EUs with concentrations that exceed the PRG to ensure that the larger exposure area meets the protective level. Rather, in some situations, it may be appropriate to reduce the contaminant level such that the average concentration for a given EU be reduced to a protective level. Therefore, some concentration values in SUs within a larger exposure area may remain that are above the PRG, so long as the average PRG for the exposure area meets the protective level. The concentration value that is to be removed to reduce the mean to the protective cleanup level may be from a subset of SUs that comprise the larger exposure area.[111] In the case of lead, the risk assessor may determine a PRG by running the IEUBK model to recommend the concentration of soil lead that corresponds to the specified "target risk" set at a target BLL where the goal is to be below 5% probability of exceeding the target BLL (see Chapter 8 for more information). Whichever approach is taken – remediating all values above the PRG or remediating so that the average concentration in an EU meets the PRG – should be clearly explained in the decision documents for the cleanup.

For residential sites with lead contamination, risk-based PRGs should be calculated with the IEUBK model using existing, pre-remedial response action, site-specific data. PRGs for residential lead sites should be established to protect children from excess exposures to soil and house dust attributable to outdoor soil and are not necessarily applicable to exposures

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[111] Decisions about whether to use an NTE or average approach depends on the quantity and quality of site characterization data and the CSM.

attributable to other sources, such as interior LBP, which should be managed on a residence-specific basis (see Chapter 3 for information on collaboration). Any consideration to take a CERCLA response action at a residence that factors in the increased risk from sources other than outdoor soil needs to be a site-specific risk management determination taking into consideration CERCLA statutory limitations on response (see Chapters 2 and 3 for more information). Additional information on using the IEUBK model to calculate PRGs can be found in the Guidance Manual for the IEUBK model (U.S. EPA 2021b, 1994b).

The next step is to get assistance from regional risk assessor(s) to run the IEUBK model with applicable site-specific input to support the selection of a site-specific PRG corresponding to a user-specified target BLL. For lead soil contamination in residential areas, PRGs are generally associated with a target risk based on IEUBK model runs using site-specific exposure information (see Chapter 8 for more information). The PRGs are important in beginning to design an effective risk reduction strategy and are used to inform soil cleanup levels when action is warranted under CERCLA.

Remedial or removal actions to address outdoor soil contamination reduce the contribution of lead from soil in indoor dust over time (von Lindern et al. 2003). The IEUBK model-derived PRGs, however, are not the only factor in determining cleanup levels. For remedial actions, cleanup levels can be based on a variety of information inputs, including state and federal regulations that may constitute an ARAR, TBC criteria, IEUBK model results, and site-specific information such as area-wide background concentrations (U.S. EPA 1990b).

EPA recommends that a soil lead concentration for residential land use areas (residential EUs) be determined so that a typical child or group of similarly exposed children exposed to lead at this level would have no more than a 5% probability of exceeding the target BLL (note: the 5% risk acceptance value does not equate to five children out of every 100 exceeding the target BLL in the community. It is an estimate of risk based on a predicted distribution of BLLs). Selecting a soil lead PRG in this manner is not a guarantee that a given individual child will be below the target BLL. Many factors other than elevated soil lead concentration may contribute to elevated BLLs, including pica behavior and exposure to other sources of lead beyond the exposure scenario. Scenarios include LBP, diet (including supplements and spices), soil at a daycare facility, camping sites, or other areas frequented by the child.[112]

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[112] In addition to the individual residence, accessible lead sources outside the residential property, such as tailings piles, should also be evaluated to understand how these potential exposures contribute to the overall risk to children. When the evaluation indicates a significant contribution to risk, response measures should be evaluated for those areas.

9.3 Prioritizing Response Actions at EPA Lead Sites

Priority should be to take immediate action at properties with greatest risk.

Residential properties can move into a different priority scheme if conditions change (*e.g.,* young children or pregnant women move into a house).

At lead sites with many properties above the RML, RSL, and/or PRG, Regions should prioritize properties so those with the greatest risks are addressed first. The need for the Regions to take early action and prioritize response actions at residential properties may be based on the levels of lead detected, current exposure potential, presence of a susceptible receptor such as young children and pregnant women, or known elevated BLLs.

While having a consistent national approach to prioritizing properties is important, every site is different, and Regions may adjust the approach as appropriate on a site-specific basis. Further, because the size and complexity of many lead sites often warrants implementation of response actions over many years, early and interim response actions may be needed to manage short-term exposure and source area concerns. If removal actions are taken at remedial residential lead sites, consistent with the NCP, they should align with the planned objectives of remedial actions.

The soil lead concentration and receptors inform the prioritization process; however, other considerations (*e.g.*, environmental justice considerations, other non-soil sources of lead exposure from lead pipes, LBP, and/or lead air emissions, as well as data on background soil lead concentration) may also inform prioritization. The RPM or OSC should determine whether immediate action is needed. A removal action may be justified if soil concentrations are above EPA's lead RML. Properties at remedial sites with soil lead concentrations less than the PRG generally do not require further investigation.

9.3.1 Early Actions to Address Short-Term Exposures

Early response actions to protect young children can be an essential aspect of reducing risk at a site, as discussed above. This approach focuses on starting early risk reduction strategies for all portions of the community. These risk reduction strategies may be implemented through removal (TCRA or NTCRA) or remedial (*e.g.*, early action ROD) authorities. The specific strategy will vary, depending on the susceptibility of the receptor at risk, soil concentrations, stage of the project, and planning period necessary prior to initiating action. These actions should be coordinated with source controls to avoid recontamination. The following list includes, but is not limited to, examples of measures that may be used to reduce the potential for recontamination when scoping an early action:

- Evaluate the feasibility of conducting the cleanup of residential areas in their entirety during an early removal phase if contamination is widespread. If this is not possible, limit early removal actions to immediate risks (*e.g.*, residences with elevated BLLs) to minimize the potential for recontamination.
- Seek permanence in selecting the cleanup alternative(s), if possible, such as at properties where there is an acute risk (*e.g.,* complete removal to depth of soil contamination).
- Consider simultaneous cleanup of adjacent properties when not doing so might threaten the permanence or effectiveness of the early action.
- Use engineering controls (ECs) such as monitoring, water trucks, vehicle washing, etc. to control fugitive dust sources, access, tracking, and erosion of contaminants to the extent possible.
- Perform high-efficiency particulate air (HEPA) street sweeping to minimize tracking of contaminants throughout a community.
- Provide informational fact sheets to homeowners on how to minimize recontamination of their property.
- Establish ICs to manage cleaned areas with contamination present at the site (at depth) after the early action is taken. This could involve local and state government agencies, and PRPs that are available to recommend BMPs for homeowner projects and provide education to the homeowner, as well as utility districts and companies that may excavate contaminated material.
- Provide site plans or other documentation of areas that have been cleaned up, as well as information on areas that are still contaminated, to the local governmental entity responsible for the maintenance of the remedy (*i.e.*, for monitoring ICs and tracking properties over time and informing residents, including new or prospective residents, of contamination and associated ICs).
- Establish a GIS for monitoring ICs and properties for remedial actions.

See EPA’s *Policy on Management of Post-Removal Site Control* (40 CFR 300.415[l]) for additional information (U.S. EPA 1990c).

9.4 Application of Cleanup Levels

This section presents approaches on how to apply cleanup levels at a site and delineate which soil areas to remediate. In addition, this section provides remedial options to achieve the cleanup goal or RAO. The recommended approaches in this section provide information to inform and support risk management decisions towards achieving a risk reduction remedial goal.

9.4.1 Recommended Options for Implementing Cleanup Levels

This section discusses options for risk managers to implement cleanup levels. A key factor driving the choice between these options is the soil sampling design and basis for the cleanup level. The method used in implementing the cleanup should be compatible with the method used in establishing the cleanup level (including the DQOs for sampling and analysis). Another important factor is the nature and extent site assessment data. Therefore, consideration of the cleanup implementation should inform the sampling design and risk assessment. Further, the decision about which approach to take should be clearly explained in the decision documents for the cleanup. This section describes advantages and disadvantages as well as the appropriate use for the two options.

9.4.1.1 Key Factors

Exposure: The exposure assumptions made in determining which approach to use should be consistent with the exposure assumptions used in risk assessment and the determination of the EPC.

Size of EU: If the size of the EU is different pre- and post-remediation due to changes in the land use, the sampling may not be appropriate to support implementation of either approach. The change in land use could be from overgrowth being allowed (covering up previously sampled areas), trees and/or overgrowth being cleared (creating more area that was not previously sampled to potentially be exposed to), or a previously sampled area being paved over for parking, a pool installation, or a patio area.

