Protective Measures Evaluation Summary

Protective Measure Category/Protective Measure Example	Description	0.2-Acre Residential				2-Acre Residential				20-Acre Pre-development			
		Human Health Effectiveness (1)	Ecological Effectiveness (1)	Cost (2)	Practicality (3)	Human Health Effectiveness (1)	Ecological Effectiveness (1)	Cost (2)	Practicality (3)	Human Health Effectiveness (1)	Ecological Effectiveness (1)	Cost (2)	Practicality (3)
		Consultant Team Suggested Rankings											
Wear Protective Clothing	Wear coveralls and hat while working in soil. Remove work clothes at completion of task and launder items separately.	●○○○	○○○○	●●●●	●●●●	●○○○	○○○○	●●●●	●●●●	NA	NA	NA	NA
Other Actions	The Task Force classified some actions outside the definition of individual protection measures.												
Request Soil Test Results	Owner or resident requests and obtains soil test results from government agency to learn about contamination levels at residential or nearby properties. Soil testing on large pre-developed lots would most likely be paid for by the property owner.	●○○○	○○○○	●●●●	●●●●	●○○○	○○○○	●●●●	●●●●	●○○○	○○○○	●●●●	●●●●
Garden Using Raised Beds	Garden within clean soil to minimize exposure while gardening and potential ingestion of contaminants on or in food crops.	●●○○	○○○○	●●●●	●●●●	●●○○	○○○○	●●●●	●●●●	NA	NA	NA	NA
Physical Barriers	Physical barriers prevent or limit unauthorized access to property or exposure to contaminated soil. May be used in combination with excavation to consolidate contaminated soil in a containment zone, especially at pre-developed properties or areas with frequent exposure. Funding for physical barriers may be provided by the landowner, local or state governments, or by the identified responsible party.												
Fencing	Construct fencing to control access to the property.	●○○○	○○○○	●○○○	●●○○	●○○○	○○○○	●○○○	●●○○	●○○○	○○○○	●●●●	●●○○
Vegetative Cover	Establish and maintain a vegetated surface on top of exposed soil to reduce dust and direct exposure to soil.	●●●○	○○○○	●●○○	●●●○	●●●○	○○○○	●○○○	●●●○	●●●○	○○○○	●●●●	●●●○
Wood Chip Cover	Cover exposed soil with a geotextile fabric and several inches of wood chips to reduce dust and direct exposure to soil.	●●●○	●●○○	●●○○	●●●○	●●●○	●●○○	●○○○	●●○○	●●●○	●●○○	●●●○	●●○○
Clean Soil Cover	Place a geotextile fabric directly on top of exposed soil followed by 6 or more inches of clean soil. Establish and maintain a vegetated surface on top of soil to minimize erosion.	●●●○	●●○○	●○○○	●●○○	●●●○	●●○○	○○○○	●●○○	●●●○	●●○○	●●●○	●●●○
Pavement Cover	Place concrete pavers or an asphalt pavement cover over exposed soil to reduce dust and direct exposure to soil.	●●●○	●●●○	●○○○	●○○○	●●●○	●●●○	○○○○	●○○○	●●●○	●●●○	●●○○	●●●○
Reducing Contamination	Actions to reduce the concentration of contaminants in soil or to remove the contamination for disposal at another location or in a containment zone. Funding for reducing contamination may be provided by the landowner, local or state governments, or by the identified responsible party.												
Soil Blending/Tilling	Mix near-surface soil containing arsenic and/or lead with cleaner soil at depth to reduce the concentration of contaminants in the newly formed surface soil.	●●●●	●●●●	●○○○	●●○○	●●●●	●●●●	○○○○	●●○○	●●●●	●●●●	●●●○	●●●○
Soil Removal and replacement	Excavate soil containing arsenic and/or lead and replace this soil with clean fill. Establish and maintain a vegetated surface on top of fill to minimize erosion of the fill. Dispose of contaminated soil at another location.	●●●●	●●●●	●○○○	●●○○	●●●●	●●●●	○○○○	●●○○	●●●●	●●●●	●●○○	●●●○
Phytoremediation	Establish and maintain sufficient plant growth on contaminated soil to promote the uptake of arsenic and lead from the soil into the aboveground portion of the plant. Harvest and dispose of the plants and then repeat process until desired concentrations are obtained.	●●○○	●●○○	●○○○	●○○○	●●○○	●●○○	○○○○	●○○○	●●○○	●●○○	●●○○	●○○○

