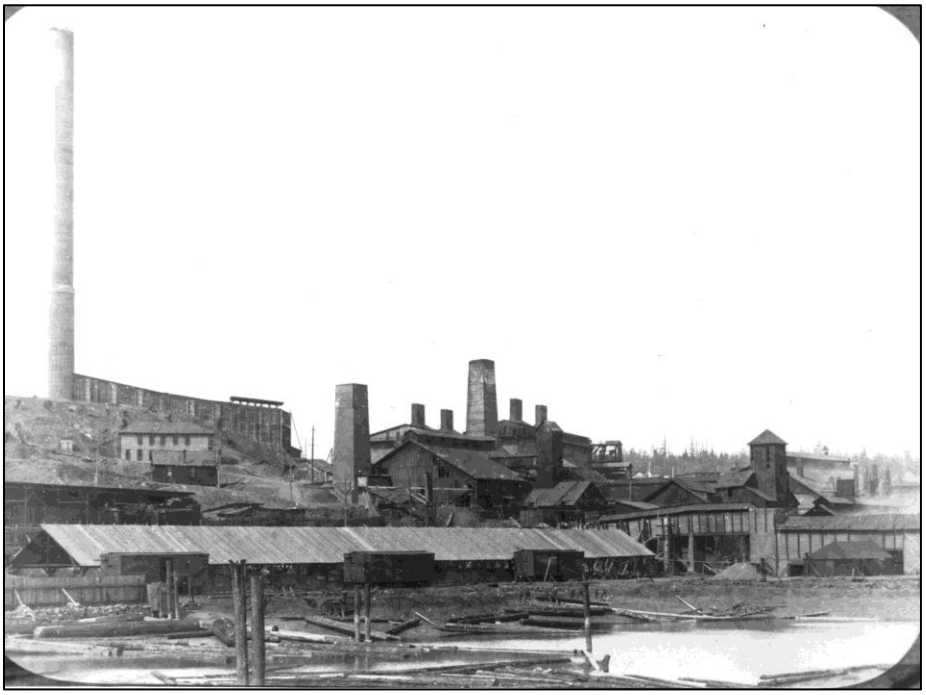
Tacoma Smelter Plume Model Remedies Guidance

Sampling and cleanup of arsenic and lead contaminated soils

For:

Formal cleanup sites
Voluntary Cleanup Program
Properties under development



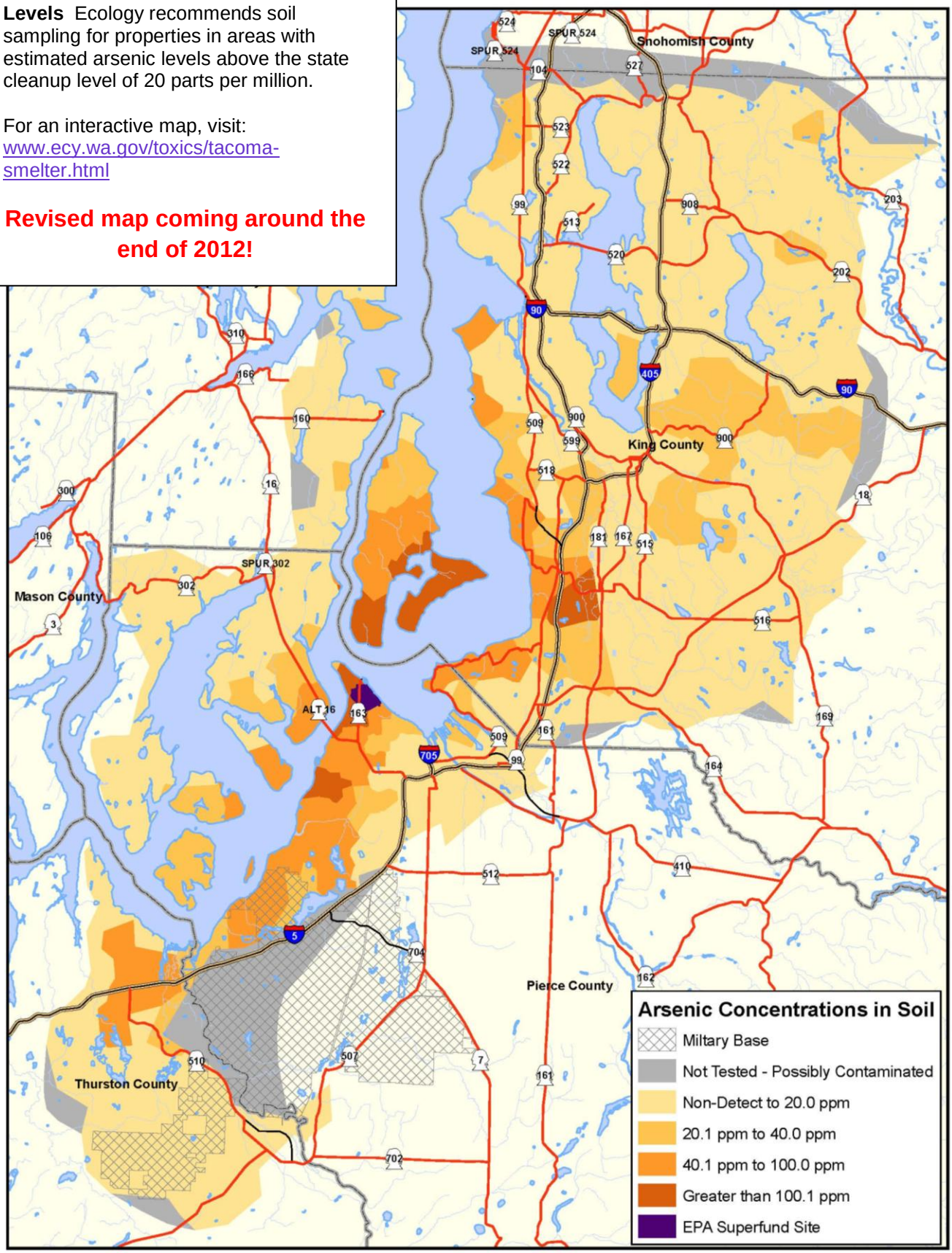
DEPARTMENT OF ECOLOGY
State of Washington

June 2012
Toxics Cleanup Program
Washington State Department of Ecology
Lacey, WA
Publication Number 12-09-086-A

Tacoma Smelter Plume Soil Arsenic Levels Ecology recommends soil sampling for properties in areas with estimated arsenic levels above the state cleanup level of 20 parts per million.

For an interactive map, visit: www.ecy.wa.gov/toxics/tacoma-smelter.html

Revised map coming around the end of 2012!



Before you get started…

On the map, is your property in an area where soil arsenic is 20 ppm or higher? Do you only suspect arsenic and lead, and not other contaminants? Use this manual for sampling and cleaning up Tacoma Smelter Plume contamination. You can meet state cleanup requirements without having to do your own feasibility study.

Sampling and cleanup steps

1. Take **characterization samples** to determine if your soil is contaminated.
2. Pick **cleanup remedies** that fit with your development plans:
    a. Excavation and removal
    b. Mixing
    c. Capping in place
    d. Consolidation and capping
3. Take **compliance samples** to make sure excavation or mixing worked.
4. Inform future property owners of remaining contamination under a cap or in a natural area through an **environmental covenant**.
5. Make sure that any caps are **protected and maintained**.
6. **Educate** residents and property users about remaining contamination.

I need a No Further Action determination from Ecology

If a local government permit office or lender requires Ecology's written approval of your cleanup, you must enter the Voluntary Cleanup Program (VCP). Also, a future buyer might want to see Ecology's written approval of your cleanup. The VCP provides technical assistance and a written opinion. **Getting written approvals via the VCP is free for projects with only Tacoma Smelter Plume contamination.**

This guidance covers a set of Ecology-approved cleanup remedies that already have a feasibility study. Work with your VCP site manager to use this guidance and ensure you are meeting all cleanup requirements. Visit http://www.ecy.wa.gov/programs/tcp/vcp/Vcpmain.htm

For more information, please call 360-407-6300 and ask for Ecology's Tacoma Smelter Plume Technical Assistance Coordinator.

Document Your Work!

Keep a copy of the forms you fill out to pass on to future property owners so they know that cleanup was done and how to maintain any non-permanent remedies. Future property owners may want this level of detail for when they sell the property.

As awareness about the Tacoma Smelter Plume grows, more buyers will be asking about soil contamination.

Disclaimer

Cleanups using these model remedies will meet state requirements under the Model Toxics Control Act (Chapter 70.105D) and its regulation (Chapter 173-340 WAC). However, you must enter the Voluntary Cleanup Program to get Ecology approval in the form of a No Further Action determination.

Cleanups are not exempt from local, state, and federal permitting requirements.

You may have flexibility in which cleanup methods you use. Please note that you may have to seek out other sources of information to complete your cleanup.

In this guidance, "average" refers to the arithmetic mean of sampling results. The model remedies do not use a geometric mean.

This guidance is for Tacoma Smelter Plume arsenic and lead contamination only. If your property has other contaminants besides lead and arsenic, like petroleum or industrial chemicals, contact Ecology. If you are in King or Kitsap counties call 425-649-7000. If you are in Pierce or Thurston counties call 360-407-6300.

Contents

Introduction

The former Asarco copper smelter in Tacoma caused widespread soil contamination in parts of King, Pierce, Kitsap, and Thurston counties. This 1,000 square mile area is known as the Tacoma Smelter Plume.

Arsenic and lead contamination pose a long-term human health risk, especially for children. Property owners and developers can help protect future owners and users by sampling and cleaning up affected properties.

Goals of this guidance:

- To streamline cleanups under the Voluntary Cleanup Program.
- To provide simple sampling guidance for any property in the plume.
- To encourage independent cleanup during property development.

Health Effects of Arsenic and Lead

Arsenic and lead are toxic metals. Exposure can increase the risk of certain health problems. Regular exposure can increase the risk of accidental ingestion of soil, or dust inhalation. Although the metals are not easily absorbed through the skin, Ecology is concerned about people that are regularly exposed to soil, such as children, construction workers, landscapers, and gardeners.

Scientists have linked long-term exposure to arsenic to a variety of health problems, including heart disease, diabetes, and cancer of the bladder, lung, skin, kidney, liver and prostate. Lead can cause behavioral problems, permanent learning difficulties, and reduced physical growth.

Whether someone is impacted depends on the amount of arsenic or lead taken into their body over time. People exposed to contaminated soil on a regular basis may be affected.

Children and workers are at highest risk

Young children are vulnerable because they play on the ground and put their hands in their mouths. The small amount of arsenic or lead that they may swallow is more harmful because they are still growing. Children can come in contact with arsenic or lead while playing outside and inside. Soil and dust can easily be tracked into homes from outside.

Construction workers, gardeners, and landscapers can also be exposed to contaminated soil at a work site. Exposure can happen by accidental ingestion of soil or inhalation of dust. Employers are responsible for meeting health and safety requirements at work sites to limit worker exposure. Employers should contact Department of Labor and Industries for more information.

Why sample?

The map in the front of this booklet is based on a small number of arsenic samples for the large size of the site. There is high variability in soil arsenic levels from property to property. Actual levels of arsenic and lead can only be found by soil sampling.

Once you know the contaminated areas, you can take actions to reduce contact with this soil and manage potential exposure on your property.

State Cleanup Level for Arsenic and Lead*

20 parts per million (ppm) arsenic

250 ppm lead

*Unrestricted land use (all land uses, including residential)

Model Remedies

Model Remedies are cleanup options that Ecology has pre-approved for Tacoma Smelter Plume contamination. Ecology did a feasibility study* to show that these cleanup remedies were appropriate under certain conditions. This means you can meet state cleanup requirements by following this guidance, without having to do your own feasibility study.

Cleanups are not exempt from local, state, and federal permitting requirements.

**Forms vs. Worksheets*

Forms for tracking your sampling and cleanup work are in the back of this booklet. **At a minimum**, fill out these forms for your records and to give to future property owners or others that need documentation of cleanup.

There are **worksheets** at the end of some of the chapters. These are designed to help you estimate the cost of cleanup and do not need to be kept.

**The feasibility study is Appendix C of the Tacoma Smelter Plume Interim Action Plan, available on Ecology's website* www.ecy.wa.gov/toxics/tacoma-smelter.html.

This page intentionally left blank

Chapter One: Characterization Soil Sampling

Purpose: Characterization sampling shows whether a property or portion of it is clean or contaminated.

Thorough sampling helps plan for cleanup
Soil arsenic and lead levels can vary across a property. Sampling is the only reliable way to find out whether it poses a health concern. Once you know where the contamination is, you can take actions to reduce contact and manage potential exposure.

Planning for sampling
Think about land use history. Undisturbed areas like forests are more likely to have elevated arsenic or lead. **Forest duff** can contain arsenic and lead and should be sampled before disposal or reuse.