Confidence in the Cleanup Level: If the cleanup level is the risk-based PRG and the EUs are well defined, then an area-wide average may be an acceptable approach. However, if the cleanup level is less “conservative” based on practical and technical considerations (*e.g.*, cost, implementability), then an area-wide average may not be an acceptable approach and a not-to-exceed approach is recommended.

Quality and Quantity of Site-Characterization Data: Confidence in the accuracy of the lead soil concentration data to represent soils that a receptor contacts over time may influence the decision on which approach to use.

9.4.1.2 Not-To-Exceed (NTE)

The NTE option typically entails treating or removing all soil DUs with contaminant concentrations that exceed the cleanup level. Implementing the cleanup level as an NTE value normally means that soil removal or treatment will continue until the analysis of soil samples (including step-out samples) indicates that the EPC from a DU will have soil contaminant concentrations below the cleanup level. After remediation is complete, the highest remaining concentration within any DU within an EU should be at or below the cleanup level, and the post-remediation EPC (average or UCL) within the EU should be lower than the cleanup level. If the risk-based PRG chosen by the risk manager is the cleanup level, then applying it as an NTE level should result in a post-remediation EPC that is below this protective level (see U.S. EPA 2005b for more information).

9.4.1.3 Area-Wide Average

The area-wide average approach assumes random exposure within the EU; all areas (including clean areas) within the EU should be included in the calculation. This approach is specifically intended for situations where adequate site characterization data are available. Implementing an area wide averaging cleanup approach requires more sampling information (*e.g.*, smaller SUs and DUs within an EU).

Where multiple exposure scenarios over different spatial scales are being assessed, it is generally recommended to use the smallest EU or DU relevant to the risk assessment or remedial decision. EUs evaluated are no larger than an individual property. For example, a residential property may be one potential EU, which includes a garden and a play area where receptor behaviors may be focused. Sampling to assess the average of a larger EU may not be adequate to achieve DQOs for smaller EUs. However, there are robust statistical methods to calculate an area-weighted average for a large EU based on the average, variance, and skewness of data from smaller EUs. In the example above, small EUs for the play area, garden, and the remainder of the yard could be sampled, and area-weighted statistics for stratified sample designs could be used to assess exposure across the yard as a single large EU.

The area-wide average approach involves remediating the areas of the EU with the highest lead concentrations until the post-remediation EPC for the EU is at or below the cleanup level. In some cases, such as when EPA would like to control both false compliance and false exceedance error rates or control the uncertainty in making multiple statistical decisions, it may be appropriate to use statistical comparison. A statistician should be consulted at both the sample planning and data analysis stages to ensure that an appropriate sample design and statistical methodology is used.[113] These approaches normally require establishing a cleanup level that is the post-remedial EPC and making a statistical determination of a remedial action level (RAL). The RAL is the level to which lead soil concentration within an EU is reduced to ensure that the post-remediation EPC for the EU does not exceed the cleanup level. The method to determine the RAL should be compatible with the method used to determine the EPC. Because the area-wide average approach may result in some high concentrations being left in place, risk managers should work with risk assessors to ensure that the remediation plan is compatible with long-term protectiveness (including consideration of potential land use changes [*e.g.*, a future resident placing a garden or swing set on the high DU], future occupants, and the potential for contamination of adjacent DUs through the movement of fine particles on the surface).

Classical statistical and geostatistical methods are generally available for calculating RALs when implementing cleanup levels as area-wide averages. The study design and spatial bias of the sample locations are a critical consideration in selecting an appropriate statistical method. Sample designs with no spatial bias (either random sampling or sampling on a grid of equal sample density across the EU or DU) greatly simplify the data analysis. Classical statistical approaches should only be selected if there is no spatial bias in the sample locations. If there is no spatial bias in the sample locations, these methods are generally appropriate regardless of the presence of spatial patterns or spatial autocorrelation. If there is spatial bias in the sample locations, a spatially weighted approach should be used. This requires an interpolation method to generate spatial weights and to appropriately account for spatial relationships and spatial autocorrelation, in addition to accounting for the variance and skewness of the data. Such methods are referred to as geostatistical methods and are generally more rigorous. Geostatistical methods may be used to account for the relationship between the contaminant concentrations and the size, receptor behavior, location, and geography of the EU. An alternative to area weighting is to apply time weighting to the DUs within an EU based on known or reported behavior of receptors.

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[113] pbhelp@epa.gov.

Three statistical methods that have been suggested for use in implementing an area-wide average approach to cleanup sites:

1. **Iterative Truncation Method**

    - Order sampling data from lowest to highest concentration.
    - Starting with the highest concentration, remove a sample and replace it with the post-remediation concentration, usually defined by the expected concentration in fill material.
    - Recalculate the UCL of the post-remediation EPC for the new data set and compare the EPC to the cleanup level
    - If the UCL of the post-remediation EPC is higher than the cleanup level, repeat the process until the UCL is less than or equal to the cleanup level.
    - When the UCL of the post-remediation EPC in the data set is less than or equal to the cleanup level, the highest sample concentration remaining in the data set is designated as the RAL.

2. **Confidence Response Goal Method**

    - Function of the mean (average) and standard deviation of contaminant compared to the cleanup level.
    - The UCL of the post-remediation distribution is calculated from the average and variance of the unremediated portion with the pre-remediation data distribution and the assumed clean fill concentrations throughout the remediated portion (spatially weighted as appropriate when sample locations are spatially biased).
    - Based on the assumption of lognormality of contaminant concentration.
    - Requires statistical expertise.

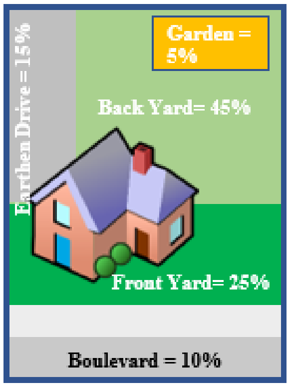
3. **Geostatistical Method**

    - Requires geostatistical expertise.
    - Estimates means, variances, and skewness within areas (*e.g.*, gridded surface, or polygons) designated by the user.
    - In most cases, can accommodate biased data. Note: step-out samples are an extreme form of spatial bias. While they are useful for characterizing the extent of contamination, they create a bias in average and UCL calculations that cannot be corrected by geospatial methods

- Requires initial analysis to determine whether a transformation of data is warranted.
- Produces variograms.
- The EPC for each EU is determined by superimposing an interpolated data grid on the site map.
- Calculating the UCL cannot be done using the interpolated data because interpolation smooths the variance of the data and produces an artificially low UCL. The UCL calculation should be done using the spatial weights created by the interpolation method and applying them to each data point to calculate the weighted UCL. Note: ArcGIS software will calculate a weighted average and a UCL. However, a statistician should be consulted to ensure that the UCL was calculated appropriately and did not use the interpolated data grid.
- An iso-concentration map is used to identify EUs that must be remediated to reduce UCLs of the EPC to less than or equal to cleanup levels and is repeated until the RAL is achieved.
- The original iso-concentration map is used to define zones with concentrations greater than the RALs.

See Figure 9-1 for an example of implementing the area-wide average approach to implementing cleanup goals.

Figure 9-1. Example of an Approach for Area Weighted Average (AWA) for Lead

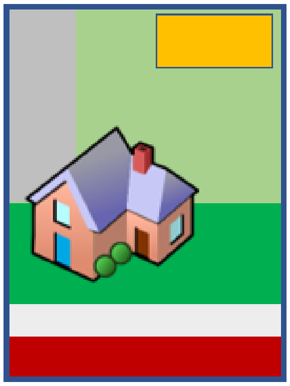


Exposure is related to concentration and to how often contact is made with that concentration. **Areas with discrete direct surface soil contact with elevated lead (hot spots) in a property may be of concern. However, if the *overall* average lead concentration to the surface soil (what is known as the AWA) is below the cleanup level, this may be acceptable.**

To calculate the AWA, the concentration for each yard component is multiplied by the percentage of the yard covered by that component. The results of all components are added to get the **AWA** for the property.