Protective Measures Evaluation Summary Footnotes

NA = Not Applicable

(1) Human health effectiveness for the institutional protective measure categories of Education Programs, Land Use/Institutional Controls, and Public Health Programs is based on the level of participation these measures attract and the ability of these programs to influence participants to change behaviors or implement recommended actions to reduce exposure to contamination. Education Programs, Land Use/Institutional Controls, and Public Health Programs protect people but not ecological receptors such as birds, rodents, and reptiles. Human health effectiveness for the physical protective measure categories of IPMs, Physical Barriers, and Reducing Contamination is based on the ability of these physical protective measures to reduce exposure to contamination. Ecological effectiveness is based on the ability of the protective measure to reduce exposure to terrestrial plants, invertebrates, and wildlife. Effectiveness ratings are based on the following scale:

○○○○ = No Effect
●○○○ = Minimal Effect
●●○○ = Some Effect
●●●○ = Effective
●●●● = Very Effective

(2) Cost for the two residential scenarios is based on applying the protective measure to the entire population described in the residential scenario (i.e. 4,000 properties, 10,000 residents). Accessible contaminated soil is assumed to be present at a depth of 0.5 to 1.5 ft over one-half of the 0.2-ac property and 90 percent of the 2-ac property. Cost for the 20-ac pre-development property is based on applying the protective measure to a single 20-ac pre-development property. Accessible contaminated soil is assumed to be present over the entire 20 acres at a depth ranging from 0.5 to 1.5 ft. Costs for application of the pavement cover protective measure to the 20-ac pre-development property assume that contaminated soil is excavated, consolidated to 20 percent of the original property size, and that an asphalt pavement cover is placed over the soil. A 30-year project life is assumed for protective measures with recurring annual costs (e.g. Education Programs, Public Health Programs). Cost ratings are based on the following scale:

○○○○ = over $200,000,000
●○○○ = $20,000,000 to $200,000,000
●●○○ = $2,000,000 to $20,000,000
●●●○ = $200,000 to $2,000,000
●●●● = $0 to $200,000

(3) Practicality is a measure of the technical, social, and administrative barriers to implementing the measure. For example, there are few social or technical barriers to holding public meetings or sending brochures, but excavating all the soil from yards on small, develped residential lots is technically challenging and socially disruptive. Practicality does not consider the ability to obtain funding for the measure. Practicality is ranked on the following scale:

○○○○ = Not Practical
●○○○ = Minimal Practicality
●●○○ = Some Practicality
●●●○ = Practical
●●●● = Very Practical

(4) See summaries on IPMs, physical barriers, and reducing contamination for descriptions and rankings.

