TECHNOLOGY OVERVIEW

EXCAVATION AND DISPOSAL OF SOLID MINING WASTE

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EXCAVATION AND DISPOSAL OF SOLID MINING WASTE

1. INTRODUCTION

Excavation and disposal of contaminated soil, sediment, or tailings is an effective and proven technology which can be used as an interim or final removal action and generally involves the removal of contaminated material with heavy equipment. This technology has several different components which can be modified to adapt to site-specific conditions. Soil, sediment, or tailings can be removed so that the remaining contaminant concentrations meet a risk-based cleanup level or removed to a certain depth or areal extent so that the clean backfill placed on top of the remaining contamination creates a physical barrier preventing direct contact with the contaminants. Excavated soil, sediment, or tailings can be disposed of either on site, in an approved repository constructed for this purpose or another location where the exposure pathways allow the material to be beneficially reused, or off site in a permitted disposal facility. Excavation and disposal can be selected as the only technology at a site or can be used in conjunction with other technologies.

2. APPLICABILITY

The following are applicable for the use of excavation and disposal technology:

- can be used on solid waste
- can treat high or low volume of material
- can be used in several different settings such as rural or urban
- can treat any contaminant of concern
- can be used as solo technology or in conjunction with others

Excavation and disposal is a very flexible permanent technology and can be designed to address soil, sediment, or mine tailings at remote, rural, and urban locations and can be used for small and large volumes of waste for any contaminant of concern. Excavation and disposal can be used by itself as an interim or final remedy or in conjunction with other technologies.

At the Oronogo-Dunweg Mining site in a rural section of southern Missouri, contamination was deposited by wind dispersion onto residential yards near the lead smelter. Individual yards were characterized, and those with soil exceeding a risk-based cleanup level were excavated. Volumes of soil excavated varied by location but were on the order of hundreds of cubic yards. At the Ore Hill Mine site in New Hampshire, 36,000 cubic yards of contaminated soil and tailings was excavated from the White Mountain National Forest during May–November 2006. Copper-, lead-, and zinc-contaminated waste rock and tailings were excavated and treated with a chemical stabilizer (Enviroblend) and placed in an on-site repository. Due to the limitations of excavation equipment, a thin layer of contaminated tailings was present at the base of the excavation on top of the bedrock. These tailings were sprayed with the chemical stabilizer prior to backfilling. At the Copper Basin, Tennessee site, hundreds of thousands of cubic yards of mine waste was removed along highways and other transportation corridors. The mining area associated with this site is over 2,000 acres, and over 30,000 acres have been impacted. Excavation is being conducted in certain areas, and other technologies are also being used in other parts of the site (e.g., anoxic limestone drain, backfilling/subaqueous disposal, bioreactors, capping/covers/grading, chemical precipitation, chemical stabilization, constructed treatment wetlands, and in situ treatment).

Excavation and disposal can be used in remote, rural, and urban areas with the limiting factors being access to the site and transportation of the soil to an off-site disposal facility or to the on-site repository. The site needs to be accessible by the heavy equipment needed to conduct the excavation activities. There should be a readily available source of suitable fill material for backfilling the excavation. For disposal in an on-site repository, the site needs to be large enough to accommodate the repository without adversely impacting downgradient receptors. For disposal at an off-site facility, there must be a way to remove the soil from the site and transport it to the facility. Excavation and disposal can be conducted in any climate; however, actual fieldwork is generally seasonally dependent. The hydrogeology at the site should be considered, and excavation may not be appropriate if the groundwater is shallow or the area is karst and subject to subsidence.