Let's look at some examples of what areas would and wouldn't be recommended for clean-up using the **AWA** and **a lead cleanup level of 250 ppm**. We'll track what happens when different yard components are given a value of 450 ppm lead. In these examples, red indicates areas of elevated lead. Although some yard components exceed the lead cleanup level in each example, cleanup is only recommended in two cases. Example #3 illustrates that the AWA is greater than the lead cleanup level of 250 ppm. Example #4 illustrates that when there is a scenario where there are high contact rates and high intensity activity such as a gardening scenario, a risk management decision may warrant cleanup. **Please note: the example cleanup level and other concentrations are for illustrative purposes only.**

Example #1



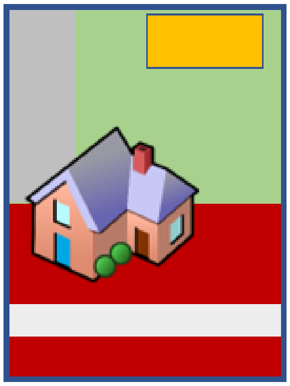
Boulevard = 10% x **450** ppm
Front yard = 25% x 100 ppm
Back yard = 45% x 150 ppm
Drive = 15% x 90 ppm
Garden = 5% x 110 ppm

AWA = 158* ppm

Lead in this boulevard is greater than the cleanup level, *but the AWA does not exceed the cleanup level.*

Cleanup NOT Required
Overall risk does not exceed acceptable limits

Example #2



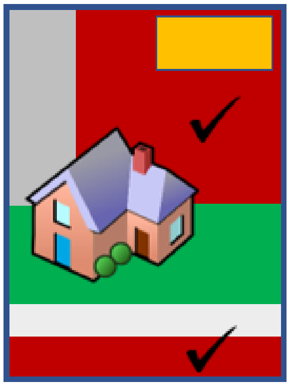
Boulevard = 10% x **300** ppm
Front yard = 25% x **450** ppm
Back yard = 45% x 150 ppm
Drive = 15% x 90 ppm
Garden = 5% x 110 ppm

AWA = 231* ppm

Lead in this boulevard *and* front yard is greater than the cleanup level, *but the AWA does not exceed the cleanup level.*

Cleanup NOT Required
Overall risk does not exceed acceptable limits

Example #3



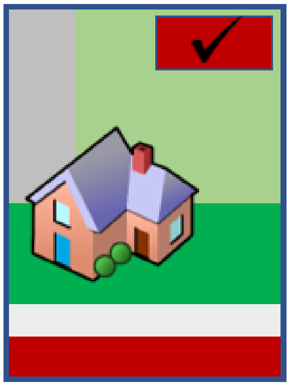
Boulevard = 10% x **300** ppm
Front yard = 25% x 100 ppm
Back yard = 45% x **450** ppm
Drive = 15% x 90 ppm
Garden = 5% x 110 ppm

AWA = 278* ppm

The AWA here exceeds the lead cleanup level. The boulevard and back yard *also exceed the cleanup level.*

Cleanup Recommended
Back yard and boulevard ✓

Example #4



Boulevard = 10% x **300** ppm
Front yard = 25% x 100 ppm
Back yard = 45% x 150 ppm
Drive = 15% x 90 ppm
Garden = 5% x **450** ppm

AWA = 160* ppm

All garden soil that exceeds 250 ppm lead will be removed. However, *the AWA does not exceed the cleanup level.*

Cleanup ✓ **Recommended Garden**

*The math, for those who want to check: Ex. 1 (45+25+68+14+6=158), Ex. 2 (30+113+68+14+6=231), Ex. 3 (30+25+203+14+6=278), and Ex. 4 (30+25+68+14+23=160)

9.4.2 Evaluating Soil Cleanup Technologies

EPA's Office of Research and Development (ORD) Superfund Technical Liaisons (STLs) may be contacted for accessing resources for your site.[114] Historically, the most commonly selected response actions for lead contamination in a residential area are: (1) excavation of contaminated soil from 0 to 12 inches bgs or to 24 inches bgs[115] followed by covering the excavated area with clean soil and/or other material to return yard to grade; and (2) placement of a material that provides a direct exposure barrier (*i.e.*, cover) without any excavation of contaminated soil. Excavation followed by the replacement of clean soil or other material may leave contamination at depth that exceeds residential cleanup levels. In those cases, a visible marker or barrier (*e.g.*, orange snow/construction fencing) is generally recommended to be placed below the clean fill to signify contamination at depth and/or prevent upward migration of contaminated soil.[116]

The evaluation of the application of fill or cover materials should consider the route of exposure (direct contact only or infiltration concerns), operation and maintenance (O&M) viability, responsibility and costs, site drainage considerations, and long-term reliability. ICs should be considered for long-term protectiveness if soil contamination remains that exceeds the protectiveness level (see Chapter 10). Any ARARs must be met or waived.

9.4.3 Minimum Excavation Depth/Soil Cover Thickness

A minimum of 1 foot (12 inches) of clean soil is generally recommended for protection of human health for the direct contact of soil.[117] Frost heaving or other routine or potential disturbances to the surface (*i.e.*, gardening or frequent athletic use) may call for greater depths of clean soil. Cover soil can either be placed after excavation as backfill or on top of the contaminated yard soil. However, if backfill is placed on top of the contaminated soil, erosion of the fill should be taken into consideration in the long-term effectiveness of the cover. Except for gardening, typical activities do not disturb soil >12 inches bgs. Mitigation measures for any infrequent activity (*e.g.*, building a structure, planting large trees) that may disturb soil below 12 inches can be addressed by implementing site-specific ICs, such as deed restrictions or a property notice, or environmental covenants.

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[114] See https://www.epa.gov/land-research/superfund-and-technology-liaison-program.

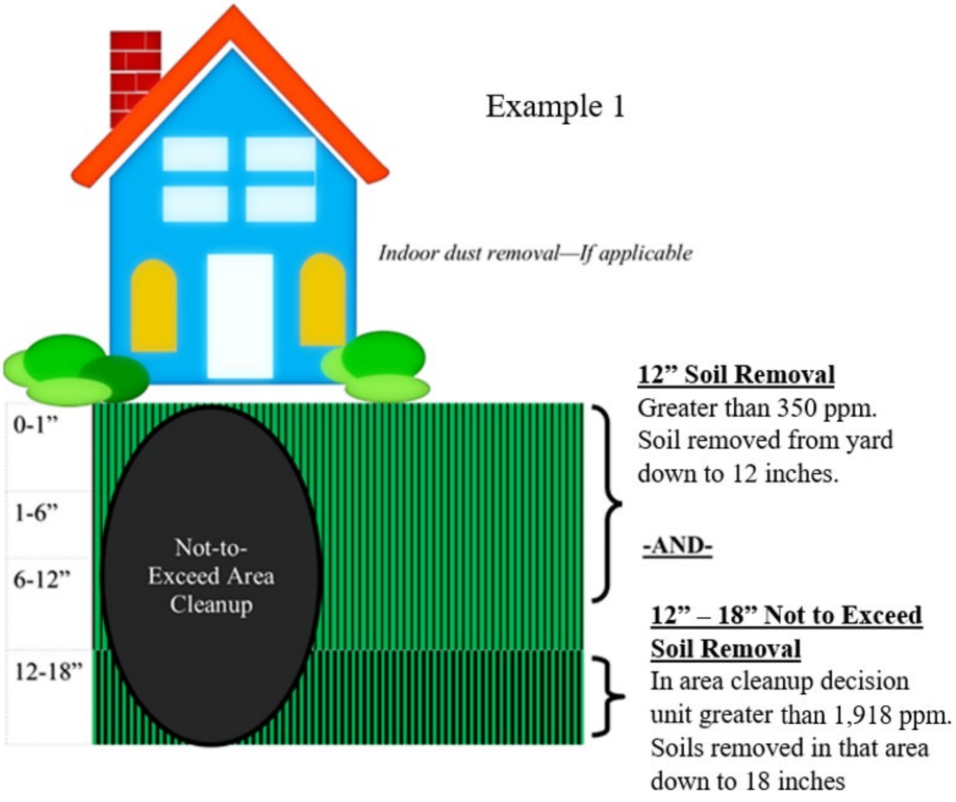
[115] Considered to be the depth for direct contact human health exposure.

[116] https://semspub.epa.gov/work/06/901287.pdf.

[117] Note: there may be state ARARs for clean fill depth.

The decision to perform soil cleanup to depths greater or less than 12 inches should be considered on a site- or property-specific basis. However, there are many properties at which lead contamination is located at depth. Full vertical soil cleanup may not be cost-effective and/or feasible at such properties. Potential for freeze/thaw upward migration, groundwater contamination, and the cost, extent, and effectiveness of ICs are some of the factors that should be considered. In Figure 9-2[118], Example 1 illustrates a hypothetical site where the receptor contacts the top 12 inches of soil. The first step evaluates contamination levels from 0 to 12 inches and evaluates each average contamination level at each soil horizon: 0-1, 1-6, and 6-12 inches. Soil cleanup is recommended when the average for any of these intervals from 0 to 12 inches exceeds the corresponding cleanup level. The second step addresses remediation of soil hotspot contamination above the NTE cleanup level. Soil hotspots exceeding the NTE at any depth sampled should be removed to a maximum depth of 18 inches.