Then, think about proposed future uses. There is a greater risk to human health if the area will be used by children or by people regularly in contact with soil.

Track this information on a map of your property. Form 1 will help you document your planning.

Decision units
Identify decision units before starting sampling. This may save time and money when it comes to cleanup. Figure 1 shows two different properties, one that has decision units based on past use, and one based on future use.

Arsenic or lead may be *below* cleanup levels in a recently graded part of the property, and *above* cleanup levels in a formerly forested part. It is more cost effective to treat these as separate decision units, since you would only clean up the area that was above state cleanup levels.

Future use can also define decision units. While Ecology encourages excavating and removing soils from home sites, you could cap soils at a community center. It would be easier to maintain a cap at a community building. At a private home, a cap would limit future homeowners' ability to install an irrigation system, build a pool, or plant trees.

Decision Unit

Area of a property expected to have a different pattern of soil contamination than other areas. Some properties will only have one decision unit. Factors include current and past land uses and development history.

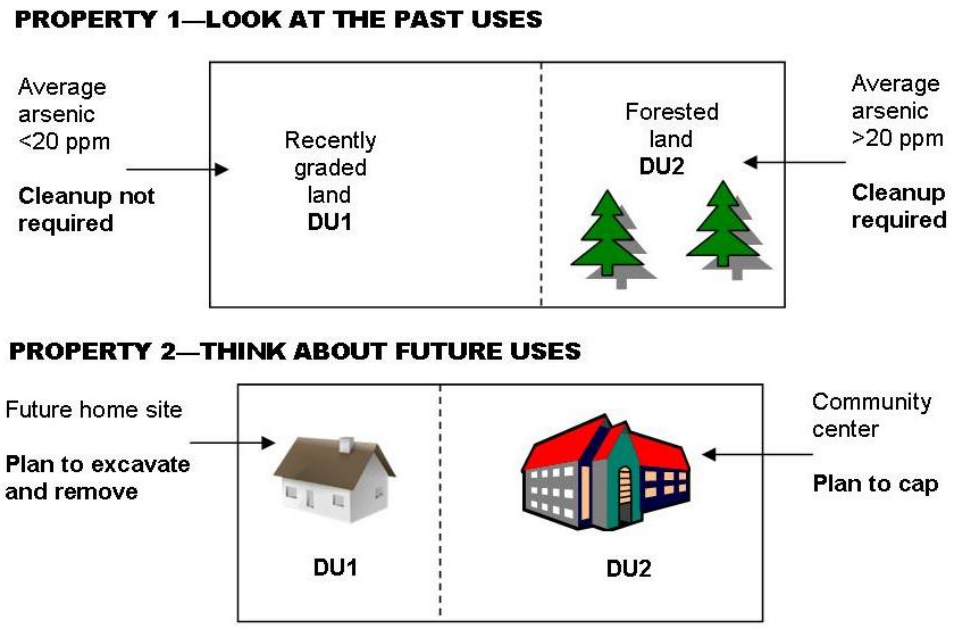


Figure 1. Dividing properties into decision units based on past or future uses

Soil: Number of samples per decision unit

Use Table 1 to find the number of sample locations you need, which depends on:

1. **Land use** – What is the **intended** use? Development or open space?
2. **Location** – Is the property in an area where arsenic has been found in soils from 20 -100 ppm or over 100 ppm (see map on inside cover)?
3. **Size** – How big is the decision unit?

For example, an undeveloped piece of property (open land or forest) will be developed into a residential plat. A land owner would need to take the number of samples needed for a residential property, not a forested or open land property.

If you also have forest duff: Number of extra samples

Mark each decision unit with significant forest duff. Plan to take **one composite sample** from each decision unit with forest duff. The composite sample will have at least six subsamples mixed together.

What is forest duff? Moderately decomposed leaves, needles, and other plant material that has gathered on the soil surface.

Why sample? Duff can have high levels of arsenic and lead. Test before mulching, reusing, or disposing of it!

Table 1. Minimum number of sample locations per decision unit

Sampling area	Residential, parks, commercial Samples needed		Forest and open land Samples needed	
Acres	**Arsenic >100 ppm**	**Arsenic 20-100 ppm**	**Arsenic >100 ppm**	**Arsenic 20-100 ppm**
0.25*	10	8	8	8
1	20	16	16	12
5	40	32	30	24
10	60	48	40	32
20	80	64	50	40
100	120	90	70	60
>100	120 + 1 per 5 acres	90 + 1 per 5 acres	70 + 1 per 10 acres	60 + 1 per 10 acres

*0.25 acres ~11,000 square feet

Soil: Where to sample

With Form 1, attach a diagram showing the property dimensions and decision units. For multiple decision units, attach a separate diagram for each, with dimensions and the location of any structures. No sampling is needed under structures or paving that will remain after development. These areas should be marked on the diagram.

For each decision unit diagram, prepare a sampling grid (Figure 2):

Step 1: Enclose the entire decision unit inside a rectangle. It is fine to have small margins around the edges.

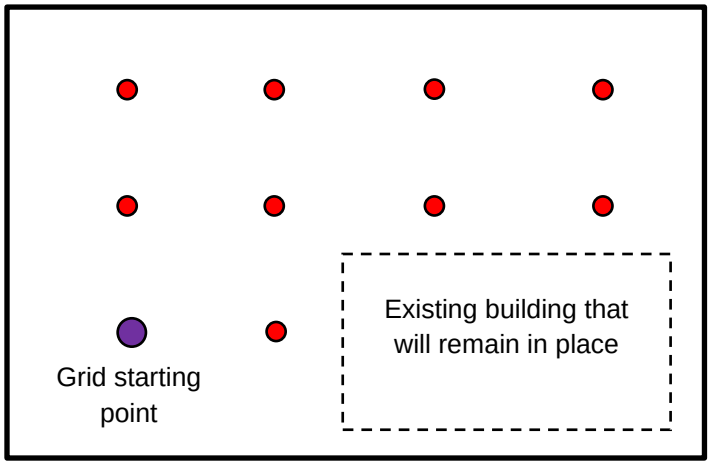
Step 2: Mark a point towards one corner of this rectangle as a starting point.

Step 3: Start with this point and begin laying out sample points in an evenly-spaced grid (Figure 2). Use the number of locations from Table 1. Grid points should cover as much area as possible. Adjust the grid or add locations to make it fit.

All samples are discrete, which means the soils for one sample come from a single sampling location.

If you also have forest duff: Where to take extra samples

Each decision unit only needs one composite sample. Each composite needs at least six subsamples. Pick at least six evenly-spaced locations throughout the decision unit to take subsamples from. You **do not** need to take them from the soil sample locations.



Decision Unit Information

Use = Residential
Size < 0.25 acres (<11,000 ft^2)
Map area = arsenic >100 ppm

Samples needed = 10

Figure 2. How to lay out a sampling grid on a decision unit

Sample depths

- **At every sample location:** Take characterization samples from the top 0-6 inches of soil, after clearing away grass, leaves, gravel, or debris on the surface (Figure 3); and
- **At every fourth sample location (25% of samples):** Also take a sample from the 6-12 inch depth.
- **If you also have forest duff:** Take each subsample from throughout the entire depth of the duff layer.

Residential development example:
For a one-acre decision unit in an area with >100 ppm arsenic and thick forest duff…

Take 20 samples from 0-6 inches
\+ 5 samples from 6-12 inches
\+ 1 forest duff composite sample
26 samples total

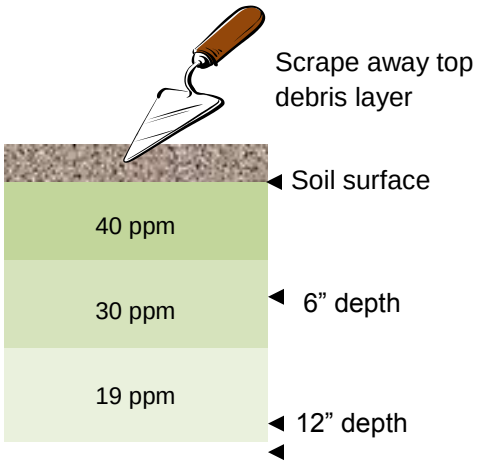


Figure 3. Example of a soil profile

Deeper soils

There may be areas where you know fill dirt, topsoil, or sod was added in the past. In every fourth sample location, also take a sample from the top 0-6 inches of the original land surface, if it is deeper than 12 inches.

Make sure you are taking enough samples
Thinking about a possible cleanup method now may help refine your sampling plan. More sampling will help to plan for excavation or mixing:

- **Excavation and removal:** You must show that the 0-6 inches under the final excavated surface meets state cleanup levels. Most projects excavate more than six inches, so at every fourth sampling location (25% of the samples), also sample from 6 -12 inches. This will help you ensure you are excavating deep enough.

- **Mixing in place with deeper soils:** Take samples from the depth you plan to mix to, at six inch intervals. At every fourth sample location, take a sample from the depth you plan to mix to. More samples than what is required for the 6-12 inch depth will give a better idea of whether the remedy will be effective.

Equipment needed:

- Stainless steel tools to dig holes and remove soil (trowel or small shovel).
- Stainless steel or glass bowl for mixing.
- Clean glass containers from the lab or zip-top plastic bags.
- Permanent marking pen to record sample locations on the jar or bag.
- Wash bucket, soap, scrub brush, and rinse water (distilled or deionized).
- Gloves and dust mask.
- Paper towels.
- Property diagrams with sampling grids.
- Map or aerial photo of decision unit.

Soil: Sampling steps
Take one sample from each depth range you need, at each sampling location marked on your decision unit diagrams. These should be collected as separate samples. Do not mix **soil** samples from different sampling locations or depth ranges.

1. Before taking any samples, contact an Ecology accredited lab (see “Help Desk”). The lab may have special instructions about labeling and delivering the samples.

2. Label each sampling location, in each decision unit, with a unique name or number. For better accuracy in recording your sample locations, use a Geographic Positioning System (GPS). Mark them on an aerial photo, if you can.

3. Using a permanent marker, label your glass jars or zip-top plastic bags with:
    - The unique identifier for the sampling location.
    - Your name.
    - The date the sample is being taken.
    - “Arsenic and lead”
4. Clear away grass, leaves, gravel or debris from the soil surface to ensure your sample is all soil. Dig a six-inch hole with the stainless steel trowel, shovel, or hand augur.
5. Using a clean trowel or spoon for each depth, scrape soil from the sides of the hole and put it in the mixing bowl. Avoid or discard pebbles, rocks, leaves, roots, and stems. Collect soil evenly from throughout the depth of the hole.
6. Mix soil thoroughly in the bowl. Fill up the jar or plastic bag with the mixed soil and seal it securely. Discard any extra back into the hole. Do not composite (mix) samples from different locations.
7. Between each sample, scrub the sampling tool and mixing bowl clean in the wash bucket, rinse, and pour the dirty water down a sanitary sewer or in a place where it can soak into the ground. Don’t pour it down the storm drain.
8. For 6-12 inch samples, dig another six inches deeper at the same location. This is a separate sample, so repeat steps 4-6, but only scrape the side of the hole where it is 6-12 inches deep.

Healthy Sampling Steps

Limit dust by dampening soil before sampling, or wear a dust mask.

Wear gloves. Wash hands, arms, and face after sampling.

Wash work clothing separately from other laundry.

Forest duff: Sampling steps

1. For each subsample, dig a hole through the whole duff layer and scrape duff all the way down the side of the hole. Use a clean trowel or spoon.
2. Wash the trowel or spoon between subsamples.
3. Mix all of the subsamples together in a stainless steel mixing bowl.
4. Take one sample from the bowl and place it in a jar or plastic bag. Make sure the jar or bag is labeled with the decision unit and type of sample (duff).
5. Follow the lab analysis guidelines.
6. Wash your bowl and sampling tools before taking another composite sample. Pour the dirty water down a sanitary sewer or in a place where it can soak into the ground. Don't pour it down the storm drain.

How deep should I sample the duff? It can be hard to tell where the duff ends and soil begins. Sample down to the point where the duff can be easily brushed away from the soil. If you have to scrape to get any deeper, you are likely in the soil.

Lab analysis

See the Help Desk section of this guidance for how to select a lab. The lab must use EPA methods 6010, 6020, or 6200 (for arsenic and lead). They may also use method 7060 for arsenic, or 7421 for lead.

Keep samples in a cool, dry place until they are analyzed. Bring the samples to the lab or follow its instructions for shipping. Include a copy of the sample inventory sheet (Form 2) and the custody form provided by the lab. Keep copies for yourself.

The lab report should include a list or separate pages of results for each sampling location. It should have results for quality control samples done at the lab. This is standard practice for all metals analysis. You will also see a chain of custody form—this is used to keep track of the samples. Keep everything you receive from the lab.