Protective Measures Evaluation- Education Programs

PROTECTIVE MEASURE	EXAMPLES	DESCRIPTION	HH and ECO EFFECTIVENESS (1)	COST	PRACTICALITY
Education Programs		Education programs refer to broad-based, community-wide efforts to inform individuals and businesses of the presence of contamination and changes in behavior that can be taken to limit or reduce exposure to the contamination. Such programs use a wide range of techniques to distribute information and increase public awareness. Application of education programs to pre-developed properties refers to educating residents living near the pre-developed property. Often implemented in conjunction with other protective measures, such as physical barriers.	Exposure to contaminants often arises from a lack of knowledge about the contaminants or what practical actions can be taken to reduce exposure. Reliable data on the effectiveness of education programs in changing behaviors that lead to reduced exposure are limited. Data from a Utah study showed limited short-term effectiveness. Education programs can reach a wide audience but must be implemented as long as the potential exposure persists(30+ years) for long-term effectiveness. No effect on ecological receptors.	Costs for education programs vary according to the size of the population being served, activities included in the programs, and the level of staffing required for them. Costs for education programs at four sites ranged from $15,000 to $75,000 per year. Requires recurring annual cost.	Education programs tend to be highly practical in that there are few technical issues or barriers to implementation and they can be administered by a variety of institutions. Social limitations include the ability and willingness of people to attend meetings and read educational materials.
	Public Meetings	Used to disseminate information on the presence of contamination, the status and progress of cleanup efforts, and steps that can be taken to limit or reduce exposure to the contamination. Typically funded through local and state governments.	Attendance and participation at public meetings is high initially but wanes considerably during course of cleanup efforts. Other outreach efforts may be more effective when attendance is low. There is limited empirical data on effectiveness of public meetings at changing behaviors that lead to reduced exposure.	Cost of public meetings depends on the frequency of meetings, the level of staffing required, the price of meeting facilities, and the extent of publicity for the meetings. Costs are generally low for agencies or organizations that regularly conduct them and therefore have access to appropriate facilities and staff resources (see above cost range).	Public meetings can be a practical means of conveying information to large groups of people in that there are few technical or administrative barriers to their implementation.
	Brochures/Fact Sheets/Newsletters/Videos/Recordings/Websites	Used to disseminate information on the presence of contamination, the status and progress of cleanup efforts, and steps that can be taken to limit or reduce exposure to the contamination. Typically funded through local and state governments.	There is little data to suggest that written educational materials alone are effective at changing behavior and reducing actual exposure. Effectiveness of written materials depends on how widely they are distributed and whether people read and retain the information.	Written materials are generally not expensive to develop and maintain. Costs depend on the method of distribution. More passive means of communicating information (e.g. website, school newsletter) are generally cheaper than more active forms of communicating information, such as distributing educational materials in a door-to-door outreach effort (see above cost range).	Written educational materials are practical in that there are few technical or administrative barriers to their implementation.
	School-based Programs	Provide education programs within the K-12 system, including school newsletters, classes on environmental issues in the community, and instruction on the importance of following IPMs or other protective measures. Typically funded by local schools with grant money available through local or state governments	School-based educational programs may be effective for families with school-aged children but are unlikely to have any effect on other individuals.	Cost is likely to be in same range as other educational programs.	School-based programs are practical in that there are few technical or administrative barriers to their implementation. Socially, they are an obvious choice for educating children, teachers, and parents.
	Post No Trespassing signs	Post No-Trespassing or other informational signs at perimeter of contaminated area. Paid for by landowner.	Signs may be effective at informing people of environmental concerns at a specific property. Signs are likely to have only minimal effect in changing behavior on the property unless they clearly convey the risks involved.	Cost for signage is relatively low.	Few if any technical barriers exist to posting signs and limited social barriers exist to posting signs on pre-developed property. However, use of signs in existing residential areas may be opposed by residents.

(1) See footnote 1 to the summary table for a definition of the effectiveness rating. Effectiveness for Education Programs is based on the level of participation the programs attract and the ability of these programs to influence participants to change behavior or implement recommended actions to reduce exposure to contamination. The effectiveness of the various protective measures that these programs recommend (e.g. dust control) is presented under the table for that particular protective measure.