Figure 9-2. Examples of Potential Alternative Soil Lead Cleanup Scenarios for Subsurface Soil Contamination



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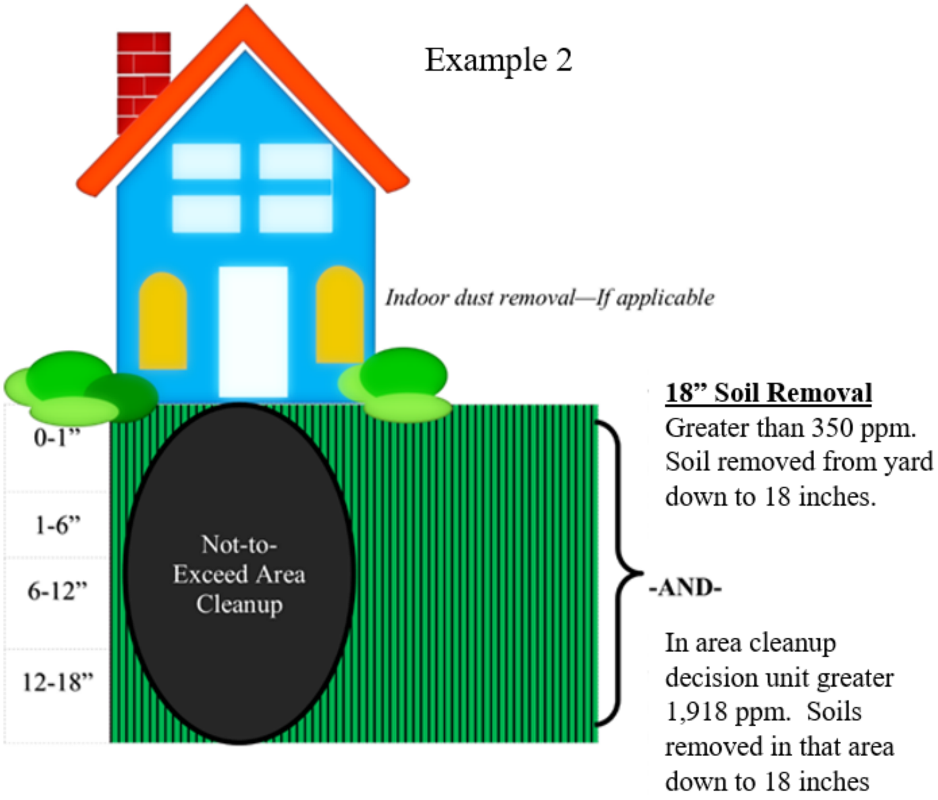
[118] The cleanup levels are for illustrative purposes and based on possible site-specific exposure scenarios.



Example 2 illustrates that the first step evaluates contamination levels from 0 to 12 inches and evaluates each average contamination level at 0-1, 1-6, 6-12, and 12-18 inches. Soil cleanup is recommended when the average for any interval from 0 to 18 inches exceeds the corresponding cleanup level. The second step addresses remediation of soil hotspot contamination above the NTE cleanup level at any depth sampled. The recommendation for any such hotspot contamination is removal to a maximum depth of 18 inches.

Full vertical removal of residential soil avoids costs of maintaining the soil cover, placing subsurface barriers and markers, and obtaining environmental easements (*i.e.*, ICs). Full removal also satisfies EPA's preference for permanent remedies and normally allows the remediated yard to return to unrestricted use.

Gardening scenarios normally consider direct contact to contaminated soil down to 2 feet bgs. Therefore, 2 feet of soil cover is generally recommended for vegetable gardens; however, site-specific conditions warranting more or less soil cover (*e.g.*, presence of burrowing animals) should be considered, depending on the difference between the EPC, cleanup level, background, and lead content of the replacement soil. The use of raised gardens may be a cost-effective response, adding 2 feet of clean soil to garden areas (see Chapter 6 on gardening for more information) and may be attractive to the residents.

When considering the use of mulch, sod, or other vegetation as part of the response, the OSC/RPM should determine that such use would not preclude property owners from full utilization of their property (*i.e.*, placement of a garden or swing set). Vegetative options generally may be considered to augment the remedy (*e.g.*, as dust control for areas where there is no direct exposure), but these are generally not considered protective as stand-alone remedial options. Since digging may still occur in these areas or the vegetation may die, potentially resulting in unacceptable exposures, a visible barrier should be placed below the application of the cover materials where utilized.

9.4.4 Examples of Implementing Cleanup Options

This section describes the implementation of two cleanup options that should be considered in conjunction with the results of the sampling efforts:

(1) Excavation and backfill (and placement of a visible subsurface barrier if applicable); or

(2) Soil cover placement (and placement of a visible subsurface barrier if applicable).

The options should be performed as described below (see also Figure 9-3). The goal should be to remove all contaminated soil or provide a minimum 12 inches of clean soil cover.

The following describes the implementation of an excavation and backfill remedy:

- If any soil down to 6 inches exceeds the cleanup level, a 6- or 12-inch excavation is recommended, depending on the 6- to 12-inch sample horizon results;
- If the 6- to 12-inch horizon exceeds the cleanup level, a 12-inch excavation is recommended. A visual subsurface barrier should always be used if the 12- to 18-inch horizon exceeds the cleanup level;
- If any soil down to 6 inches exceeds the cleanup level and the 6- to 12-inch horizon does not exceed the cleanup level, a 6-inch excavation is recommended; a visual subsurface barrier is not recommended.

The following describes the implementation of a soil cover remedy:

- If any soil down to 6 inches exceeds the cleanup level, a 12-inch soil cover and visual barrier should be used;
- If the 6- to 12-inch horizon exceeds the cleanup level (but not the 0- to 1-, 1- to 6-, or 0- to 6-inch intervals), a 6-inch soil cover should be used;
- If only the 12- to 18-inch horizon exceeds the cleanup level, capping is not recommended.

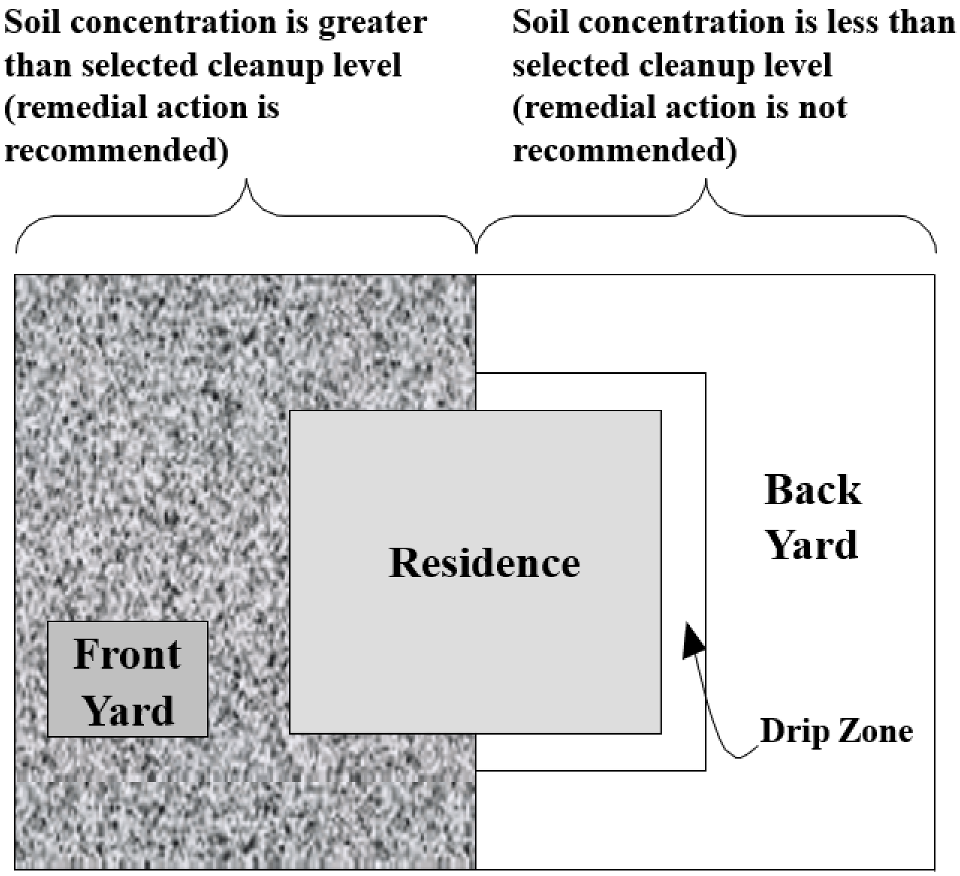
Figure 9-3. Example Interpreting Sampling Results