Soil: Understanding your characterization results

Use the sample results to plan your next steps. If arsenic or lead levels are "elevated" for any decision unit on the property, it needs cleanup. Elevated means:

- Average arsenic >20 parts per million (ppm) or average lead >250 ppm; **or**
- Maximum (any one sample) arsenic >40 ppm or maximum lead >500 ppm.

Use Form 2 to calculate average and maximum arsenic and lead for each decision unit, at each depth. Mark which decision units exceed state cleanup levels.

"Elevated" arsenic and lead levels

- Average* arsenic >20 parts per million (ppm)
- Max arsenic >40 ppm

- Average* lead >250 ppm
- Max lead >500 ppm

**Arithmetic average*

Forest duff: Understanding your results

If any of your composite samples are over 20 ppm arsenic or 250 ppm lead, the duff will pose a risk if reused or composted. You must dispose of the duff at an appropriate disposal facility. For information about waste disposal within the Tacoma Smelter Plume:

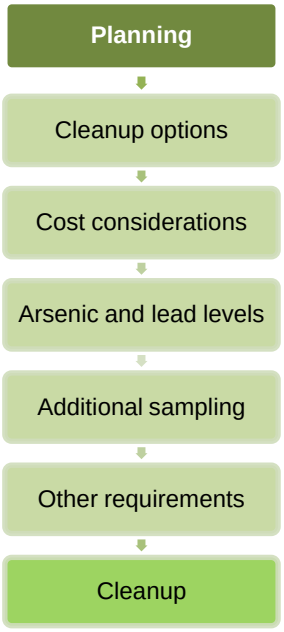
Tacoma-Pierce County Health Department
http://www.tpchd.org/environment/waste-management/

King County Landfills
http://your.kingcounty.gov/solidwaste/facilities/wasteclearance.asp

What to do next

If none of your decision units are "elevated," stop here. If one or more decision units are elevated, you must select one or more cleanup options from Chapter 2. Ecology also recommends:

- Doing cleanup as part of your development project.
- Taking healthy actions like hand-washing and taking shoes off at the door (see the Help Desk section).
- Notifying tenants or property users of healthy actions and why to use them.



Chapter Two: Planning for Cleanup

Cleanup options

Table 2 summarizes the four Tacoma Smelter Plume Model Remedies. Some cleanup options are only model remedies when arsenic and lead are at or below a certain level (Table 3).

Excavation and mixing are the two permanent remedies, whereas capping needs ongoing maintenance and property restrictions.

Cost: The location, accessibility, and features of the property can make certain options less expensive. Many cleanup activities can be incorporated into existing plans, which is more cost-effective.

Table 2. Model Remedy options

	Model Remedy	Action	Considerations
Permanent	**Excavate & Remove (Ch. 3)**	Excavate contaminated soils and properly dispose of them.	⇒ The top 6" of soil must have <20 ppm average arsenic and <250 ppm average lead after excavation. Take samples at depth to make sure you remove all contamination. ⇒ Performance monitoring required.
Permanent	**Mix (Ch. 4)**	Mix the top 6-12" of contaminated soils with imported soils or deeper, clean soil.	⇒ Not for soils >40 ppm average arsenic. ⇒ Performance monitoring required.
Non-Permanent	**Cap in Place (Ch. 5)**	Cover contaminated soils with a geotextile barrier and soil cap, or a hard cap.	⇒ Hard caps include asphalt or concrete. ⇒ Thicker soil cap required for higher levels. ⇒ Institutional controls required. ⇒ Performance monitoring required. ⇒ Confirmational monitoring required.
Non-Permanent	**Consolidate and Cap (Ch. 6)**	Excavate and consolidate contaminated soils into an area of the property and place under a cap (above).	⇒ Thicker cap required for higher levels. ⇒ Not for average arsenic >200 ppm or lead >1000 ppm ⇒ Performance monitoring required. ⇒ Confirmational monitoring required. ⇒ Institutional controls required.

Natural Areas
In 2013, Ecology hopes to have further guidance for natural areas. In some cases, there is more value in preserving a natural area, than in destroying habitat just to clean up the soil.

Currently, projects must do a separate disproportionate cost analysis to get Ecology approval to leave contamination in place. For more information, please call 360-407-6300 and ask for Ecology's Tacoma Smelter Plume Technical Assistance Coordinator.

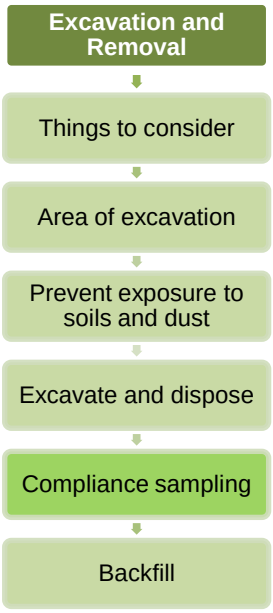
Table 3. Model remedies by arsenic and lead soil level

Characterization sampling results in parts per million (ppm)		Permanent		Non-Permanent	
Average	**Maximum**	**Excavate & remove**	**Mix**	**Cap in place**	**Consolidate and cap**
Arsenic 20-40 Lead 250-500		Yes	Yes	Yes	Yes
Arsenic 40-100 Lead 250-500	**<200 <1000**	Yes	No	Type 1 or 2*	Type 1 or 2*
Arsenic 100-200 Lead 500-1000		Yes	No	Type 2 cap only	Type 2 cap only
Arsenic >200 Lead >1000		Yes	No	Type 2 cap only	No

*Type 1 and 2 caps are described in Chapter 5.

Additional sampling
Excavation and removal and mixing require compliance sampling (Chapter 7) to show the cleanup is complete. When importing soils, Ecology recommends requesting sample results from the soil provider or doing imported soil sampling yourself (Chapter 9). Soil disposal may also require stockpile sampling.

Follow other government requirements for your project
This guidance only covers Model Toxics Control Act requirements. It does not cover other federal, state, and local rules and regulations that may apply to your project. For example, your local planning department will not allow you to destroy a wetland in order to clean up soil contamination.



Chapter Three: Excavation and Removal

Purpose: To permanently clean up any level of arsenic or lead contamination on your property by digging out soils, properly disposing of them at a landfill, and backfilling with clean soils.

Things to Consider

Arsenic and lead levels: Use excavation at any level of contamination.	
Pros: • Permanent. • Only permanent remedy for average arsenic >40 ppm, lead >500 ppm. • Works for all levels of arsenic or lead soil contamination.	**Cons:** • May require a waste disposal authorization for landfill disposal. • Can be expensive to transport and dispose of soils and import new soil. • Requires sampling for disposal and for importing new soils.
Costs: There are costs with removal, proper landfill disposal, and bringing in clean fill. However, there are no long term costs for maintenance and monitoring because the remedy is permanent. Estimate costs using the worksheet at the end of the chapter.	

Excavation and Disposal Process (see Form 3)

1. Determine your area of excavation. You should only excavate areas that you do not plan to clean up using other methods. Make sure that you have sufficiently narrowed down your decision units. You can use more sampling to eliminate areas that already meet state cleanup levels for arsenic and lead.

2. Prevent contaminated soils and dust from leaving the site. Control dust on the worksite during dry months by watering down the soil. If you are storing soil until it can be disposed of, make sure it is covered to prevent runoff. Install proper erosion control devices to prevent contaminated soil from leaving the project area.

You will need to apply for coverage under the construction stormwater general permit (http://www.ecy.wa.gov/programs/wq/stormwater/construction/) if your property is over one acre. There may be additional local stormwater control requirements.

If possible, trucks should avoid driving through contaminated soils. Trucks removing soil should be tightly covered, their wheels should be rinsed to prevent contaminated soil from leaving the worksite, and quarry spall should be used at entrance.

3. Plan to protect workers. The Washington Department of Labor and Industries regulates health and safety at worksites. For guidance on arsenic in soils, visit: http://www.lni.wa.gov/WISHA/Rules/arsenic/HTML/ht2Arsenic.htm.

4. Excavate and test soils before disposal. For any property or decision unit with arsenic or lead above state cleanup levels, all soil, sod, and duff must be disposed of at a permitted landfill.

Use stockpile sampling (Chapter 8) to determine your arsenic and lead levels. This information or a toxicity characteristic leaching procedure (TCLP) may be required for a Waste Disposal Authorization, or to dispose of soils in a private landfill. You may also be able to use characterization sampling results.

For information about waste disposal within the Tacoma Smelter Plume:

Tacoma-Pierce County Health Department
http://www.tpchd.org/environment/waste-management/

King County Landfills
http://your.kingcounty.gov/solidwaste/facilities/wasteclearance.asp

5. Take compliance samples after excavation is complete. Soils from 0-6" below the excavated surface should have average arsenic at or below 20 ppm and average lead at or below 250 ppm. If not, excavate further. Chapter 7 describes how to take compliance samples.

6. Backfill the excavated areas with clean soil, if needed. Before you purchase soil, check with the supplier to ensure it has below 20 ppm arsenic and below 250 ppm lead. Some questions to ask your supplier include:

- Where does this soil come from?
- Is it blended with compost or additives? If so, where do they come from?
- Has it been tested for chemical contamination?
- Will the soil support sod, vegetation, etc.?

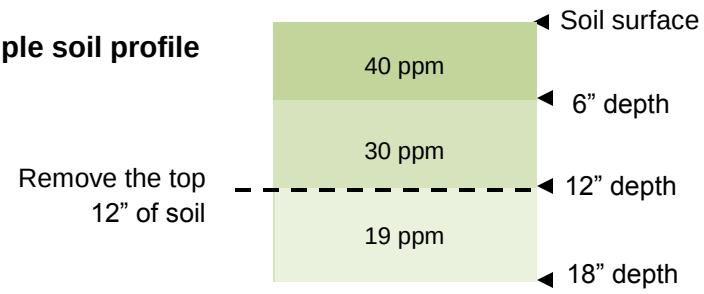
If you are unsure of whether these soils meet state cleanup levels, do imported soils sampling (Chapter 9) or ask the supplier to sample. If you are planning to use onsite soils to backfill, do stockpile sampling to make sure they won't re-contaminate the excavated area.

Worksheet: Planning for excavation and removal

1. Calculate soil removal depth by decision unit

Remove enough soils to reach soils meeting state cleanup levels below the contaminated surface soils (Figure 4).

Figure 4. Example soil profile for arsenic



2. Calculate the volume of soil to be removed in cubic yards (yds^3), by decision unit (DU).

DU1 area _____ sq ft **x** removal depth _____ ft**/**27 **=** _____ yds^3

DU2 area _____ sq ft **x** removal depth _____ ft**/**27 **=** _____ yds^3

DU3 area _____ sq ft **x** removal depth _____ ft**/**27 **=** _____ yds^3

DU4 area _____ sq ft **x** removal depth _____ ft**/**27 **=** _____ yds^3

3. Calculate soil transport cost by volume.

_____ yds^3 (from step 1) x 1.5 tons/yds^3 x $_____ /ton = $_____

4. Select a municipal or private permitted landfill and call for waste disposal authorization fee information.

Landfill name: _____

Phone: (____) _____ Fee: $_____

5. Ask the permitted landfill or your local health department what type of sampling is required for soil disposal.

It may require stockpile sampling (Chapter 8) or toxicity characteristic leaching procedure (TCLP) testing. This test determines if soil is safe for landfill disposal. Ask your lab if they can do TCLP, which typically costs $75-100.

Sampling or TCLP: $ _____

6. Calculate the soil disposal cost by volume.

_____tons of soil x $_____ /ton= $_____

7. Calculate the fill cost by volume.

Use the excavated soil volume from step 1 as your backfill volume. To ensure you are not re-contaminating the property, check the soil quality with your supplier. Ask if they have any data on metals in their soils. If not, ask if they can sample for you (see Chapter 9).

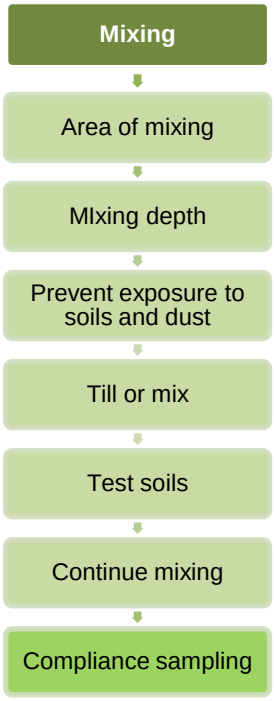
_____ yds^3 fill x $_____ /cubic yd = $_____

8. Other costs: Estimate the labor and equipment costs of soil removal and backfilling. Also think about the cost of compliance sampling (Chapter 7) and possible imported soil sampling (Chapter 9).

$_____

9. Total the costs

3	Soil transport	$ _____
4	Disposal fee	+ $ _____
5	TCLP	+ $ _____
6	Soil disposal	+ $ _____
7	Backfill	+ $ _____
8	Other costs	+ $ _____
		= $ _____



Chapter Four: Mixing

Purpose: To permanently clean up soils with average arsenic of 40 ppm or less (or average lead of 500 ppm or less) through dilution.