3. ADVANTAGES

Excavation and disposal technologies have the following advantages:

- permanent
- immediate result for the removal of exposure pathways
- easily implemented
- limited long-term monitoring and institutional controls
- flexible

Excavation and disposal offers many advantages as a treatment alternative. The main advantage is that it is a permanent remedy and the source of the contamination is eliminated, thus addressing both acute and chronic risks to human and ecological receptors. When soil is excavated, there is an immediate removal of the exposure pathway since there is not a period of time required for the technology to treat or break down the contamination. With the removal of the contaminated soil, there is no longer an active source to leach contaminants to the downgradient surface water or groundwater. Excavation provides a relatively rapid effect in the reduction of contamination in downgradient surface water bodies. Contaminant reduction will also been seen in downgradient groundwater sources, and whereas the time frame for determining a downward trend will likely be longer than for surface water bodies, it will be relatively rapid in comparison with other solid source treatments.

Long-term monitoring of downgradient surface water or groundwater may be required; however, with the removal of the source material, the duration of monitoring will likely be shorter than if an in situ technology were used. Whereas, excavation is a proven technology, the degree to which excavation is used (i.e., the concentration of contaminants that will remain or if only a portion of the contamination will be removed) depends on site-specific factors such as the potential receptors and completed exposure pathways; thus, modeling of the site-specific conditions is recommended. Worker health and safety concerns with the implementation of excavation and disposal are generally associated with the physical hazards of working around heavy equipment and potential exposure to contaminated material. Excavation is generally supported by the public.

3.1 On-Site Disposal

On-site disposal in a repository is generally more cost-effective than off-site disposal. Depending on the site conditions, the cell may or may not need to be lined with a nonpermeable liner. If the site conditions allow, the cell can be located in such a manner so that it blends with the site topography and is not visually apparent. With the contamination covered and not available for exposure to the receptor, often the area can be reused as long as the cell is not disturbed, which may require the use of an environmental covenant or other kind of institutional control. Another disposal option which can be used either on or off site is the beneficial reuse of the soil. At the Washington County Lead District Potosi Area site in Missouri, contaminated soil was excavated from residential yards and used as cover material over the barren mine tailings for revegetation. The arsenic, cadmium, and lead concentrations were too high for a residential scenario; however, they were low enough to be used as cover for highly contaminated tailings in a nonresidential scenario. By beneficially reusing this material, the soil did not have to be disposed of in a repository or at an off-site disposal area, and other material did not have to be purchased to cover the tailings. Both issues resulted in cost savings to the project. Although on-site disposal is generally supported by the public, often additional information needs to be given regarding future limitations and monitoring that will be needed.

3.2 Off-Site Disposal

Off-site disposal of the excavated material at a permitted disposal facility has the advantage that once the soil is accepted by the disposal facility, no additional work is required regarding these soils. Off-site disposal may have a shorter time frame for completion than the construction of an on-site repository. No long-term monitoring of a repository, cell repair actions, or institutional controls limiting site actions are required. Off-site disposal is usually supported by the public as the risk to exposure to the contaminants has been removed and there are no restrictions on the property.

4. LIMITATIONS

- high cost
- destructive
- availability of inexpensive backfill

The main limitation with the excavation and disposal technology is the relatively high cost generally associated with this technology. The costs stem from the large amount of heavy equipment needed to excavate and transport the soil as well as the fees associated with disposal. Another consideration is the availability of inexpensive backfill from a nearby location. This consideration becomes more critical at those sites where a large volume of soil is being removed. Excavation is a fairly destructive and imprecise technology and may not be appropriate in areas where there are sensitive environments or historical significance. Depending on the size and location of the area to be excavated, erosion and soil migration may be a concern and the need for a storm-water pollution prevention plan should be evaluated.

4.1 On-Site Disposal

The creation of an on-site repository has additional physical site requirements and regulatory hurdles which must be considered. At the site, there must be sufficient space to locate a repository where it will not be adversely impacted by upgradient surface water sheet flow or where the cell itself will adversely impact downgradient surface water or groundwater resources. Other space considerations include the need for an equipment staging area. The design and construction of an on-site repository may also fall under regulations of the state solid waste regulatory agency governing nonhazardous waste or hazardous waste landfills. These regulations may require a solid waste construction permit and public comment period as well as specific monitoring requirements for the cover and leachate control measures.