Protective Measures Evaluation- Land Use Controls

PROTECTIVE MEASURE	EXAMPLES	DESCRIPTION	EFFECTIVENESS (1)	COST	PRACTICALITY
Land Use Controls		Actions by government or private agreements to limit or prohibit activities that could result in exposure to contaminants or harm a physical barrier or other engineered control. Also includes site-specific actions to increase knowledge of contamination, such as disclosure approaches. Often implemented in conjunction with other protective measures, such as physical barriers.	Affected by: enforceability of the control (and by whom); how information about the control is distributed or accessed; and the longevity of the control (e.g., does it run with the land?). Land use controls have limited long-term effectiveness. Land use controls do not address ecological protection.	Little information currently available about cost of implementation. Most significant costs may be long-term enforcement or reductions in property values.	Affected by: who administers the control and under what authority; funding source; methods of monitoring; social acceptance of local land use laws.
	Zoning	Governmental limits on land use that could lead to exposure to contamination. Enacted, enforced, and typically funded by local governments in accordance with state statutes. Estimated costs do not include loss-of-use costs by property owners.	Variable; affected by requirements under zoning, enforcement, and longevity. Local political pressures for development can make it easier to repeal the restrictions on a given site or make it harder to enforce existing restrictions. Advantages: designated uses run with the land and can be applied to a large number of parcels. Doesn't limit current uses.	Relatively low cost; typically already conducted by local government.	Use of zoning by local government is well-established. Affected by level of oversight. Socially accepted in most urban areas, less accepted in rural areas.
	Permits and licenses	Enhanced governmental review of projects that could lead to exposure to contamination can be required for variety of activities from any level of government (local, state, federal). Typically funded by the level of government issuing the permit or license. Estimated costs do not include property owners' costs for obtaining permits/licenses or loss-of-use.	Enforceable by law. Affected by requirements under permit, enforcement. Can limit changes in current uses such as constructing additions to existing structures.	Relatively low cost. Affected by: enforcement and level of oversight; administrative / processing expenses.	Commonly implemented at all levels of government. Affected by: types of permits required; level of government involved; and level of oversight.
	Covenants, conditions, and restrictions	Proprietary controls voluntarily placed on a deed by a property owner. Generally apply to a single piece of property, or property being subdivided, and may have a specific life-span, often ten years. Typically funded by private parties. Estimated costs do not include loss-of-use costs by property owner.	Effectiveness is limited by the voluntary nature of these controls. Enforceability usually reserved for the holder of the covenant or easement. Advantages: may be binding on subsequent owners.	Relatively low cost. Affected by purpose, parties involved, enforcement, and oversight provided.	Affected by: parties involved, purpose, and oversight provided. Private agreements can be socially acceptable in areas zoning and permits are not.
	Easements	Proprietary controls that may be voluntarily placed by a property owner or required by government (e.g. easements for roads are required). May cover a wide variety of activities or use limitations. Generally last forever.	Effectiveness enhanced by the ability to establish easements without property owner consent.	Relatively low cost. Affected by purpose, parties involved, enforcement, and oversight provided.	Affected by: parties involved, purpose, and oversight provided. Private agreements can be socially acceptable in areas zoning and permits are not.
	Deed and plat notices	Informational devices, not a limit on use. Applied to individual parcels of land or, for plat notices, to an entire plat. Typically, costs incurred by party establishing deed or plat notice and by level of government that records them.	Affected by enforceability, oversight, and availability of information. Typically, for a land transfer, future land owners (or potential owners) rely on county or state systems of deed records to learn about land use restrictions and potential hazards due to soil contamination.	Relatively low cost. Use of model language decreases cost to entity placing control.	Implementation can be incorporated into existing systems. Affected by level of oversight.
	Real estate disclosure forms and practices	Information provided to potential purchasers as part of real estate transactions (e.g. areawide environmental disclosure).	Affected by: information available to property sellers, implementation method. Little effect until time of property transfer.	Relatively low cost. Costs borne by property sellers.	Increased if can be incorporated into existing disclosure system.

(1) See footnote 1 to the summary table for a definition of the effectiveness rating.