Mix contaminated soils with clean imported soils or clean soils underneath the contaminated surface soils. Soil can be mixed in place, or piled into rows, mixed, and spread back out. Mixing is only for areas with average arsenic below 40 ppm and average lead below 500 ppm. It is impractical to dilute higher levels of arsenic or lead. The effectiveness of mixing depends on how deep you mix, how deep contamination goes, and the efficiency of mixing equipment.

Things to Consider:

Arsenic and lead levels: Use mixing only when <40 ppm arsenic and <500 ppm lead (average).	
Pros: • Permanent. • Does not require excavation or off-site disposal.	**Cons:** • Low remediation levels. • Only practical for contamination not deeper than 12". • Higher sampling costs. • Extra sampling may cause delays.
Costs: Mixing can be labor-intensive. However, there are no long term costs because the remedy is permanent. You also do not have the cost of soil disposal. Estimate costs using the worksheet at the end of the chapter.	

Characterization sampling helps to plan for mixing

Review your characterization sample results (Form 2) to make sure:

1. Average arsenic is below 40 ppm and average lead is below 500 ppm.
2. Contamination is not deeper than 12 inches.
3. Arsenic and lead levels in deeper soils (12-18" and 18-24") have low enough arsenic and lead levels to dilute surface soils.

Use the worksheet in this chapter to calculate your mixing depth.

Mixing Process (see Form 4)

Ecology has tested mixing methods on large areas of arsenic and lead contaminated soils in central Washington. However, there is no detailed guidance on how to use mixing as a cleanup method. There is some guesswork in knowing how much to mix soils, but compliance sampling (Chapter 7) will show if the cleanup level is met.

1. Determine your mixing area. Only mix decision units with average arsenic at or below 40 ppm (or lead at or below 500 ppm).

2. Calculate your mixing depth. Use the worksheet at the end of this chapter to determine how deep to mix, or how much clean soil to import.

3. Prevent contaminated soils and dust from leaving the site. Control dust on the worksite during dry months by watering down the soil. If you are storing soil until it can be mixed, make sure it is covered to prevent runoff. Install erosion control devices to keep dirty water from leaving the site. You will need to apply for coverage under the construction stormwater general permit if your property is over one acre (http://www.ecy.wa.gov/programs/wq/stormwater/construction/). There may be additional local stormwater control requirements.

4. Plan to protect workers. The Washington Department of Labor and Industries regulates health and safety at worksites. For guidance on arsenic in soils, visit: http://www.lni.wa.gov/WISHA/Rules/arsenic/HTML/ht2Arsenic.htm.

5. Begin tilling or mixing. Using the calculated depth from the worksheet, add the appropriate depth of soil or mix to that depth. There are three ways to mix:

A. Till soils **in place** using several passes of the equipment, blending contaminated surface soils with cleaner, deeper soils. This may be difficult when rocks or roots are present in the soil.

B. **Import clean soils** and till them into contaminated soils (see Chapter 9).

C. Dig up contaminated surface soils and stockpile them. Either import clean soils or dig up cleaner, deeper soils. Next, mix these soils **on the land surface**. Use stockpile sampling (Chapter 8) to tell if soils are clean enough before spreading them back over the site.

6. Test your soils. Once an area is well mixed, take soil samples. Analyze each sample for arsenic and lead using an XRF device (see box) or send it to a lab. Lab analysis may take weeks, but samples can be rushed in

XRF

An X-ray fluorescence spectroscopy (XRF) device gives instant arsenic readings in the field.

Very few consultants have these devices, which require special training to use. They can be rented from companies that sell them. You will need to compare the rental cost to the cost of lab analysis.

about 24 hours.

7. Continue mixing. If arsenic or lead is still above state cleanup levels, continue mixing.

8. Take compliance samples after mixing is complete (Chapter 7). Take samples every six inches, from the soil surface, down to the deepest point you mixed (Figure 5). Send them to a lab.

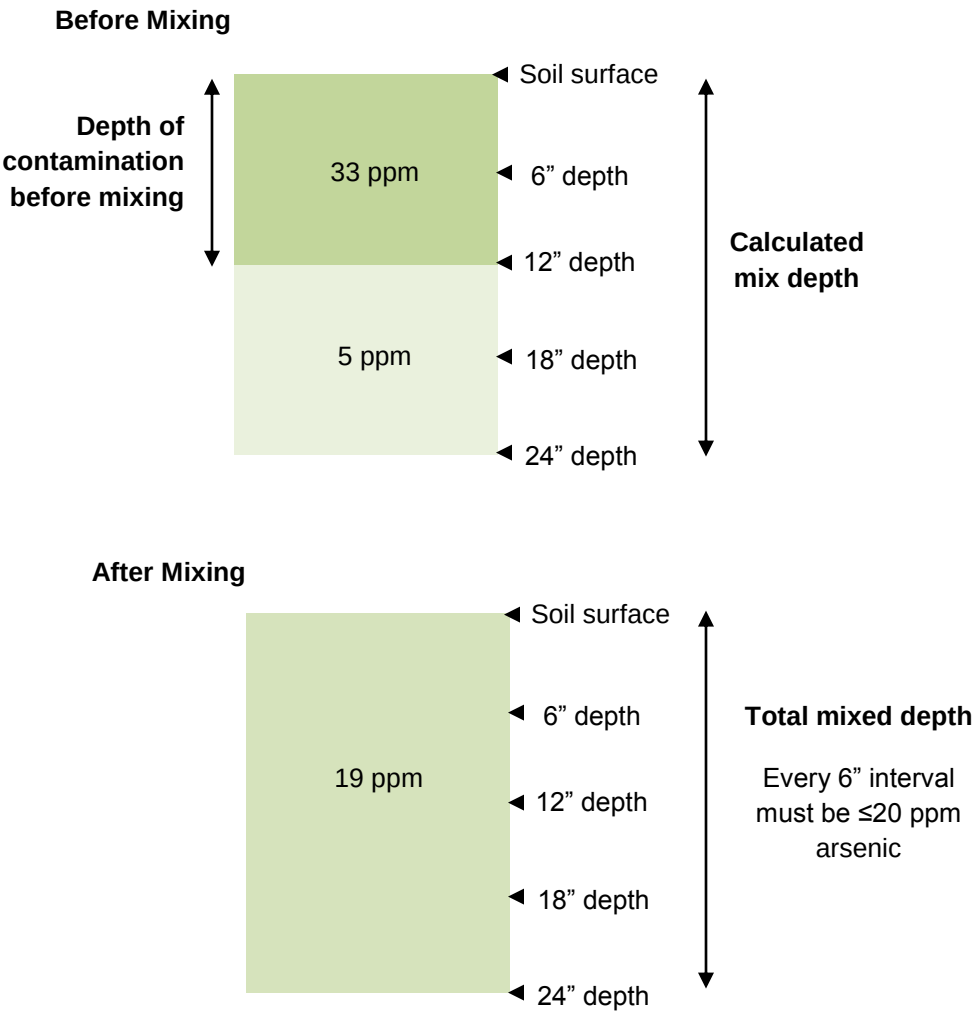


Figure 5. Soil profile before and after mixing

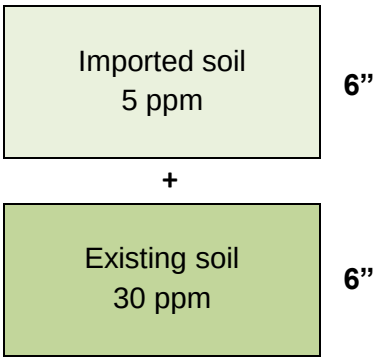
Worksheet: Planning for mixing

1. Mixing depth examples

For lead, use the same mixing depth calculations, with 250 ppm as the cleanup level.

A. Importing soil to mix in

This example assumes some level of background arsenic in local soils. Don't bring contaminated soils onto the property—ask the supplier for soil test results or stockpile sample imported soils. To calculate whether a certain depth of imported soils will dilute the contaminated soils:



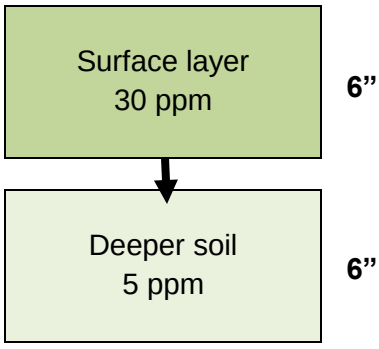
$$\frac{\text{Imported soil arsenic x depth + existing soil arsenic x depth}}{\text{Imported depth + existing depth}}$$

(5 ppm x 6" + 30 ppm x 6")/(6"+6") = 210 ppm"/12" = **17.5 ppm**

→ 17.5 ppm meets the cleanup level of 20 ppm for arsenic.

B. Mixing with deeper soils (undisturbed areas)

Undisturbed soils tend to have contamination mainly in the top 6" of soil. To calculate how deep to mix:



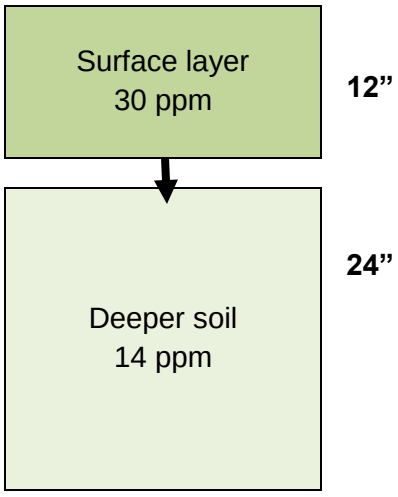
$$\frac{\text{Surface soil arsenic x depth + Deeper soil arsenic x depth}}{\text{Surface depth + deeper depth}}$$

(30 ppm x 6" + 5 ppm x 6")/(6"+6") = 210 ppm"/12" = **17.5 ppm**

→ 17.5 ppm meets the cleanup level of 20 ppm.

C. Mixing with deeper soils (disturbed areas)

Areas that have been graded, sloped, or otherwise disturbed may have higher levels in deeper soils. Characterization samples may be needed at 12-18" or deeper. This example uses characterization samples down to 36". To calculate how deep to mix:



$$\frac{\text{Surface soil arsenic x depth + Deeper soil arsenic x depth}}{\text{Surface depth + deeper depth}}$$

(30 ppm x 12" + 14 ppm x 24")/(12"+24") = 696 ppm"/36" = **19.3 ppm**

→ 19.3 ppm meets the cleanup level of 20 ppm.

2. Imported soil volume

_____ ft mix depth **x** _____ ft^2 decision unit /27 = _____ yd^3 soil

3. Imported soil cost

Fill cost by volume. Check the soil quality with your supplier (chapter 9).

_____ cubic yds of soil x $_____ /cubic yd = $_____

4. Equipment

a. Describe soil type and mixing depth when asking about rental costs for mixing equipment.

$_____

b. An X-ray fluorescence spectroscopy (XRF) gun provides instant arsenic and lead readings in the field. A few consultants may have these devices and the expertise to operate them. Otherwise, take samples to a lab.

$_____

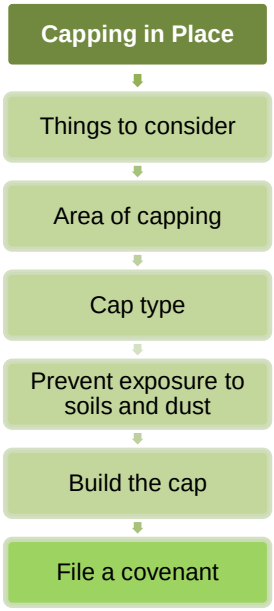
c. Labor—Mixing cannot be done with a single pass from a tiller. Go over each section several times to ensure contamination is diluted. This process can be labor intensive. Account for the time it will take to sample soils along the way.

$_____

5. Total estimated costs

3	Imported soil	$ _____
4a	Mixing equipment	+ $ _____
4b	XRF or lab samples	+ $ _____
4c	Labor	+ $ _____
		= $ _____

This page intentionally left blank



Chapter Five: Capping in Place

Purpose: To cover contaminated soil where it lies with a soil cap or hard cap. The cap prevents exposure to contaminated soils on the property.

A hard cap is a building, parking lot, pavement, or driveway. A soil cap is a certain depth of clean soil over a geotextile. Part of the soil cap can be landscaping material. Select a cap type (Figure 6) based on the arsenic and lead levels.

Important: Ecology expects excavation and removal of contaminated soil during residential development, rather than capping yards. Excavation and removal is permanent to the maximum extent practicable.

Development presents a chance to remove all contaminated soil during grading. It is also a good time to do mixing if arsenic levels are below 40 ppm and lead is below 500 ppm. Mixing can be less expensive because it does not require landfill disposal.