	Depth	Soil Concentration Exceed Action Level?							
	0-1”	Yes	Yes	Yes	Yes	No	No	No	No
	1-6” (or 0-6”)	Yes	Yes	No	No	No	Yes	No	Yes
Remedial Action Options	6-12”	Yes	No	Yes	No	No	No	Yes	Yes
Option 1: Excavation (& Backfill)	Depth of excavation	12”	6”	12”	6”	No action	6”	12”	12”
Option 2: Capping	Soil cover thickness	12”	12”	12”	12”	No action	12”	6”	12”

The figure shows remedial action recommendations based on the results of composite soil samples collected for each of the depth intervals shown. The figure includes two remedial action options: (1) excavation followed by backfilling, and (2) placement of a clean soil cover without removal of soil that exceeds the action level. To use the figure, find the column of the table that agrees with the soil sample results for your site, then read down the table to determine the recommended depth of soil to remove (option 1: excavation remedies) or the thickness of the recommended soil cover (option 2: capping remedies). For example, the heavy border around the third column of the table corresponds to a situation where the lead concentration in the 0- to 1- and 1- to 6-inch depth intervals exceed the action level, but the 6- to 12-inch interval does not. In this example, it is recommended to remove the top 6 inches of contaminated soil and replace it with clean soil, or to place a 12-inch clean soil cover (cap). The goal is to provide a minimum 12-inch barrier of clean soil when the underlying soil exceeds the action level.

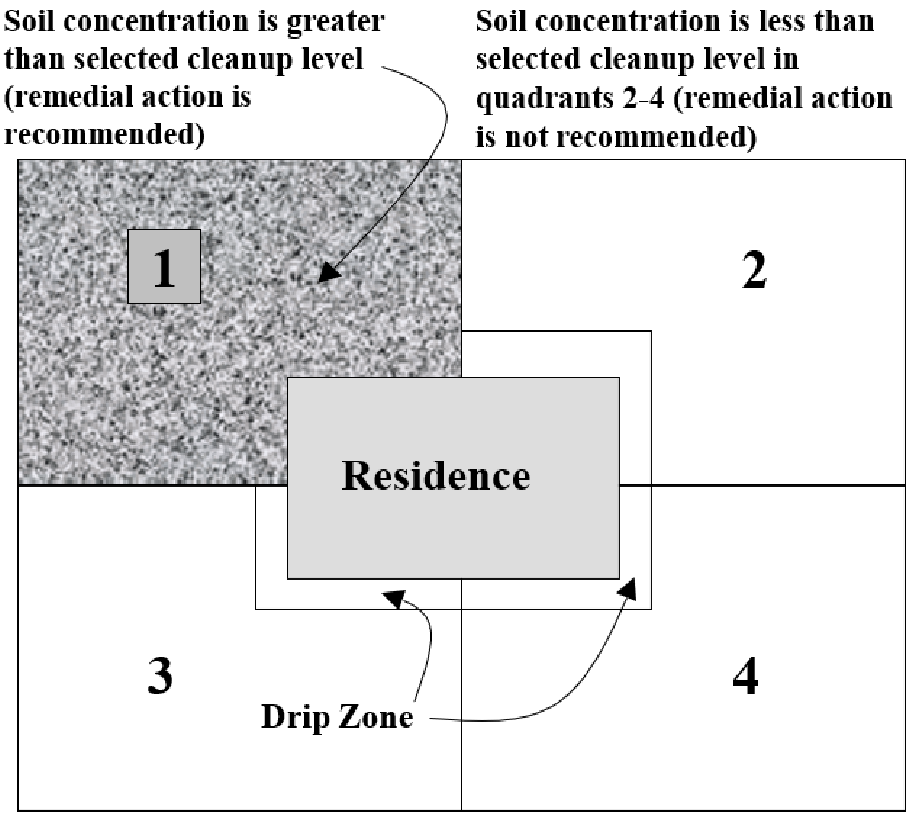
Sampling results obtained for residential lots may indicate that only a portion of the lot contains soil that exceeds the selected cleanup level. Although it will depend on relevant site-specific factors such as the actual square footage of the residence, properties could be divided into multiple SUs and DUs for remedial decisions. For example, for properties <5,000 square feet, the recommended spatial scale for the remedial decision should be one-half of the yard. For properties >5,000 square feet, the property may be divided into four quadrants and a remedial decision should be made for each quadrant. It is usually protective to excavate only the portion(s) of the lot that exceed the cleanup level (Figures 9-4 and 9-5). However, in such a scenario, removal of the sod layer and re-sodding/reseeding the unexcavated portion(s) of the lot is strongly recommended to promote consistency in the vegetative cover of the yard to help address homeowner satisfaction and community acceptance.

Figure 9-4. Partial Cleanup of Residential Lot Less than or Equal to 5,000 Square Feet in Size



In this hypothetical example, the lead concentration measured in the front yard exceeds the selected cleanup level while the concentration measured in the backyard does not. The entire drip zone should be cleaned up if the average lead concentration exceeds the cleanup level. The drip zone in the back yard (as well as the front yard) should be cleaned up if the average concentration in the drip zone exceeds the cleanup level.

Figure 9-5. Partial Cleanup of Residential Lot Greater than 5,000 Square Feet in Size



In this hypothetical example, the lead concentration measured in quadrant 1 exceeds the selected cleanup level while the concentration measured in quadrants 2-4 do not. Cleanup may be limited to quadrant 1, although it is recommended that the sod layer in the entire lot be removed to promote consistency in the vegetative cover on the property for homeowner satisfaction and community acceptance. The entire drip zone should be cleaned up if the average lead concentration exceeds the cleanup level. For example, in the above figure, the drip zone in quadrants 2-4 (as well as quadrant 1) should be cleaned up if the average concentration in the drip zone exceeds the cleanup level.

If the only portion of the yard that exceeds the selected cleanup level is the drip zone, the exterior paint should be checked for lead content (see Section 6.7). If the drip zone contamination does not appear to be paint-related, the drip zone should generally be cleaned up if action is taken under CERCLA. If the drip zone contamination appears to be solely paint-related, EPA should promote the remediation of the exterior LBP by local health agencies, other local government agencies, state health agencies, and/or the homeowner. At a minimum, the resident should be notified and informed of relevant disclosure requirements (Appendix M). The Superfund site team (or other identified convener) should notify and collaborate with the relevant EPA programs, and state, territorial, tribal, and local government agencies, as appropriate. For this reason, separate sampling or avoidance of drip zone soils should be addressed by the QAPP and associated field sampling plan.

9.5 Yard Excavation Cleanup Specifics

The steps of a typical soil cleanup are shown in the text box below.

Steps of a Typical Soil Response Action

Step 1 (Consent to Access) - Collect access consent form(s) from each owner (or tenant, if necessary) before any work is conducted (see Appendices F and G). Access from the tenant or renter is likely not sufficient. If questionnaires requesting information on indoor lead sources have not yet been provided, need to be updated, or are otherwise incomplete, these may also be provided with the access agreement.

Step 2 (Initial Survey) - Interview the owner/resident(s) to determine if there are any specific problems that need attention, and if there are any structures or property the owner wants left untouched. The contractor will conduct a thorough documentation of the property using drawings, digital photographs, and digital video. Once documented, the owner should sign a property agreement that documents any special requests or considerations in cleaning up the yard, any contaminated yard areas that will not be cleaned up, provisions for structural concrete and fence restoration, and deviations from strict soil excavation and capping.

Step 3 (Excavation) - Each tract is excavated by the contractor(s), who will also complete documentation and provide depth confirmations. Ensure that documentation meets any technical requirements needed for the particular site-specific situation.

Step 4 (Backfill) - After excavation of properties where full excavation to depth has been performed, the excavated area is backfilled and compacted. After excavation of properties with a vertical excavation limit, a permanent, permeable barrier/marker may be placed in the excavated area. After placement of any barrier/marker, the excavation area is backfilled and compacted (see Section 13.1).

Step 5 (Restoration) - Restoration of the property, including landscaping, sod/seeding, fencing, stone, and concrete (as needed) is conducted.

Step 6 (Final Inspection) - After restoration activities are complete, EPA or its agent (*e.g.*, Army Corps of Engineers) will conduct a final inspection.

Step 7 (Closeout Form) - A property closeout form should be signed by the property owner, which documents that the owner is satisfied with the remediation of the property. Any outstanding issues between the EPA and the homeowner that have not been fully resolved should be documented in the closeout form.