During site characterization, the soil, sediment, or tailings to be excavated need to be evaluated. Generally, mine waste is exempt from Resource Conservation and Recovery Act (RCRA) hazardous waste rules as a result of the Bevill Amendment; however, there are some instances where it is not exempt, so it is necessary to consult EPA if the state is not RCRA-authorized by EPA. A good place to start is with the basic information that EPA offer online (http://www.epa.gov/epawaste/nonhaz/industrial/special/mining/). In some cases, it may be necessary to use the Toxicity Characteristic Leachate Procedure (TCLP) to determine whether the material exceeds the TCLP criteria and is considered to be a hazardous waste. If the excavated material is considered a hazardous waste, it may not be appropriate for disposal in an on-site repository without prior treatment or stabilization. Site conditions, such as type and leachability of contamination, soil types and depths, depth to groundwater, volume of annual precipitation, potential downgradient receptors, and distance to downgradient surface water bodies, may necessitate the need for liners to be placed on the bottom and top of the cell to prevent migration of the contamination from the repository itself.

Long-term management of an on-site repository requires the application of institutional controls so that the integrity of the cell is not compromised. Usually a deed restriction or institutional control which limits the type of construction activities that can occur near the cell is needed, as well as a requirement to maintain adequate vegetative cover as a preventative measure for erosion of the cover material. The interval for inspections of the repository depends on the risk to potential receptors if the integrity is breached. Generally, there are annual inspections for at least the first five years and less frequently in the years following. These inspections may need to be conducted for the life of the repository, which could mean perpetual maintenance. If there is a structural failure with the repository, it will need to be repaired, or, if the failure cannot be repaired, the repository would need to be removed and the contaminated soils treated with another technology. The estimated lifespan of the repository should be evaluated during the planning process. In conjunction with the Bureau of Land Management and the U.S. Forest Service, EPA developed a policy document (EPA 2005) for the creation of joint repositories at hardrock mine sites located on both public and private land.

Selection of the location for the repository should take into account multiple technical factors, but potential impacts to user groups should also be considered. The large repository location at the Ore Hill Mine site in New Hampshire was selected for several reasons, including that it was relatively high in elevation and dry and on a flat, outsloping bench, which would allow the higher vertical stacking of material, creating a smaller areal footprint. Another consideration at this site was the proximity to the Appalachian Trail and whether or not the repository would be visible from the trail.

At the Annapolis Lead Mine in Missouri, a Time-Critical Removal Action began in May 2004. Settling basins were constructed to manage and divert storm-water runoff. Contaminated sediment and tailings were consolidated into a ravine, which was the original disposal location. The repository design allowed for a 3-foot clay and soil cover over the tailings but did not include a liner on the bottom of the repository. The topsoil cover was included to allow for vegetation to increase stability and slow erosion. Environmental covenants are being put in place across the entire site and vary according to the location; however, at the repository location, the covenants restrict future digging and well installation.

4.2 Off-Site Disposal

The main limitation in disposing of the contaminated soils at an approved off-site disposal facility is the high cost generally associated with this technology. The soil must be loaded into containers or another DOT-approved transportation mechanism and then transported to the facility. If the site is in a remote area, moving the soil off site could present significant cost. At the U.S. Forest Service Mahoney Zinc Mine in Alaska, the tailings were excavated and loaded into 0.6-cubic yard supersacks to be slingloaded by a helicopter from the site onto a marine barge to take to the nearest town for repackaging and transportation to a disposal facility. A facility which will accept the soil may be hundreds of miles away, and transportation may require the use of trucks, trains, and barges. If the soil exhibits hazardous waste characteristics, as determined by the TCLP, the soil will have to go to a licensed Subtitle C Resource Conservation and Recovery Act (RCRA) hazardous waste facility. Nonhazardous waste materials could be disposed of an approved disposal facility. There are few licensed Subtitle C RCRA hazardous waste facilities in the United States; thus, there would be increased transportation cost to get the material to the facility as well as increased cost from the transporter to handle the material and increased cost for disposal from the facility based upon the additional requirements regarding storage of hazardous waste.