Things to Consider:

<table>
<tr><td colspan="2">Arsenic and lead levels:
Use Type 1 caps only when average <100 ppm arsenic and <500 ppm lead or maximum <200 ppm arsenic and <1000 ppm for lead.

Use Type 2 caps at any level of contamination.</td></tr>
<tr><td>Pros:
Can be integrated into existing development plans.
Does not require off-site disposal.
Certain cap types can be used for any arsenic or lead level.</td><td>Cons:
Not permanent; potential for exposure if the cap is removed.
Soil caps add 1-2 feet of elevation.
Long-term monitoring and maintenance needed.
Requires environmental covenant.</td></tr>
<tr><td colspan="2">Costs: The up-front costs of capping in place can be lower, especially if integrated into existing development plans. However, there are long-term monitoring and maintenance costs. Estimate costs using the worksheet at the end of the chapter.</td></tr>
</table>

Soil caps: Cap soils must meet state cleanup levels for arsenic and lead. Otherwise, you will re-contaminate the property. Do imported soils sampling (Chapter 9) or ask the supplier to sample. Ask where the soil came from, if it has additives, and if it will support vegetation.

Landscaping materials: Up to 6 inches of the Type 1 or Type 2 soil cap can be materials other than soil. This includes wood chips, bark, mulch, sand, and gravel. Keep in mind that these materials can wear away quickly if they are in a play area or high traffic area. Gravel is better for pathways and trails. The landowner must maintain the cap.

Geotextiles: A geotextile indicates that soil beneath it may still be contaminated, and that maintenance is needed when it becomes exposed. Use a bright color to warn future property users. The fabric also minimizes capped soils from being brought to the surface by animals. Check with your supplier to make sure the geotextile is not bio-degradable, and thick and durable enough to last underground.

Hard caps: Hard caps are most cost-effective when they are part of the original development plan, like a building or driveway.

Remember to follow proper engineering practices and local, state, and federal regulations when installing both soft and hard caps.

Capping Process (see Form 5)

1. **Determine the capping area.** Use more sampling to narrow down the area.

2. **Pick a cap type.** Many developments can use a combination of hard caps—buildings and paved areas—and soil caps for landscaped areas.

3. **Prevent contaminated soils and dust from leaving the site.** Control dust on the worksite during dry months by watering down the soil. Be sure install proper erosion control devices to prevent dirty contaminated water from leaving the project area. You will need to apply for coverage under the construction stormwater general permit if your property is over one acre. (http://www.ecy.wa.gov/programs/wq/stormwater/construction/) There may be additional local stormwater control requirements.

4. **Plan to protect workers.** The Washington Department of Labor and Industries regulates health and safety at worksites. For guidance on arsenic in soils, visit: http://www.lni.wa.gov/WISHA/Rules/arsenic/HTML/ht2Arsenic.htm.

5. **Build the cap.** Use enough materials to create the necessary cap depth (Figure 6). Make sure it covers the contaminated area.

6. **File an environmental covenant.** This is a legal mechanism that warns future property owners that contamination remains on the property. It also restricts uses that would damage the cap and sets an inspection schedule and cap maintenance instructions. See Chapter 10 for more information.

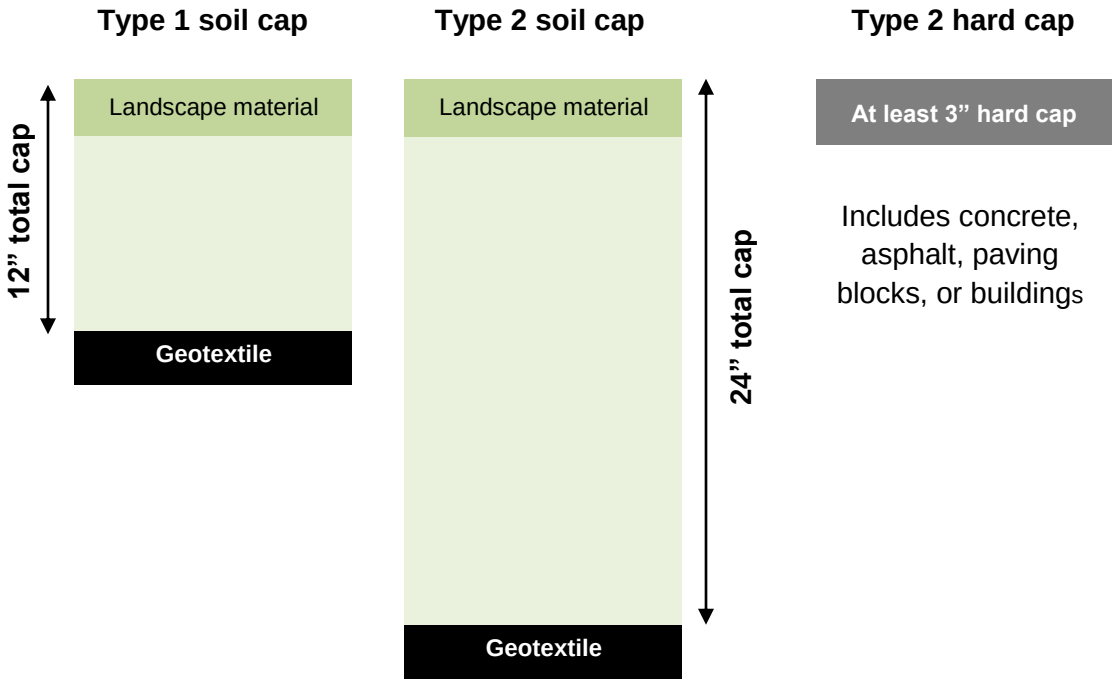


Figure 6. Cap types

Worksheet: Planning for capping in place

1. Hard cap - There should be no extra cost to your project if the building or pavement area was part of the original plan.

2. Soil cap - There should be little additional cost for areas where landscaping was part of the original development plan.

a. Calculate the volume of soil by decision unit (DU)

DU area _____ft^2 **x** _____ft depth of cap **/** 27 = _____ yd^3

b. Request a cost estimate for the new soil and delivery.

$ _____/yd^3 **x** _____yd^3 = $_____

c. Calculate the cost of the geotextile

DU area _____ ft^2 **/** 9 **x** $ _____/yd^2 material = $ _____

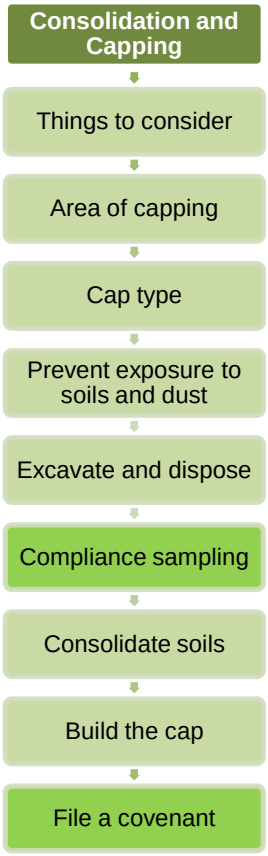
d. Labor. Cost of Installing the cap $_____

3. Monitoring and maintenance

Inspect caps at least once every year. Factor in the cost of regular inspections and repairs. Maintenance may include replenishing soil or landscaping materials.

4. Total estimated costs

2b	Soil cap	$ _____
2c	Geotextile	+ $ _____
2d	Labor	+ $ _____
3	Monitoring and maintenance	+ $ _____
	=	$ _____



Chapter Six: Consolidation and Capping

Purpose: To dig out contaminated soils, consolidate them in one place, and cover them with a soil cap or hard cap. The consolidation reduces the footprint of contamination on the property and the cap prevents exposure.

A hard cap is a building, parking lot, pavement, or driveway. A soil cap is a certain depth of clean soil over a geotextile. Part of the soil cap can be landscaping material. Figure 6 in Chapter 5 shows both cap types.

Important: Ecology expects excavation and removal of contaminated soil during residential development, rather than capping yards. Excavation and removal is permanent to the maximum extent practicable.

Development presents a chance to remove all contaminated soil during grading. It is also a good time to do mixing if arsenic levels are below 40 ppm and lead is below 500 ppm. Mixing can be less expensive because it does not require landfill disposal.

Things to consider:

Arsenic and lead levels:
Use Type 1 caps only when average <100 ppm arsenic and <500 ppm lead.
Use Type 2 caps only when average <200 ppm arsenic and <1000 ppm lead.

Pros:	**Cons:**
• Can be integrated into existing development plans. • Does not require off-site disposal. • Confines contamination to a smaller footprint on the property. • Can be used for high arsenic and lead levels.	• Not permanent; potential for exposure if the cap is removed. • Soil caps add 1-2 feet of elevation. • Long-term monitoring and maintenance needed. • Requires environmental covenant. • Excavated soils may not be suitable as subgrade for paving or buildings.

Costs: The up-front costs of consolidation and capping can be lower, especially if integrated into existing development plans. There are long-term monitoring and maintenance costs. Estimate costs using the worksheet at the end of the chapter.

Process for consolidation and capping (see Form 6)

1. **Determine the capping area.** Use additional sampling to narrow down the area that needs to be capped.

2. **Pick a cap type.** Many developments can use a combination of hard caps (buildings and paved areas) and soil caps (landscaped areas).

7. **Prevent contaminated soils and dust from leaving the site.** Control dust on the worksite during dry months by watering down the soil. Be sure install proper erosion control devices to prevent dirty contaminated water from leaving the project area.

   You will need to apply for coverage under the construction stormwater general permit if your property is over one acre (http://www.ecy.wa.gov/programs/wq/stormwater/construction/). There may be additional local stormwater control requirements.

3. **Plan to protect workers.** The Washington Department of Labor and Industries regulates health and safety at worksites. For guidance on arsenic in soils, visit: http://www.lni.wa.gov/WISHA/Rules/arsenic/HTML/ht2Arsenic.htm.

4. **Excavate contaminated soils from the entire decision unit.** Use the worksheet in this chapter to help determine your excavation depth.

5. **Take compliance samples after excavation is complete.** Soils from 0-6" below the excavated surface should have average arsenic at or below 20 ppm and average lead at or below 250 ppm. Chapter 7 describes how to take compliance samples.

6. **Consolidate the soils.** Carefully transport excavated soils to the area where they will be capped. These soils can contaminate other parts of the property if they escape during transport.

7. **Build the cap.** Use enough materials to create the needed cap depth (Figure 6 in Chapter 5). Make sure it covers the contaminated area. Sample any imported soils (Chapter 9) to make sure the cap material is not contaminated.

8. **File an environmental covenant.** This is a legal mechanism that warns future property owners that contamination remains on the property. It also restricts uses that would damage the cap and sets an inspection schedule and cap maintenance instructions. See Chapter 10 for more information.

Worksheet: Planning for consolidation and capping

1. Consolidation - Labor and equipment costs may vary depending on the volume of contaminated soil and how far it is being moved.

2. Hard cap - There should be no additional cost to your project if the building or pavement area was part of the original plan.

3. Soil cap - There should be little extra cost for areas where landscaping was part of the original development plan.

a. Calculate the volume of soil

Consolidated area _____ft^2 **x** ____ft depth of soil cap **/** 27 = _____ yd^3

b. Request a cost estimate for the soil

$ _____/yd^3 **x** _____yd^3 = $_____

c. Calculate the cost of the geotextile

DU area _____ ft^2 **/** 9 **x** $ _____/yd^2 material = $ _____

d. Labor. Cost of Installing the cap $_____

4. Monitoring and maintenance
Inspect caps at least once every year. Factor in the cost of regular inspections and repairs. Maintenance may include replenishing soil or landscaping materials.

5. Total estimated costs

1	Consolidation	$ _____
3b	Soil cap	+ $ _____
3c	Geotextile	+ $ _____
3d	Labor	+ $ _____
4	Monitoring and maintenance	+ $ _____
		= $ _____

This page intentionally left blank

Chapter Seven: Compliance Sampling

Purpose: Sampling to determine if excavation or mixing worked. Samples must meet state cleanup levels for arsenic and lead.

When to do compliance sampling

- Excavation and removal – After excavation and before backfilling.
- Mixing – After mixing is complete.
- Consolidation and capping – After excavation and before backfilling.

Sampling area

Use Form 7 to record the sampling area, sample numbers, and locations. You may treat contiguous decision units with the same cleanup remedy all as one unit for compliance sampling (Figure 7).

However, you may want compliance sample results for different parts of the property. For example, if you plan to sell certain parcels, purchasers may wish to see compliance results for their specific parcel. In this case, determine the sampling area, and number and location of samples for each of the areas. Attach a separate diagram for each.