Protective Measures Evaluation- Public Health Programs

PROTECTIVE MEASURE	EXAMPLES	DESCRIPTION	HH and ECO EFFECTIVENESS (1)	COST	PRACTICALITY
Public Health Programs		These programs generally involve activities designed to identify and focus protective measures on specific populations within a community considered to be at high risk. Application of public health programs to pre-development properties refers to providing these programs to residents living near the pre-development property.	Data on effectiveness is limited. Because they are targeted at specific individuals at risk, they are more effective than community-wide education programs. The long-term effectiveness of education programs is limited unless these programs are maintained as long as the potential exposure persists. Public health programs do not address ecological protection.	Depending on the scale of the effort, these actions can be very costly because they require direct contact between health professionals and individuals at risk. Requires re-occurring annual cost.	Very practical because there are limited technical and administrative barriers. Social acceptance of health programs administered by health professionals is high.
	Health monitoring	Health monitoring includes measuring blood lead levels in children and arsenic levels in hair and urine and providing test results and written material on appropriate actions to reduce exposure. Typically funded through local and state governments.	Blood lead screening can be an effective method for identifying exposed individuals if there is a high level of participation in the testing program and testing is performed at times that capture high exposure periods. Methods for monitoring arsenic (urinary arsenic measurements and hair samples) are available. However, a number of implementation and interpretation issues exist that limit the utility of these methods for identifying persons with elevated exposures.	Costs for health monitoring depend primarily on the size of the population served and the type and frequency of monitoring. Little actual cost data available. Estimated health monitoring costs based on cost estimates for the Vasquez Boulevard/Interstate 70 Superfund Site are $50,000 for setup and $100,000-$150,000/yr for ongoing monitoring (approximately 700 samples analyzed per year).	The basic institutional structures needed to implement health monitoring are already in place in Washington through state and local health departments.
	Home visits/one-on-one education	Trained professionals perform routine visits at high risk residences to evaluate and address sources contributing to elevated exposures and to provide individual instruction on measures to reduce exposure. Typically funded through local and state governments.	Available information indicates that education programs involving home visits can be beneficial (in terms of modifying participants behavior to reduce exposure to lead and arsenic) in some situations. Health officials in some areas have reported 15-50% reduction in blood lead levels following education outreach activities. Some of these programs have also been shown to be effective in reducing the proportion of children with blood lead levels above 15-20 ug/dL.	Costs for home counseling/case management depend on the level of participation and can be very high if the number of residences receiving home visits is large. Limited cost data for home counseling/case management is available.	Home counseling/case management programs tend to be practical in that there are few technical issues or barriers to implementation and they can be administered by a variety of institutions.
	Intervention activities	Responses to a finding of elevated blood lead levels or urinary arsenic levels may include 1) referral to physician, 2) source investigations and/or implementation of appropriate intervention activities	See summaries on IPMs, physical barriers, and reducing contamination	See summaries on IPMs, physical barriers, and reducing contamination	See summaries on IPMs, physical barriers, and reducing contamination

(1) See footnote 1 to the summary table for a definition of the effectiveness rating. Effectiveness for Public Health Programs is based on the level of participation the programs attract and the ability of these programs to influence participants to change behavior or implement recommended actions to reduce exposure to contamination. The effectiveness of the various protective measures that these programs recommend (e.g. dust control) is presented under the table for that particular protective measure.