Step 8 (Cleanup Documentation Letter) - After the property owner signs a property closeout form, EPA documents its actions by issuing a letter to the owner, which documents that the property has been remediated. Any areas that are not cleaned up via the owner's request, such as gardens, should be noted in the letter. Additionally, a map and photos of areas left and/or where marker layers/ barriers were placed should be included. For properties where contamination is not completely removed, the cleanup letter should also document, if applicable, the presence of contamination at depth, and should describe any protective measures (including ECs or ICs) that were taken to prevent exposure to the remaining contamination (*i.e.*, barriers/markers).

It is important to define the properties that will be remediated during a response. The use of property boundaries rather than temporary features, such as a fence, to delineate boundaries is recommended. The use of temporary features may confuse remediation contractors and result in the partial cleanup of some properties and increases the chance of trespassing on adjacent properties.

It is the responsibility of the RPM or OSC to make site-specific recommendations regarding yard size limitations, and whether to clean up empty lots and other sources of lead (*e.g.*, alleyways). The remedial approach should be based on the reasonably anticipated land use as discussed in the May 25, 1995, memorandum entitled, *Land Use in CERCLA Remedy Selection Process* (Directive 9355.7-04 [U.S. EPA 1995a] and the March 17, 2010, memorandum entitled, *Considering Reasonably Anticipated Land Use and Reducing Barriers to Reuse at EPA Lead-Superfund Remedial Sites* (Directive 9355.7-19). In general, "remedial [action] objectives should be developed in order to develop alternatives that would achieve cleanup levels associated with the reasonably anticipated future land use over as much of the site as possible" (see page 6, U.S. EPA 1995a).

9.5.1 Yard Cleanup: Development and Screening of Alternatives

Whether remediation consists of placement of a soil cover, excavation and placement of a soil cover, or another technology, consultation with the property owners is important to the development and implementation of response actions and may necessitate property-specific deviations to the guidelines listed in this section. Table 9-1 illustrates an example of an evaluation of various remedial options. The evaluation criteria in development and screening of remedial alternatives are as follows:

- Effectiveness – The effectiveness evaluation focuses on the potential effectiveness of the process options in handling volume of soils or areas of concern and meeting the RAOs, the potential risk to human health and the environment during implementation, and how proven or reliable the technology and process is for handling contaminants at the site;

- Implementability – The implementability evaluation examines the technical and administrative feasibility of implementing a technology and process option; and

- Cost – The cost evaluation looks at relative capital costs rather than detailed estimates. Engineering judgement is used to determine whether the costs associated with each process option are high, medium or low relative to other process options under that technology type.

Table 9-1. Development and Screening of Remedial Alternatives: Example of Site-Specific Evaluation of Remedy Components and Process Options for Residential Soil

General Remedy Components for Residential Soil	Remedial Technology Types	Process Options	Short- and Long-Term Effectiveness	Implementability	Relative Cost	Option Retained?
Containment controls	Engineered cover	Soil cover	Moderate	Low	Moderate	No
		Soil-clay cover	Moderate	Low	Moderate	No
		Asphalt cover	High	Low	High	No
		Concrete cover	High	Low	High	No
		Synthetic membrane	High	Low	High	No
Migration controls	Surface controls	Grading, revegetation, erosion controls	Low	Moderate	Moderate	Retained for use in conjunction with other process options
Soil removal/ replacement	Excavation	Conventional earth moving	High	High	Moderate	Yes
	Onsite disposal	Construct onsite waste repository	Moderate	Low	Low	No
	Offsite disposal	Dispose at appropriate landfill	High	High	Moderate	Yes
Soil treatment	Chemical treatment	Soil amendments	Low	Moderate	Low	No
	Physical treatment	Soil tilling	Moderate	Moderate	Low	No

Containment controls are engineered barriers that limit exposure to, and the potential mobility of, soil or waste. Typical process options for containment include engineered soil cover, soil-clay cover, asphalt cover, concrete cover, and synthetic membrane cover. Soil and soil-clay covers are somewhat effective provided they are appropriately maintained. Asphalt, concrete, and synthetic membrane covers may be highly effective when long-term maintenance is applied. Covers are difficult to install and maintain over small, non-contiguous areas such as residential properties or portions of yards, making the implementability of these options low for this example site. Cost to construct and maintain soil covers is relatively low, costs for soil - clay covers are medium, and costs to install and maintain asphalt, concrete, or synthetic covers are relatively high. Although there are advantages and disadvantages to each of these containment process options, all require significant long-term maintenance to be effective. Because of this, covers are not retained for further consideration in this example site.

Migration controls reduce the movement of contamination from source areas into the surrounding soils. Surface controls are the only migration control technology considered in this site example. Process options for surface controls include grading, revegetation, and erosion protection. These options are generally employed in concert at larger sites to reduce the amount of precipitation coming in contact with contaminated soils or wastes. Grading, erosion control, and revegetation can be effective in reducing the migration of contaminants away from source areas; however, the soil disturbance associated with grading and establishing new vegetation could expose workers or neighbors to airborne dust containing unacceptable levels of lead. Stormwater flow is considered when grading would be employed both to protect the replaced soil from erosion and to ensure that there are not negative impacts to neighboring properties. Stormwater drainage controls may be required as part of this response action in this example site. Surface controls require ongoing maintenance to remain effective in the long term. O&M considerations make the effectiveness of surface controls low when considered as a stand-alone option. Ultimately, grading, revegetation and erosion control are retained to be used in conjunction with soil removal and replacement options for residential areas in this example site.

Soil removal and replacement is a three-stage process involving excavation of contaminated soils, disposal of excavated materials, and replacement with clean soils. In some cases, where contamination is left in place below the depth of the excavation, a visible barrier material will be placed, such as snow fence or geotextile. Conventional earth moving refers to the variety of excavation techniques that may be employed for moving soil utilizing hand tools and/or heavy equipment as space allows. Removal and replacement are highly effective at preventing or reducing long-term exposures to soils containing unacceptable levels of lead, even though excavation activities may result in short term impacts such as dust generation and disturbance to vegetation. At some properties, exterior painting may be appropriate to encapsulate peeling or chipping LBP, which has the potential to impact the soil remedy. If all site-related contamination above levels that allow for UU/UE is removed, there are generally no ongoing O&M requirements that must be considered for soil removal and replacement. However, if sampling data indicate that some contamination will be left in place at depths greater than the prescribed excavation depth, there may be ongoing O&M requirements and ICs (*i.e.*, placement of snow fence or geotextile barrier) to be considered for soil removal and replacement. Soil removal by excavation is readily implementable and is retained for further consideration in this example.

Process options for disposal of contaminated soils or wastes are onsite and offsite disposal. Onsite disposal involves building a waste repository onsite near the location of original waste generation and moving contaminated soils to that repository. Designing and building a waste repository can be a very long process, which lowers the short-term effectiveness of this option. When construction of an onsite repository is a viable option, it can be highly effective at reducing exposures to waste in the long term and can be less costly than offsite disposal. Whether onsite disposal is a viable option depends on current site ownership, land use, topography, the volume of waste to be disposed of, and the available area(s) onsite appropriate for a waste repository. Significant time and effort may be required to identify an area suitable for a waste repository and to negotiate with landowners for consent for EPA to design and build a repository at a given location. These factors may prevent onsite disposal from being implemented in a timely manner. For purposes of this example, it was determined that significant time and effort would be required to identify a suitable area for a waste repository and to negotiate consent agreements with landowners. For these reasons, onsite disposal of waste was determined not to be implementable from a technical or administrative standpoint at this example site and is not retained for further consideration.

Offsite disposal at a landfill is a protective option for disposing of wastes that pose an unacceptable risk to human health or the environment. Landfills may be RCRA Subtitle C facilities or sanitary landfills depending on the nature of the waste to be disposed. Offsite disposal is an effective, proven, and reliable option for reducing human contact with soils containing unsafe levels of arsenic and/or lead. Offsite disposal is readily implementable and is retained for further consideration when developing and screening remedial alternatives at this example site. Two primary treatment technologies were evaluated for potential use at the example site, including chemical treatment (soil amendment) and physical treatment (soil tilling). The process option considered for chemical treatment is the application of phosphate soil amendments. Phosphate stabilization is a procedure in which phosphate salts or acids are physically mixed into soil. This chemical additive can reduce the bioavailability of lead in soil below levels that are unsafe for human exposure. However, phosphate would not impact the bioavailability of arsenic or other metals in soil. Phosphate addition has the potential to increase the solubility of some metals, most notably arsenic, as discussed in the EPA's June 2015 *Phosphate Amendment Fact Sheet* (U.S. EPA 2015b). Phosphate stabilization is moderately effective and moderately implementable; however, there are challenges and situations where treatment may not be applicable (Kastury et al. 2023).