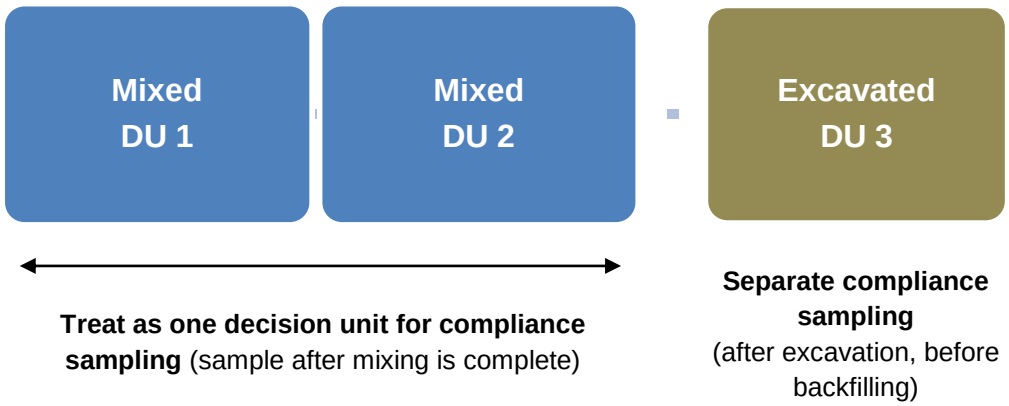


Figure 7. Combining decision units for compliance sampling

Table 4. Minimum number of compliance sample locations per decision unit

Sampling area size (acres)	Samples needed Mapped arsenic >100 ppm	Samples needed Mapped arsenic <100 ppm
0.25*	10	8
1	20	16
5	40	32
10	60	48
20	80	64
100	120	90
>100	120 + 1 per 5 acres	90 + 1 per 10 acres

*0.25 acres ~11,000 square feet

Number of Samples and Sampling Grid

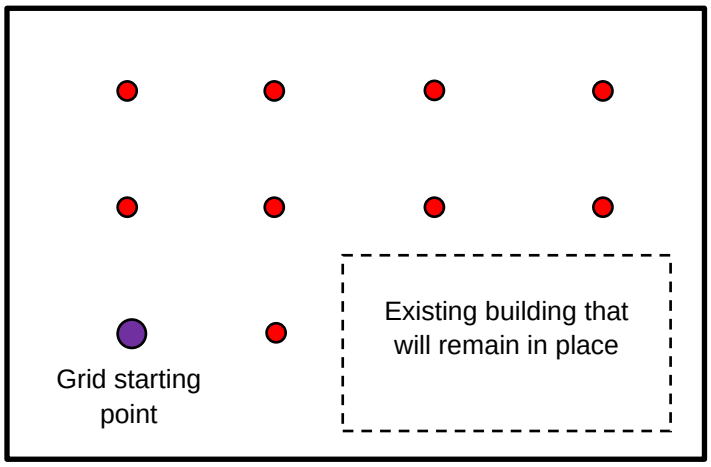
Use Table 4 to find the number of sample locations. It depends on the acreage and if the property is in a map zone where arsenic is over 100 ppm (see inside cover).

Next, attach a diagram showing cleaned up areas of the property, and the location of buildings or paved areas, which are not included in compliance sampling. For each decision unit diagram, prepare a sampling grid (Figure 8):

Step 1: Enclose the entire decision unit inside a rectangle.

Step 2: Mark a location towards one corner of this rectangle as a starting point.

Step 3: Lay out sample locations in an evenly-spaced grid (Figure 8). Use the number of sample locations from Table 4. Grid points should cover as much of the decision unit area as possible.



Decision Unit Information

Use = Residential
Size < 0.25 acres (<11,000 ft^2)
Map area = arsenic >100 ppm

Samples needed = 10

Figure 8. How to lay out a sampling grid on a decision unit

Sample Depth

1. **Excavated soils:** Take compliance samples from the top six inches of the soil surface after an area has been excavated (but not filled back in). Do this for every sampling location.

2. **Mixed Soils:** For areas where soils have been mixed, at every sample location, take samples from the entire depth profile, at six inch intervals. For example, if you mixed to a depth of 24 inches, you need to sample four depths—0-6, 6-12, 12-18, and 18-24 inches below the finished surface at each sampling location.

Sampling process

Compliance sampling is similar to characterization sampling (Chapter 1). Begin by preparing the same type of equipment:

- Stainless steel tools to dig holes and remove soil (trowel or small shovel).
- Stainless steel or glass bowl for mixing.
- Clean glass containers from the lab or zip-top plastic bags.
- Permanent marking pen to record sample locations on the jar or bag.
- Wash bucket, soap, scrub brush, and rinse water (distilled or deionized).
- Gloves and dust mask.
- Paper towels.
- Property diagrams with sampling grids.
- Map or aerial photo of the decision unit.

As in Chapter 1, take samples from each location marked on the decision unit diagrams. These should be collected as separate samples. Do not composite (mix) samples from different locations.

1. Before taking any samples, contact Ecology accredited lab. To find out more information see the "Help Desk" section of this guidance. The lab may have special instructions about labeling and delivering the samples to their labs.

2. On your diagram, label each sampling location with a unique name or number.

3. With permanent marker, label the jars or zip-top bags with the sampling location identifier from the diagram. Mark your name, the date the sample is being taken, and "arsenic and lead".

4. Dig a six or twelve inch hole with the trowel or hand augur. Using a separate, clean trowel or spoon for each depth, scrape soil evenly from the sides of the hole and place it in the stainless steel mixing bowl.

5. Mix soil thoroughly in the bowl. Fill up the jar or plastic bag with the mixed soil and seal it securely. Discard any extra soil back into the hole.

6. Scrub the trowel or shovel clean in the wash bucket and pour the dirty water down a sanitary sewer or in a place where it can soak into the ground. Don't pour it down the storm drain.

7. List all of the soil samples in the sample inventory on Form 7.

See the Help Desk section for how to select a lab. The lab must use methods 6010, 6020, 6200, or 7060 for arsenic and methods 6010, 6020, 6200, or 7421 for lead. Keep samples in a cool, dry place until they are analyzed. Bring the samples into the lab in person or follow the lab's instructions for shipping. Be sure to include a copy of the sample inventory sheet and the lab custody form provided by the lab with the samples. Keep copies for yourself.

Understanding compliance results

Evaluate the compliance sample results to confirm that each decision unit meets state cleanup levels. If arsenic or lead levels are elevated (box to the right) for any decision unit, you will have to take further action to clean up the soils:

- **Excavate** at least six inches deeper and do compliance sampling again.
- **Mix** in more clean soil, or mix deeper.

"Elevated" arsenic and lead levels

- Average arsenic <20 parts per million (ppm)
- Max arsenic <40 ppm
- Average lead <250 ppm
- Max lead <500 ppm

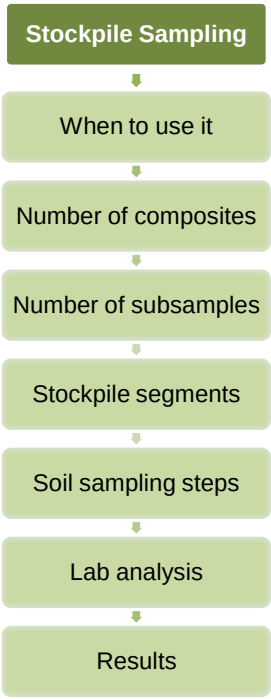
When am I done?

Cleanup is complete when all excavated or mixed areas meet state cleanup levels for soil arsenic and lead. Make sure that you have a complete packet for Ecology, future property owners, and your own records. This packet should include:

- Characterization sampling lab report and chain of custody
- Forms 1 and 2 (characterization sampling)
- Form 7 (compliance sampling)
- Compliance sampling lab report and chain of custody
- One completed form for each cleanup method used, covering all decision units needing cleanup.
- Maps documenting characterization and compliance sample locations and cleanup work.
- For capping, consolidation and capping, or institutional controls, a copy of the environmental covenant filed at the County Auditor for the property.

Next Steps

Keep a copy of the forms you filled out to pass on to future property owners so they know that cleanup was done and how to maintain any non-permanent remedies. Future property owners may want this level of detail for when they eventually sell their property. As awareness about the Tacoma Smelter Plume grows, more buyers will be asking about soil contamination.



Chapter Eight: Stockpile Sampling

Purpose: To determine if a stockpile of soil meets state cleanup levels for arsenic and lead.

When to do stockpile sampling

- When sampling soils after excavation and before transporting offsite. It may be required for a Waste Disposal Authorization (see note below right).
- Ensure soils mixed in stockpiles are clean enough to reuse onsite or dispose of.

Stockpile sampling is different than characterization sampling. You will be taking your samples from a pile of soil that you excavated and plan to dispose of or reuse onsite as clean. The samples are called "composite" samples, meaning you are taking many subsamples and mixing them together for analysis. Use Form 8 to track your sampling.

Planning for Sampling

Prepare the same type of equipment used in Chapter 2.

- Stainless steel tools for digging sampling holes and removing soil.
- Stainless steel mixing bowl and spoon for compositing.
- Clean glass containers from the analytical lab or Ziploc ™ plastic bags.
- Permanent marking pen to record sample locations on the jar or bag.
- Wash bucket, soap, scrub brush, and rinse water (distilled or deionized).
- Gloves and dust mask.

Note on disposing soils: Check with the local health department's waste management staff about specific guidance for sampling and interpreting results.

They may be able to use results from characterization samples instead of re-sampling stockpiles.

Number of samples: Take composite samples from each stockpile. Table 5 shows how many samples are needed for a certain size stockpile. The number also depends on arsenic levels. Each composite should contain six subsamples that get mixed together into a single sample (Figure 9).

Table 5. Number of composite samples per stockpile

Stockpile volume (cubic yds)	# of composites (DU arsenic >100 ppm)	# of composites (DU arsenic <100 ppm)
<500	2	2
500-999	4	4
1,000 – 4,999	8	6
5,000 – 9,999	14	10
10,000 – 19,999	20	14
≥20,000	20 + 1 per 4,000 cubic yds	14 + 1 per 5,000 cubic yds

Example: volume = 600 cubic yards

1. Divide the stockpile into four segments for four total composite samples.

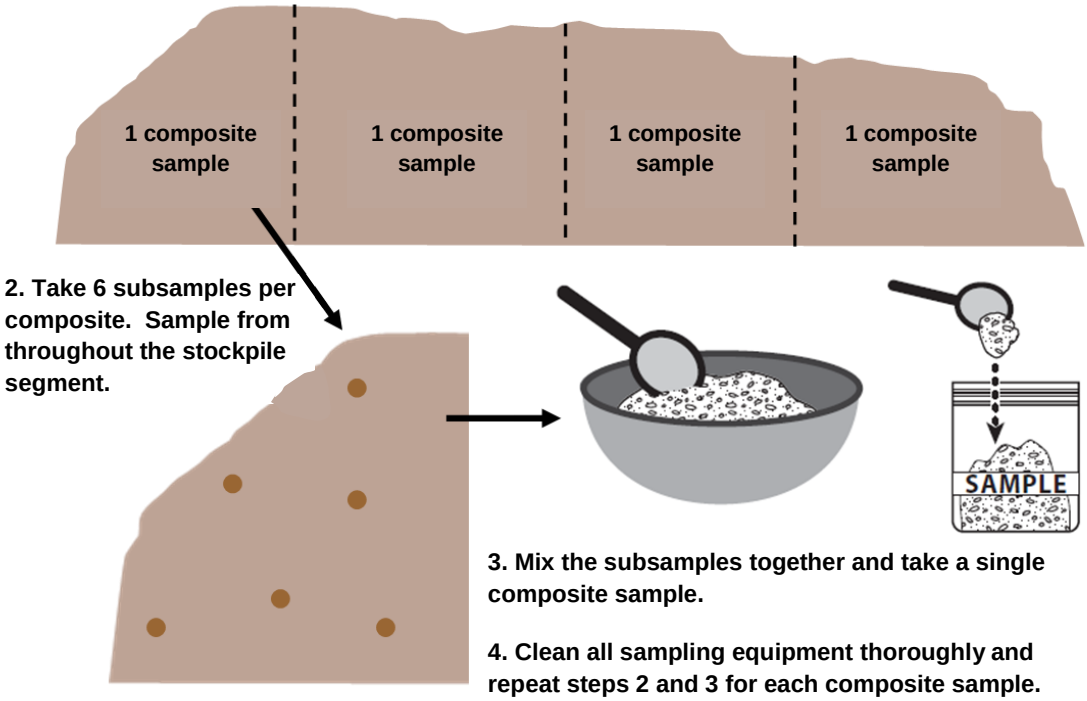


Figure 9. Stockpile sampling process

Sampling Process

1. Before taking any samples, contact an Ecology accredited lab. To find out more information see the "Help Desk" section of this guidance. The lab may have special instructions about labeling and delivering the samples to their labs.
2. Check the number of composites needed and divide your stockpile into that many sections. Plan to take one composite per segment, so they are well distributed throughout the stockpile (Figure 9).
3. Using the permanent marker, label the glass jars or Ziploc™ bags with:
    - The stockpile identifier.
    - Composite number (you will take multiple composites per stockpile).
    - Your name.
    - The date the sample is being taken.
    - "Arsenic and lead"

For each composite sample, for each stockpile segment:

4. Divide your six subsamples evenly among surface samples, mid-depth samples, and deep samples. Make sure these samples are taken from several different parts of the pile. Clean the trowel in the wash bucket and change the dirty water between samples.
5. Place all subsamples for a single composite into the stainless steel bowl. All subsamples should be the same size. Mix thoroughly with the stainless steel spoon. Scoop a jarful or bagful as your composite sample.
6. Repeat the sampling process until all composites are taken.
7. Between individual composite samples, scrub the bowl and spoon clean in the wash bucket, rinse, and pour the dirty water down a sanitary sewer or in a place where it can soak into the ground. Make sure to not pour dirty water down the storm drain.
8. List all of the composite soil samples in the sample inventory on Form 8.