Protective Measures Evaluation- Individual Protection Measures

PROTECTIVE MEASURE	EXAMPLES	DESCRIPTION	HH and ECO EFFECTIVENESS (1)	COST	PRACTICALITY
Individual Protection Measures		Individual protection measures (IPMs) are simple day-to-day activities that students, teachers, residents, and employees can follow to limit or reduce exposure to soil contaminants in certain circumstances. Individual Protection Measures (IPMs) could involve implementation of actions suggested through educational or public health programs. Property owners or residents typically provide all labor and/or money to implement IPMs, which are usually low cost items.	Limited data exists on the effectiveness of the individual IPMs listed below in preventing and/or reducing exposure to lead and arsenic because IPMs are typically implemented together with other IPMs or protective measures so the effects of individual IPMs can be difficult to isolate. IPMs do not address ecological protection nor are they considered to be effective in the long term.	Costs to implement most IPMs are typically low relative to other protective measures	No technical or administrative barriers. Social acceptance uncertain; in many cases the measure is merely a heightened level of attention to an existing practice.
	Practice personal hygiene	Wash hands and face thoroughly after working or playing in the soil, especially before eating. No eating or smoking while doing tasks in potentially contaminated areas.	Effective in removing lead and arsenic from surface of skin but unlikely to contribute significantly to overall exposure reduction.	$0.00	Highly practical for adults, less practical for children
	Wash garden vegetables and fruits	Wash or peel garden vegetables and fruits carefully to remove all soil particles.	Effective in removing lead and arsenic from surface of fruit and vegetables. For people with gardens, this can be one of the most effective actions they can take to reduce risk.	$0.00	Highly practical
	Remove work and play shoes before entering home	Remove work and play shoes before going inside after working or playing in or walking on contaminated soil.	Effective in limiting the entry of lead and arsenic into the home but unlikely to contribute significantly to overall exposure reduction.	$0.00	Highly practical
	Damp-mop and dust house or vacuum with HEPA vacuum	Damp-mop and dust floors and counters frequently. Vacuum floors and upholstery frequently using a vacuum with a HEPA filter.	Studies that evaluated the combined effect of home counseling/case management and dust control using HEPA vacuuming and other dust control measures (e.g. damp-mop and dusting) generally report small reductions in blood lead concentrations but relatively high reductions in dust-lead loadings.	Incremental cost for supplying HEPA type vacuums. No other additional cost is assumed.	Less practical relative to other IPMs due to the need for residents to conduct frequent cleaning
	Moisten soil to minimize dust while gardening or digging	Wet down soil while gardening or digging to limit the amount of dust inhaled.	Effective at limiting soil inhalation during gardening if soi is thoroughly wetted but unlikely to contribute significantly to overall exposure reduction.	$0.00	Highly practical
	Wear protective clothing	Wear coveralls and hat while working in soil. Remove work clothes at completion of task and launder items separately.	Effective at limiting the spread of contamination from work site to home but unlikely to contribute significantly to overall exposure reduction.	$0.00	Highly practical
Other	Request Soil Testing Results	Owner or resident requests and obtains soil test results from government agency to learn about contamination levels at residential or nearby properties. Soil testing on large pre-developed lots would most likely be paid for by the property	Effective at learning whether a potential exposure hazard exists. Knowledge may be somewhat effective at causing change in behavior.	$200-$500/0.2-ac property, $300-$700/2-ac property	Highly practical
	Garden using raised beds	Garden within clean soil to minimize exposure while gardening and potential ingestion of contaminants on or in food crops.	Effective at limiting exposure to contaminants during gardening if clean soil remains separated from contaminated soil. Effective at preventing contaminants from attaching to surface of fruits and vegetables and at limiting contaminant uptake if roots do not extend to contaminated soil. For people with gardens, this can be one of the most effective actions they can take to reduce risk.	Small cost for constructing raised bed and obtaining clean soil.	Highly practical

(1) See footnote 1 to the summary table for a definition of the effectiveness rating

Protective Measures Evaluation- Physical Barriers

PROTECTIVE MEASURE	EXAMPLES	DESCRIPTION	HH and ECO EFFECTIVENESS (1)	COST (2)	PRACTICALITY
Physical Barriers		Physical barriers prevent or limit unauthorized access to property or exposure to contaminated soil. May be used in combination with excavation to consolidate contaminated soil in a containment zone, especially at pre-developed properties or areas with frequent exposure. Funding for physical barriers may be provided by the landowner, local or state governments, or by the identified responsible party.			
	Fencing	Construct fencing to control access to the property.	Fencing may not effectively prevent access nor does it prevent residents living within fenced area from contacting contaminated soil. Fencing does not prevent generation or transport of air-borne particulates. No effect on ecological receptors.	$6K-$12K/0.2-ac property. $21K-$50K/2-ac property. $80K-$180K/20-ac property.	Fencing can typically be readily installed on most properties and is a practical means of limiting access to pre-developed properties. Owners of developed residential properties may resist installation of fencing due to loss of property use or aesthetic impacts on the property or neighborhood.
	Vegetative Cover	Establish and maintain a vegetated surface on top of exposed soil to reduce dust and direct exposure to soil.	Effectiveness depends on land use, climate, and maintenance. Irrigation may be needed. Not effective during intrusive activities. No effect on ecological receptors.	$1K-$3K/0.2-ac property. $4K-$9K/2-ac property. $30K-$80K/20-ac property.	Vegetative covers can typically be readily installed on most properties. Maintaining cover effectiveness will, in most cases, require long-term maintenance which reduces practicality.
	Wood Chip Cover	Cover exposed soil with a geotextile fabric and several inches of wood chips to reduce dust and direct exposure to soil.	Effectiveness depends on thickness, land use and maintenance. Not effective during intrusive activities. Geotextile fabric may provide some ecological protection.	$3K-$6K/0.2-ac property. $40k-$80K/2-ac property. $390K-$840K/20-ac property. (includes wood chip replacement every 10 years)	Wood chip covers can typically be readily installed in appropriate areas on most properties. Aesthetic qualities and appropriate surface uses may limit the use of wood chip covers to small areas thereby making this protective measure less practical on large residential or pre-developed properties. Maintaining cover effectiveness requires periodic replacement of wood chips.
	Clean Soil Cover	Place a geotextile fabric directly on top of exposed soil followed by 6 or more inches of clean soil. Establish and maintain a vegetated surface on top of soil to minimize erosion.	Effectiveness depends on thickness, land use, climate, and maintenance. Not effective during intrusive activities. Geotextile fabric may provide some ecological protection.	$6K-$12K/0.2-ac property. $50K-$110K/2-ac property. $380K-$810K/20-ac property.	Clean fill covers can typically be readily installed on most properties, however, some regrading may be needed to accommodate additional fill. Maintaining cover effectiveness will, in most cases, require long-term maintenance. Practical means of containing contaminated soil at pre-developed properties.
	Pavement Cover	Place concrete pavers or an asphalt pavement cover over exposed soil to reduce dust and direct exposure to soil.	Very effective at preventing direct contact except during intrusive activities.	$15K-$30K/0.2-ac property. $200K-$430K/2-ac property. $1.0 mil-$1.8 mil/20-ac property. (includes pavement resurfacing every 10 yrs)	The use of paved surfaces as covers is typically limited to driveway and patio areas at residential properties. Practical means of containing contaminated soil at pre-developed properties if soil is consolidated under pavement.