Another process option evaluated for physical treatment at the example site is soil tilling. Soil tilling involves the physical turning over and mixing of the soil column. Tilling the surficial 12 inches of the soil column may reduce surface concentrations of lead below risk-based cleanup levels. Soil tilling with revegetation is a viable stand-alone alternative when surficial soil concentrations are close to cleanup levels and concentrations of contaminants are much less deep in the soil column. However, soil tilling is not a viable option when contaminant concentrations are similar throughout the soil column or when very high concentrations exist within the depth interval to be tilled. Soil tilling is typically used in large areas such as agricultural fields where heavy equipment can maneuver easily. For small areas, soil tilling may be impractical to implement. Soil tilling overall is a moderately effective process option because it can be highly effective in certain cases, but ineffective in others. Due to the small size of properties within the study area, it may not be a viable option to retain or use in conjunction with other approaches.

Prior to cleanup of a residential property, access to the property should be obtained from the property owner, not just from tenants or renters. It is recommended that access be obtained by going door-to-door. If residents are not home, a blank access consent form with instructions for signature and submission to the EPA, along with relevant contact information, should be left at the residence and not in a mailbox. An example access consent form is presented in Appendix F. Consider, if possible, obtaining access for remediation at the time that access for sampling is being sought.

Prior to initiating cleanup activities, the condition of each property should be documented and recorded in a property inspection form. 'Cleanup activity' includes any disturbance of the property, including the removal of debris and dilapidated structures that may be required prior to initiating the excavation of contaminated soil. An example of a property inspection form is provided in Appendix L. EPA (or other agency or entity performing work) should memorialize in the consent form signed by the owner any special requests or considerations in cleaning up the yard. For example, during a response action, if EPA removes a concrete sidewalk to complete the response action and the homeowner would prefer a brick walkway as a special request, it may be possible to prepare the area for homeowner improvement rather than replace the walkway with another concrete walkway. In this example, EPA would not install the improved walkway, but would prepare the area such that the homeowner could replace the walkway with material of their choice. Additionally, the homeowner can work directly with the remedial contractor to facilitate the special requests and payment, as EPA would not accept payment for these improvements. All additional costs associated with special requests and considerations must be borne by the homeowner. Any contaminated yard areas that will not be addressed through the response, special resident concerns, and any deviations from strict soil excavation or capping should be noted in the consent form.

Temporary relocation of residents during yard soil remediation is rarely needed and is generally not recommended (U.S. EPA 1999b).[119]

The Health and Safety Plan (HASP) should describe safety issues for the remedial team during residential cleanup, including ingress and egress to the residential property. For example, access should be coordinated with the property owner/residents and spelled out in the site-specific HASP before remedial activity.[120]

Removal of contaminated soils is generally preferred, but a barrier may be considered for areas where cleanup is not feasible, to limit exposure. Incomplete barriers made from rock or gravel or minimal use areas such as areas under porches should be cleaned up to the extent practical. For example, for areas underneath porches, a shotcrete barrier may be used in some cases (sprayed concrete that can easily be placed in tight or confined areas). It may be preferable to place a more complete barrier such as asphalt on heavily trafficked roads or driveways, especially those that experience severe erosion, rather than gravel.

In most cases, every attempt should be made to clean up contaminated areas of the entire yard (as well as qualifying areas within 100 feet of the property as appropriate); however, any residential property areas without permanent barriers that the resident requests to leave unremediated, such as gardens or patios, should be sampled separately to determine if a response action is needed. If the cleanup level is exceeded and the owner refuses to allow

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[119] Guidance is available online at: https://www.epa.gov/superfund/superfund-relocation-information.
[120] See https://response.epa.gov/main/healthsafety.aspx.

cleanup of that portion of the yard, then the cleanup documentation letter issued to the owner should note the unremediated area and also describe any ICs consistent with the decision document(s).

9.6 Other Cleanup Considerations

The CSM should define the exposure area for a young child, and the area remediated on a single residential property generally should not exceed the 1-acre area around the residence. Remediation should prioritize risk and exposure over lot lines and land ownership.

The recommendation for cleanup of a residential property that exceeds 1 acre is to excavate or cap the portion of the yard that is in frequent use and continue to limit exposure in the unremediated portion of the yard. To this end, it may be appropriate to address the yard such that it is fenced to clearly delineate the remediated and unremediated areas and to limit the potential for offsite tracking of contaminants by humans (*e.g.*, tracking contaminated soil from the unremediated area to the remediated area of the yard). Exceptions to this general approach may include areas outside the 1-acre remediated area that are used for recreation and gardening, high incidence child use areas, areas with the potential for residential development, and residential areas outside but near the 1-acre remediated area.

If contaminated soil is not removed to the full depth of contamination on a property, a permanent barrier/marker that is permeable, visible, and not prone to frost heave should be placed to separate the clean fill from the contamination. This applies to both incomplete vertical excavation with placement of a soil cover and placement of a soil cover without excavating contaminated soil. Selection of an appropriate permanent barrier/marker should be based on the type of contamination left in place, the chemical/physical characteristics of the soil (*e.g.*, pH), the potential for upward migration of the contamination, and/or the types of ICs developed for the site. Examples of suitable barriers/markers include snow fencing (usually orange), a clean, crushed limestone layer, or geotextile fabric.

Empty lots that are zoned residential and contain soils with lead concentrations greater than the cleanup level should be cleaned up when nearby residential lots are remediated because exposure to soil and soil-dust occurs beyond individual lots. Also, unpaved parking areas should be sampled and cleaned up if necessary, or access restrictions put in place, to prevent recontamination (*e.g.*, vehicle tracking of contaminants) even if no current direct exposure exists. The selected remedy needs to be protective for reasonably anticipated future uses although the timing of the response may prioritize specific areas depending on current land use.

While some research to date suggests that treatment of soil may be used to reduce the bioavailability of lead, additional research (Sowers et al. 2022, 2021, Scheckel et al. 2005, Cao et al. 2003) continues to evaluate the long-term effectiveness of the methods. Treatment technologies that have been preliminarily investigated include amending the soil with potassium-jarosite, phosphate compounds (*e.g.*, apatite [calcium phosphate], fish bones), biochar, or compost. If regions are considering these technologies, they should work with the TRW Bioavailability Committee and their STL to perform a site-specific treatability study.

EPA has generally not selected phytoremediation or plant-based covering methods such as phytostabilization, mulching, seeding, and sodding as elements of remedial actions at lead sites. While these approaches may provide short-term protectiveness as part of an interim response action to prevent near-term exposure, minimize contaminated soil transport, and help restore properties to their original condition, they generally rank low on permanence or long-term effectiveness. The following factors related to phytoremediation should be considered in a nine-criteria analysis (the detailed analysis of the alternatives identified in the screening stage): (1) the lead concentrations may not be within the optimal performance range for the plants; (2) the plants may concentrate lower level lead contamination and present an increased disposal cost if the plants fail the toxicity characteristic leaching procedure (TCLP) test (they would then need to be disposed of as a RCRA hazardous waste); (3) the length of time required for meeting cleanup goals; (4) local regulations regarding yard maintenance; and (5) the depth of contaminated soils.

9.6.1 Background Lead Concentrations

Some of the sites on the NPL are in areas with relatively high anthropogenic or natural background lead concentrations that may exceed PRGs. Unacceptable lead levels from the release may be exacerbated by the presence of high background concentrations of lead in various media (such as soil and groundwater) from anthropogenic sources. CERCLA 104 (a)(3)(B) generally limits the Agency from taking response actions to address a "... naturally occurring substance in its unaltered form, or altered solely through naturally occurring processes or phenomena, from a location where it is naturally found" (U.S. EPA 2000a). CERCLA cleanup levels generally are not below natural or anthropogenic background concentrations (U.S. EPA 2018b, 2002a, 2002c, 1997b, 1996b).

Public education about widespread risks should be started early in the process to help the community understand that Superfund actions are designed to address risks from site-specific releases to the environment (U.S. EPA 2002a). In situations where the risk is due solely to natural and anthropogenic background, it is important to inform the public of the risk and any limitations under CERCLA to address that risk. Both remedial and removal site teams should coordinate with health districts, state departments of environmental protection, housing agencies, and private parties to identify other programs or regulations that may have the authority and capability of addressing risks associated with high natural or anthropogenic background (see Section 3.2; U.S. EPA 2002a). Additional guidance is available for developing a risk management-based response strategy that is protective of human health and the environment (U.S. EPA 1988a).

9.6.2 Prevention of Recontamination

RPMs and OSCs should take steps to mitigate recontamination. During site closeout and five-year reviews (FYRs), the project manager may also sample for recontamination to determine whether any recontamination presents an unacceptable risk.