Keep samples in a cool, dry place until they are analyzed. Bring the samples into the lab in person or follow the lab's instructions for shipping. Be sure to include a copy of the sample inventory sheet and the lab custody form provided by the lab with the samples. Keep copies for yourself.

Understanding your results

If any composite result is over 20 ppm for arsenic or 250 ppm for lead, that segment must be properly disposed of. If reused on the property, the soil will need to be capped to meet model remedies requirements. If arsenic is at or below 40 ppm, contaminated stockpiles may be mixed with clean soils and retested to ensure that arsenic is at or below 20 ppm.

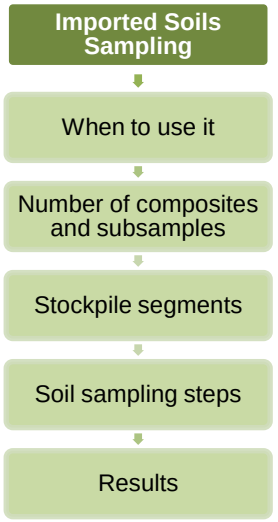
Disposal: If you plan to dispose of these soils, check with your local health department's solid waste division about their requirements. A waste disposal authorization form may be needed.

Tacoma-Pierce County Health Department
http://www.tpchd.org/environment/waste-management/

King County Landfills
http://your.kingcounty.gov/solidwaste/facilities/wasteclearance.asp

Reusing soils on site as "clean" soils: If none of your stockpiles exceeds state standards, you may reuse the soils in other locations on the property.

Transporting stockpiled soils offsite for use on another property is not a model remedy and not advised, even if sampling shows they meet state cleanup levels.



Chapter Nine: Imported Soils Sampling

Purpose: To determine if imported soil meets state cleanup levels for arsenic and lead.

When to do imported soils sampling

- When backfilling an excavation.
- When mixing with existing soils to dilute contamination.
- When creating a soil cap.
- Bringing imported fill for construction projects, gardening, or landscaping projects.

Before you purchase soil, check with the supplier to ensure it has below 20 ppm arsenic and below 250 ppm lead. Some questions to ask your supplier include:

- Where does this soil come from?
- Is it blended with compost or additives? If so, where do they come from?
- Has it been tested for chemical contamination?
- Will the soil support sod, vegetation, etc.?

If you are unsure of whether these soils meet state cleanup levels, do imported soils sampling or ask the supplier to sample.

The samples are called “composite” samples, meaning you are taking many subsamples and mixing them together for analysis. Use Form 10 to track your sampling.

Number of composite samples: Take three composite samples from each stockpile of the imported soil source. Each composite should have three subsamples.

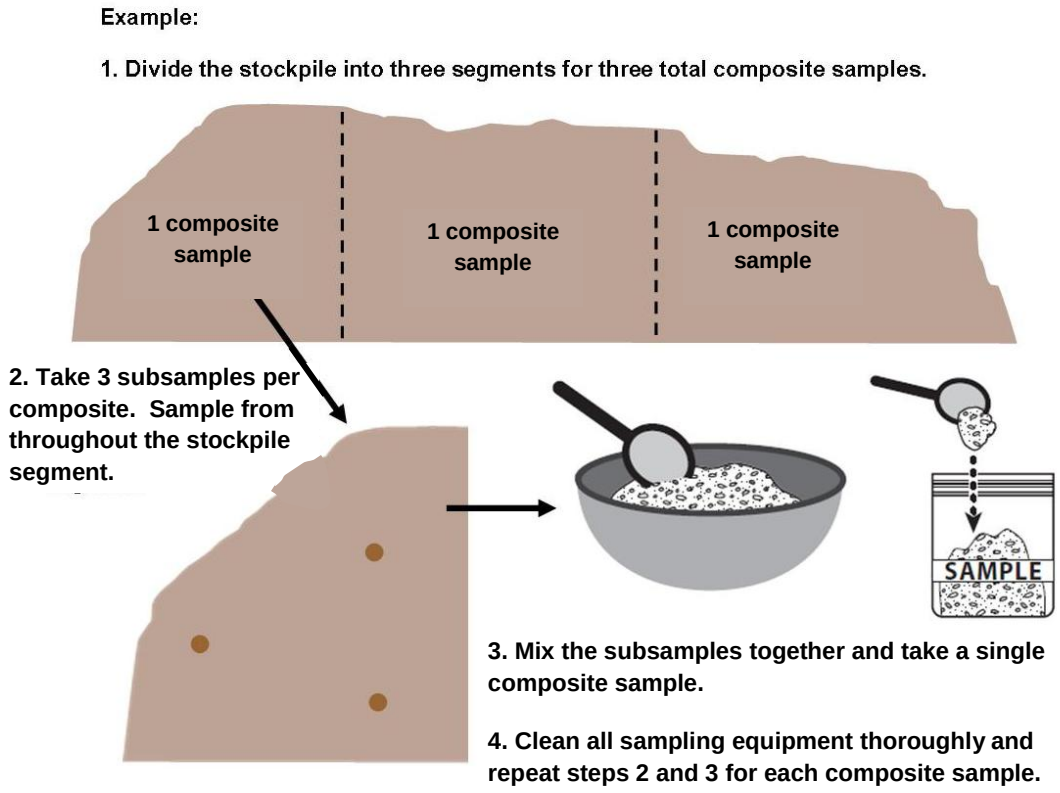


Figure 10. Imported soil sampling process (similar to stockpile sampling)

Sampling Process

Use the same sampling process as in Chapter 8.

Understanding your results

On the inventory sheet, fill in each sample result. If any of the composite samples are over 20 ppm arsenic or 250 ppm lead, the soil should not be used on the property.

Chapter Ten: Environmental Covenants and Institutional Controls

Purpose of institutional controls: To restrict access to areas with remaining contamination, to protect the remedy and protect human health.

Purpose of environmental covenants: To inform future property owners of contamination left on the property and how to maintain the remedy.

Institutional controls include:

- **Site access restrictions**, which prevent or discourage people from coming into a contaminated area. Common access restrictions are fencing, warning signs, or a combination of both.

- **Land use restrictions**, which are legal measures such as environmental covenants. They warn future land owners of contamination. They also prevent activities or land uses that could make the cleanup less effective, such as removing or digging through a cap.

  Environmental covenants or clauses in sales contracts can ensure ongoing monitoring and maintenance even when land ownership changes.

Land use restrictions can discourage direct contact, but unlike site access restrictions, they do not provide a physical barrier to contact.

When to file an environmental covenant
Capping in place and consolidation and capping model remedies both require environmental covenants.

Environmental covenants are recorded with the county and remain with the land until all contamination is cleaned up. They warn future property owners that contamination remains, and explain how to maintain the cap or access restrictions such as fencing, educational materials.

What to include in an environmental covenant

Prepare the environmental covenant using Ecology's template, found at the bottom of: http://www.ecy.wa.gov/programs/tcp/vcp/vcp2008/vcpRequirements.html.

At a minimum, it should include:

- Location of remaining contamination, including maps.
- Nature of remaining contamination, including sampling results.
- How and when lessees, users, and future property owners will be notified.
- Cap locations and dimensions.
- Cap depth and materials used.
- Inspection schedule and cap maintenance.

Options for restricting access to capped areas

Access restrictions can help limit wear and tear on a cap through physical barriers or education. Physical barriers are fencing or plantings that discourage foot traffic or use of the area. If the development will have residents or regular users, they should receive educational materials about the remaining contamination. Posting signs can also help protect a capped area.

For more about educational materials, visit:
http://www.ecy.wa.gov/programs/tcp/sites_brochure/tacoma_smelter/ts_hp.htm.

Help Desk

Selecting an analytical lab
Ecology maintains a list of labs accredited by the state to do soil analysis (http://www.ecy.wa.gov/apps/eap/acclabs/labquery.asp). The lab must use methods 6010, 6020, 6200, or 7060 for arsenic and methods 6010, 6020, 6200, or 7421 for lead. The above website lists what methods each lab uses.

Labs can also be found in the Yellow Pages under "Laboratories-Analytical". You do not have to use a local lab, since many labs can work with you through the mail. Most labs should be able to provide results within three to four weeks. Costs vary.

When you talk to the lab, find out the following information:

- Can they screen the soil sample to 2 millimeters?
- Can they report the results on a dry weight basis?
- Will they provide a quality review of the data and a summary of the quality control results?
- How long will it take to get results?
- How much it will cost? (Typically $30-60 per sample.)

Hiring and working with a consultant
Ecology has a guide for finding and hiring a consultant:
http://www.ecy.wa.gov/biblio/ftcp92116.html

You may want to start the search by asking other companies in your industry, environmental professional organizations, and banks for recommendations. Follow up with your own research. Environmental consultants are also listed in the Yellow Pages. Ask questions and get at least three different proposals and cost estimates.

Questions you may want to ask include:

- What is your firm's experience with soil sampling and related cleanup work? Request a list of completed projects and references.
- What work might be subcontracted? Request the names of their

subcontractors and check their experience.

- What is your firm's experience with regulatory requirements?
- Which staff members will be assigned to my project? Ask for resumes, roles, and project manager.
- Is your field staff trained in safety procedures required by the Washington Industrial Safety and Health Act (WISHA)?
- Do your firm and subcontractors have environmental liability insurance?
- How will you plan to be cost-effective?

Ask each firm to prepare a proposal for the sampling work. The proposal should include a detailed approach and cost estimate by specific task. It may be difficult to provide specific estimates for future work because it will depend on the characterization sampling results.

Special situations: rights of way, utility trenches, swales, small construction
For all projects, check if federal, state, or local land use permits are needed.

Rights of Way – Some developments may include roadways that will eventually be owned and maintained by local government, a homeowner association, etc. If contaminated soils are consolidated under a roadway cap, the future owner must sign the covenant.

Utility Trenches - Utility trenches are excavations. Typically, contamination will not extend any deeper than the trench bottom. For deeper contamination, Ecology recommends further excavation and backfilling with clean soils to bring the trench to the correct depth. Do not use contaminated soils to fill in the trench once utility lines are placed. It will pose a risk to anyone working on the utility line in the future.

Storm Water Swales - Areas planned for storm water swales should have a permanent cleanup remedy—excavation or mixing. Contamination left in the swale could be carried into groundwater or run off.

Small Structure Construction (cell towers, pump stations, sheds) - It may not be practical to go through the full sampling and cleanup process when building small structures with minor soil disturbance. For example, a portion of a completely paved area is opened up to place a concrete pad or shed. At a minimum:

- Properly dispose of any soils coming from the property—stockpile sampling (Chapter 8) will be needed for a Waste Disposal Authorization.
- Follow Department of Labor & Industries worker safety regulations.
- Ensure that the final construction covers any bare soil.

Other Situations - For situations not covered by this guidance, call 360-407-6300 and ask for Ecology's Tacoma Smelter Plume Technical Assistance Coordinator.

Healthy actions to reduce exposure to contaminated soils
Anyone living in the Tacoma Smelter Plume, or working or playing in soils should follow a few simple actions:

- Wash hands after working or playing outside, and before eating.
- Take off shoes at the door or use a doormat.
- Damp dust, damp mop, and vacuum with a HEPA filter regularly.
- Wear gloves when working in soil.
- Wash fruits and vegetables well.
- Keep pets clean.

For a full list of healthy actions, visit:www.ecy.wa.gov/toxics/tacoma-smelter.html

Form 1 Characterization Sampling

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

Part 1: Determine Your Decision Units

1. Total property size: _____ acres

2. In an area of arsenic >100 ppm (see map on inside cover): yes no

3. Check all that apply and identify decision units in any of these cases:

- ☐ Property is larger than 0.25 acres.
- ☐ Property currently or historically had a mix of forested and developed land.
- ☐ More than one type of land use is planned for the development.
- ☐ Parts of the property will be play areas, gardens, or other high use areas.
- ☐ Property has different geographic features, such as hills or slopes.
- ☐ Areas have forest duff that needs separate sampling.