(1) See footnote 1 to the summary table for a definition of the effectiveness rating.
(2) See footnote 2 to the summary table for assumptions used in developing costs.

Protective Measures Evaluation- Reducing Contamination

PROTECTIVE MEASURE	EXAMPLES	DESCRIPTION	HH and ECO EFFECTIVENESS (1)	COST (2)	PRACTICALITY
Reducing Contamination		Actions to reduce the concentration of contaminants in soil or to remove the contamination for disposal at another location or in a containment zone. Funding for reducing contamination may be provided by the landowner, local or state governments, or by the identified responsible party.			
	Soil Blending/Tilling	Mix near-surface soil containing arsenic and/or lead with cleaner soil at depth to reduce the concentration of contaminants in the newly formed surface soil.	Very effective in short term and long term for both human health and ecological receptors if subsurface soil is clean.	$7K-$27K/0.2-ac property. $30K-$240K/2-ac property. $300K-$2.6 mil/20-ac property.	Practicality depends on depth of contaminated layer and presence of obstructions such as utilities and buildings. For shallow contamination with clean subsurface soil, easily implementable away from buildings and utilities.
	Soil Removal and Replacement	Excavate soil containing arsenic and/or lead and replace this soil with clean fill. Establish and maintain a vegetated surface on top of fill to minimize erosion of the fill. Dispose of contaminated soil at another location.	Very effective in short term and long term for both human health and ecological receptors	$11K-$60K/0.2 ac property. $100K-$600K/2-ac property. $1.1 mil-$6.7 mil/20-ac property.	Practicality depends on access, depth of contaminated soil, proximity to disposal location and clean fill source, and presence of utilities and buildings. Easily implementable in areas with good access to mechanical excavating equipment and few site interferences such as at pre-developed properties.
	Phytoremediation	Establish and maintain sufficient plant growth on contaminated soil to promote the uptake of arsenic and lead from the soil into the aboveground portion of the plant. Harvest and dispose of the plants and then repeat process until desired concentrations are obtained.	Effectiveness in reducing concentrations is unknown with little full-scale experience on treatment of lead and arsenic-contaminated soil. Time required for completion dependent on soil concentration and plants selected. Emerging technology.	Limited cost data available. $8K-$40k/0.2-ac property. $150K-$670K/2-ac property. $1.6-$8.0 mil/20-ac property.	Need for long-term (greater than 5 years) planting, harvesting, and disposal greatly reduces practicality. Phytoremediation limits the use of land undergoing treatment. Testing needed to establish proper plants for the contaminant and climate. Little full scale experience. Can be used in areas with limited access.

(1) See footnote 1 to the summary table for a definition of the effectiveness rating.

(2) See footnote 2 to the summary table for assumptions used in developing costs.