At large sites, cleanup occurs over a long period of time and through multiple phases, throughout which the potential for recontamination exists. During each of these phases, windblown dust sources, vehicle tracking, and flooding can cause recontamination. Initially, cleanup may prioritize the properties with the greatest risk, which could be scattered, before addressing adjacent properties systematically. In addition to dust monitoring, dust control, vehicle washing, and other mitigation, confirmation samples should be collected to identify potential recontamination.

Flooding can pose a serious problem for these areas in that flood waters can erode clean materials, exposing subsurface contamination, and entrained sediments bearing contamination may be left on top of newly remediated properties.

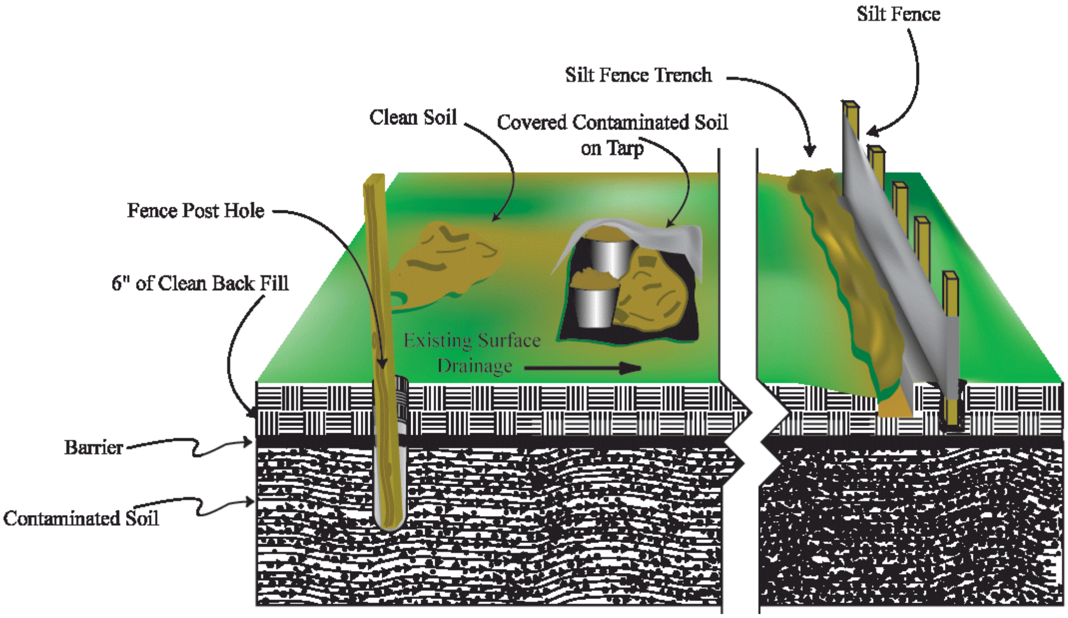
Inadequate drainage can recontaminate previously cleaned areas (*e.g.*, lead particles on a crowned road with no curb and gutter may be rinsed onto adjacent residential properties with normal rainfall). Burrowing animals can bring contaminated soils to the surface.

Best Management Practices (BMPs) – In general, BMPs are a combination of practices that are determined to be the most effective and practicable means of controlling point and nonpoint pollutants at levels compatible with environmental quality goals.

An Institutional Control Implementation and Assurance Plan (ICIAP) should have procedures in place that can help prevent residents from breaching visual subsurface barriers when installing fence posts, planting a new tree or shrub, or conducting other activities that threaten the integrity of the remedy (see Chapter 10 for more information on ICs). Education and licensing of contractors who work on areas with clean soil cover/visual subsurface barriers should generally be required (*e.g.*, as part of a local ordinance) to ensure the longevity of the remedy. Also, at many sites (*e.g.*, Bunker Hill Superfund Site), ICs have been most effective when linked to the *call before you dig* program typically operated by many counties to avoid disruption of utility service (see, *e.g.*, Panhandle Health District's Institutional Controls Program,[121] which also includes free haul-away of contaminated soil and free replacement clean fill, HEPA vacuum loans, and other services to protect people).

Large-scale residential development projects (*e.g.*, that may raze old housing and replace it with new residential housing) may recontaminate areas by moving lead-contaminated soil that was left at depth, without appropriate BMPs in place. BMPs include silt fences (and other barriers) to limit movement of contamination off a project site and stockpiling of contaminated soil on a tarp to prevent contamination of underlying soil (Figure 9-6). EPA provides guidance on the implementation of BMPs in construction activities at sites where contamination is present (U.S. EPA 1997c) and it has been shown that BMPs typically add about 5% to project cost (TerraGraphics 2000). Periodic inspections of residential areas should be performed by the local government to ensure that projects within the site are conducted in accordance with BMPs.

Figure 9-6. Implementing a Clean Soil Cover During Construction Work



The BMPs shown in the above figure represent one component of the ICs that may be put in place by local ordinance to ensure the long-term protectiveness of the remedy and to prevent recontamination. The staging of contaminated soil on tarps and/or in small buckets, and the installation of silt fences downgradient of the construction area are examples of BMPs intended to prevent the migration of contaminated material from the construction site.

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[121] https://panhandlehealthdistrict.org/institutional-controls-program/.

Windblown dust can pose a significant threat to the health of individuals at a site and can cause recontamination. Tailings impoundments that have dried can be large sources of windblown lead dust with potential to recontaminate residential properties downwind. Windblown dust should be addressed to minimize recontamination.

Although mechanisms vary from site to site, the types of response actions put in place and the sequence in which these actions take place can play a significant role in enhancing the permanence and effectiveness of a remedy.

An engineered soil repository may be needed because municipal landfills may not accept contaminated soil. Without free or low-cost disposal for contaminated soil available to each homeowner or renter, improper disposal is more likely, which could result in recontamination. In addition, a disposal area may be needed if certain materials at a site fail TCLP and cannot be commingled with solid waste.

In some cases, the property owner may not provide access to allow sampling or respond to contaminated soil. In these cases, changes in property ownership over time should be monitored and new landowners should be contacted. Local implementation helps ensure that cleanup of these properties occurs as soon as possible, further ensuring the protectiveness of the remedy by minimizing the potential for recontamination to the extent possible.

9.6.2.1 Long-term Remedial Actions

Some or all of the following measures may be useful to address the risk of recontamination during the remedial action and post-design phase:

- Evaluate the permanence and effectiveness of the various remedial actions under consideration. Consider the economic feasibility of complete contaminated soil removal to minimize reliance on ICs.
- Conduct a cost analysis comparing the cost of long-term ICs to those of complete removal (U.S. EPA 2000d).
- Remedial action should strive to remediate the contamination in the community. This decision is, in part, made based on input from the community (community acceptance is one of the nine criteria in the NCP). Each segregable area should be cleaned up as quickly as possible (*e.g.*, within one construction season) to minimize recontamination of cleaned properties and to compound the protection to human health (U.S. EPA 2000a,d).

- Fugitive dust and access to contaminated sources should be controlled. Air monitoring along with depositional modeling may be necessary to determine if windblown dust presents a significant threat of recontamination. Significant sources of windblown dust should be controlled prior to or simultaneously with cleanup of adjacent residential areas. Readers may consider HEPA street sweeping during remediation and immediately following completion of cleanup to minimize tracking of contaminants throughout a community.

- Complete removal of contaminants should be considered in flood prone areas or areas with a high groundwater level due to the inherent difficulty in maintaining a soil cover remedy in these areas. Drainage-ways containing contamination within the floodplain that are not addressed in the remedy could also lead to remedy failure if the contaminants are eroded to other areas.

- Remediation of contaminated rights-of-way should occur within segregable areas simultaneously, if possible, or as close together in time as possible to minimize vehicle tracking and recontamination of driveways from the rights-of-way.

- Infrastructure improvements should also be considered, as appropriate. At the Bunker Hill Superfund Site, EPA has funded street paving, drainage improvements, and other infrastructure needed to protect the remedy.[122]

- Control measures for all remaining sources, such as mining waste piles surrounding the community, should be developed to ensure that the remediated neighborhoods are kept clean. ECs and ICs should be established to ensure the control, or proper use and disposal, of any wastes remaining on site.

- If the residential remedy includes replacement of soils, removal or encapsulation of deteriorating exterior LBP (*e.g.*, by pressure washing, or painting) could be considered to minimize the soil recontamination potential.

- Other sources of residential property recontamination should also be considered. For example, homeowners may unknowingly bring in contaminated soil for fill or other uses on their property.

- Unless all contaminant levels meet risk reduction goals, some level of ICs will be necessary to help effectuate a protective remedy.

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[122] See https://semspub.epa.gov/work/10/100363132.pdf.