4. On the next page, list the decision units on your property and their size in Table 1. Use Table 2 to determine the number of samples needed for each decision unit.

Part 2: Sample Depth

5. Fill in Table 1 on the following page with the sample depths.

- **At every location:** Take samples from the top 0-6 inches of soil, after clearing away grass, leaves, gravel, or debris on the surface (Figure 3).
- **At every fourth location (25% of the samples):** Also take a sample from the 6-12 inch depth.
- **Areas where fill dirt or topsoil was added in the past:** At every fourth location, take a sample from the top 0-6 inches of the original land surface, if it is deeper than 12 inches.
- **If using mixing as a remedy:** At every fourth sample location, take a sample from the depth you plan to mix to.
- **For forest duff:** Take six subsamples throughout the decision unit and combine into one sample.

Part 3: Overlay a sampling grid for each decision unit

6. Attach a diagram showing property dimensions and locations of decision units.

7. Attach a separate diagram for each decision unit, including dimensions, existing structures, and which structures will remain after development.

Table 1. Characterization sampling plan

Decision unit description (past use, planned use)	**Acres/ft^2**	**# of samples**	**Sample depth/duff layer**
1.			
2.			
3.			
4.			

Table 2. Number of sample locations per decision unit by planned use and estimated arsenic level.

Sampling area	**Residential, parks, commercial** (# samples needed)		**Forest and open land** (# samples needed)	
Acres	**Arsenic >100 ppm**	**Arsenic <100 ppm**	**Arsenic >100 ppm**	**Arsenic 20-100 ppm**
0.25*	10	8	8	8
1	20	16	16	12
5	40	32	30	24
10	60	48	40	32
20	80	64	50	40
100	120	90	70	60
>100	120 +1 per 5 acres	90 + 1 per 5 acres	70 + 1 per 5 acres	60 + 1 per 5 acres

*0.25 acres ~11,000 square feet

Form 2 Characterization Sampling Results

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

Filling in the sample inventory

List the samples by decision unit in the inventory on the back of this page. Enter the depth of each sample. When sampling multiple depths at a single location, mark each depth as a separate sample number.

Optional: If you have duff, remember to sample and analyze that separately from the soil.

Next, fill in the date and time. Note any unusual observations (high soil disturbance, heavy rain, etc.) in the "Comments" column.

Complete the rest of the columns when you get the sampling results.

Determining if arsenic or lead is elevated

1. Calculate average arsenic and lead levels for each decision unit and enter them on the inventory sheet. For each decision unit where average arsenic exceeds 20 ppm, or average lead exceeds 250 ppm, circle the average.*
2. Circle every value where maximum arsenic exceeds 40 ppm and where maximum lead exceeds 500 ppm.
3. Attach a copy of your lab results and chain of custody.
4. For decision unit with a circled value (maximum or average), note in the "Comment" column that cleanup is needed for that entire decision unit. Turn to Chapter 2 to review options for cleaning up those decision units.

   If no decision units have elevated arsenic or lead, no cleanup is necessary. Because no cleanup is being done, you do not need to take any compliance samples. The characterization samples demonstrate that your soils meet state standards. Treat these results as "compliance" sampling results and read Chapter 7 for next steps.

* Milligrams per kilogram is equivalent to ppm.

Characterization Sampling Inventory Sheet

Property address: Phone: Sampled by:						Testing Parameters (ppm)			
DU	Sample no.	Soil Depth /Duff	Date	Time	Notes	Arsenic	Avg. arsenic	Lead	Avg lead

Form 3 Excavation and Removal

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

1. Decision units being excavated **Depth**

_____ _____

_____ _____

_____ _____

2. Prevent soils from escaping the site and plan for worker safety

- ☐ Water source for dust control.
- ☐ Install erosion control devices.
- ☐ Cover trucks carrying contaminated soil.
- ☐ Rinsing area for truck wheels and quarry spall at the entrance.
- ☐ Follow Department of Labor & Industries worker safety regulations.

3. Soil disposal

Name of landfill facility: _____

Contact name and phone: _____

- ☐ Attached a copy of the Waste Disposal Authorization form

4. Source of new soils:

- ☐ Off-site soils - Supplier: _____

  Supplier phone: _____
- ☐ On-site soils

5. Stockpile sampling or imported soil sampling:

- ☐ Completed stockpile sampling for onsite soils and filled out Form 8.
- ☐ Completed imported soil sampling and filled out Form 9 or soils certified to be clean by the supplier.

6. Compliance Sampling:

- ☐ Filled out Form 7.
- ☐ Attached a map showing areas excavated and the depth of excavation.

This page intentionally left blank

Form 4 Mixing

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

Decision unit	Area	Mixing depth

2. Prevent soils from escaping the site and plan for worker safety

- ☐ Have dust and erosion practices installed.
- ☐ Follow Department of Labor & Industries worker safety regulations.

3. Equipment used

Type of mixing equipment: _____

- ☐ XRF device
- ☐ Lab testing

4. Mixing method (check all that apply)

- ☐ Mixing in place
- ☐ Mixing with imported soils
- ☐ Mixing on land surface and reusing

5. Stockpile sampling
Use stockpile sampling before spreading or disposal

- ☐ Filled out Form 8

6. Compliance Sampling:

- ☐ Filled out Form 7 - required for all mixed soils left on the property

This page intentionally left blank

Form 5 Capping in Place

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

Decision unit	Type of cap	Cap depth	Geotextile used?

2. Prevent soils from escaping the site and plan for worker safety

- ☐ Have dust and erosion practices installed.
- ☐ Follow Department of Labor & Industries worker safety regulations.

3. Source of soils: _____

Phone: _____

4. Environmental Covenant

- ☐ Filed a deed notice with: _____ County

  Recording number: _____

5. Attachments

- ☐ Attached a map showing areas capped and any additional details about the cap a future property owner would need to know.
- ☐ Attached a maintenance and monitoring plan.
- ☐ Attached a copy of the environmental covenant.

This page intentionally left blank

Form 6 Consolidation and Capping

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

1. Excavation and consolidation

Decision unit	Excavation depth

- ☐ Did compliance sampling after excavation and filled out Form 7.

2. Prevent soils from escaping the site and plan for worker safety

- ☐ Have dust and erosion practices installed.
- ☐ Follow Department of Labor & Industries worker safety regulations.

3. Cap description (type and depth)

- ☐ Geotextile barrier used
- ☐ Attached a map showing both excavated and consolidated capped areas. Include details about the cap a future property owner would need to know.

4. Source of soils: _____

Phone: _____

5. Environmental Covenant

- ☐ Filed a deed notice with: _____ County

  Recording number: _____

6. Attachments

- ☐ Attached a map showing areas capped and any additional details about the cap a future property owner would need to know.
- ☐ Attached a maintenance and monitoring plan.
- ☐ Attached a copy of the environmental covenant.

This page intentionally left blank

Form 7 Compliance Sampling

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

1. Total acreage for each area excavated: _____acres

   or mixed: _____acres

Include only areas where soil is accessible for sampling (not paved or built over).

2. Calculate the number of samples needed using the Table 1: _____

Table 1: Compliance samples by acre

Sampling area	**Samples needed**	
Acres	**Arsenic >100 ppm**	**Arsenic <100 ppm**
0.25*	10	8
1	20	16
5	40	32
10	60	48
20	80	64
100	120	90
>100	120 +1 per 5 acres	90 + 1 per 5 acres

* 0.25 acres ~ 11,000 square feet

3. Sample depth

Excavated areas = 0-6”

Mixed areas = total mixing depth profile: _____

samples per sampling location : _____ (one per 12” depth)

4. Attachments

- ☐ Attached a property diagram with compliance sampling grid overlaid (see Chapter 7). Show which areas were cleaned up and the locations of paved or built areas.

Filling in the sample inventory

List the samples by decision unit in the inventory on the next page. Enter the depth of each sample. When sampling multiple depths at a single location, mark each depth as a separate sample number.

Next, fill in the date and time. Note any unusual observations (high soil disturbance, heavy rain, etc.) in the "Comments" column.

Complete the rest of the columns when you get the sampling results.

Determining if arsenic or lead is elevated

1. Calculate average arsenic and lead levels for the area sampled and enter them on the inventory sheet. For each decision unit where average arsenic exceeds 20 ppm, or average lead exceeds 250 ppm, circle the average.*
2. Circle every value where maximum arsenic exceeds 40 ppm and where maximum lead exceeds 500 ppm.
3. Attach a copy of the lab results and chain of custody.
4. For each sampled area with a circled value (maximum or average), note in the "Comment" column that more cleanup is needed for that area. Return to Chapter 2 to review options for cleaning up those decision units.

If no decision units have elevated arsenic or lead, read Chapter 7 for next steps.

Compliance Sampling Inventory Sheet

Property address: Phone: Sampled by:						Testing Parameters (ppm)			
DU	Sample no.	Depth	Date	Time	Notes	Arsenic	Avg. arsenic	Lead	Avg lead

This page intentionally left blank

Form 8 Stockpile Sampling

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

Each composite should contain six subsamples mixed together. In Table 1, fill in the number of composite samples needed for each stockpile, based on its size (Table 2).

Table 1. Planning for stockpile sampling

Stockpile identifier	Stockpile volume	# of subsamples	# of composites
		6	
		6	
		6	
		6	

Table 2. Composites per stockpile

Stockpile volume (cubic yards)	# of composites (arsenic >100 ppm)*	# of composites (arsenic <100 ppm)*
<500	2	2
500-999	4	4
1,000-4,999	8	6
5,000-9,999	14	10
10,000-19,999	20	14
>20,000	+1 per 4,000 cubic yards	+1 per 5,000 cubic yards

*When removing soils from a property, refer to the map on the inside cover to find the estimated arsenic levels for the area the property is in.

Filling in the sample inventory

List the composite samples by stockpile in the inventory on the next page. Next, fill in the date and time. Note any unusual observations in the "Comments" column. Complete the rest of the columns when you get the sampling results.

Determining if arsenic or lead is elevated

1. Mark each composite over 20 ppm arsenic or 250 ppm lead. These segments cannot be reused on the property. See Chapter 8 for next steps.
2. Attach a copy of the lab results and chain of custody.

Stockpile Sampling Inventory Sheet

Property address: Phone: Sampled by:					Testing Parameters (ppm)	
Stockpile no.	Composite Sample no.	Date	Time	Notes	Arsenic	Lead

Form 9 Imported Soils Sampling

Reminder: Keep a copy of the filled out forms to pass on to future property owners.

Shorter projects: For projects less than six months long, collect one set of data from the imported soil source. This should include three composites, with six subsamples in each composite.

Longer projects: If the project goes for longer than six months, collect a new set of three composites, with six subsamples in each composite, every six months.

New soil source: If the source soil changes, then collect a new set of three composites, with six subsamples in each composite.

1. Once you have the results from your three composite samples, enter the arsenic and lead levels into the table below.

2. Attach a copy of the lab results and chain of custody.

Do not import soils from the supplier if any composite sample is over 20 ppm arsenic or 250 ppm lead.

Soil supplier name: Phone: Sampled by:				Testing Parameters (ppm)	
Sample no.	Date	Time	Notes	Arsenic	Lead
1					
2					
3					
1					
2					
3					

This page intentionally left blank

Sampling and Cleanup Checklist

CHARACTERIZATION SAMPLING

Form 1: Planning for Sampling with sampling grid maps

- ☐ Appropriate number of samples per decision unit (0-6" depth)
- ☐ 25% of samples from 6-12"

Form 2: Sample Inventory and Whether Soils Are Elevated

- ☐ Maximum arsenic <40 ppm and average arsenic <20 ppm (stop here)
- ☐ Maximum arsenic >40 ppm or average arsenic >20 ppm (continue below)

CLEANUP & COMPLIANCE SAMPLING

1. Excavation and Removal
   - ☐ **Form 3** with cleanup map
   - ☐ **Form 7** with sampling grid map
   - ☐ **Form 8** stockpile sampling (if applicable)
   - ☐ **Form 9** imported soils (if applicable)

Compliance sample depth should be at least 6".

2. Mixing
   - ☐ **Form 4** with cleanup map
   - ☐ Compliance sampling grid map

Take compliance samples every 6" throughout the mixing depth.

3. Capping in Place
   - ☐ **Form 5**
   - ☐ Environmental covenant*

4. Consolidation and Capping
   - ☐ **Form 6**
   - ☐ Environmental covenant*

To be protective, cap depth should meet the guidelines in Chapter 5 or 6. Ensure future owners know to maintain the remedy by providing them with the sample results and cleanup information.

**The environmental covenant should describe remaining contamination and how to inspect and maintain the remedy.*

This page intentionally left blank

811 Know what's below. Call before you dig.

DEPARTMENT OF ECOLOGY
State of Washington

Southwest Regional Office
P.O. Box 47775
Olympia, WA 98504-7775
Reception: (360) 407-6300