5. PERFORMANCE

Excavation and disposal is an effective, proven alternative technology. Performance measures include the protection of human health and ecological environment in the reduction of contact with contamination, reduction of contaminant migration and subsequent restoration of downgradient water bodies, and promotion of a healthy wetland ecosystem.

At the Oronogo-Dunweg Mining site in southern Missouri, individual residential yards were excavated and backfilled with clean fill in order to prevent human and ecological receptors from being exposed through direct contact. At the Ore Hill site in New Hampshire, post–removal action monitoring was conducted in about 30 locations of the surface waters on site and for about a mile downstream. Sample results have shown significant reduction in metal concentrations and the pH has increased to almost the background level. Concentrations of zinc, lead, and copper in the surface water on site have been reduced by 80% with an additional 15% reduction as the objective, which would enable the surface water downstream from the mine to meet water quality standards. Prior to the excavation, surface water showed high toxicity impacts for at least a mile downstream of the site. At the Valzinco Mine site in Virginia where a limited removal was conducted of 0–2 feet in depth in a creek bed, long-term monitoring has shown an increase in the average pH concentration and a decrease in the total dissolved mineral concentrations. Aquatic vegetation cover has also increased, and studies have shown that the composition and species diversity seen after the removal are now similar to background areas.

6. COSTS

Excavation and disposal is a relatively expensive alternative with the main component being the high cost associated with the use of heavy equipment, transportation, and disposal. For those sites with high volumes of waste to be excavated, the need for multiple pieces of equipment over a long period will cause the cost to be greater. In addition, site location will play a role in the cost to mobilize the equipment and other necessary materials to the site. It will be more costly for remote sites than for urban sites. However, logistical issues such as material handling and stockpiling and equipment staging locations are generally easier at a remote site rather than in a neighborhood with traffic and a significant population. The distance required to transport available clean backfill can also greatly affect the cost of the cleanup. At the Washington County Lead District Potosi site in Missouri, individual residential yards were excavated to various depths, generally 1–2 feet, with the contamination hauled either to a repository or disposal facility; the cost per cubic yard ranged from $45–$250.

On-site disposal in a repository is generally more cost-effective than off-site disposal. Costs associate with on-site disposal include site preparation, repository materials (liners, cover), heavy equipment, and manpower. If the material fails the TCLP criteria, there may be increased cost for chemical stabilization prior to disposal in an on-site repository.

Cost associated with the transportation and disposal of the material off site are most dependent on site location and accessibility. Sites located in more remote areas are generally farther from an approved disposal facility, and therefore the transportation cost is greater. If the material fails the TCLP criteria, there will be increased costs from the transporter to move the material as well as from the disposal facility due to the increased monitoring and regulations governing the storage of regulated hazardous waste.

7. REGULATORY CONSIDERATIONS

Additional regulatory permits or approvals which may be needed may include, but are not limited to, a Clean Water Act permit or state fish and game permit if the excavation is to be conducted in the marine environment or an anadromous fish stream. At the Valzinco Mine in Virginia, mine tailings and spoils were present in a creek bed. Prior to constructing a treatment wetlands, tailings to a depth of 2 feet were excavated from the creek bed, and the remaining contamination was covered with clean borrow material. This action required a Clean Water Act permit from the U.S. Army Corps of Engineers, a process which lasted almost a year. If sediment from a marine intertidal area or anadromous fish stream will be excavated, an evaluation of aquatic habitat should be conducted. The excavation should be conducted within a time frame as to have as minimal an impact as possible on spawning or rearing fish populations; coordination with the state fish and game regulatory agency is needed. The same holds true for terrestrial species. Threatened or endangered species, if present at a site, may suffer an impact due to the intrusive nature of the process. Depending on the size of the area to be excavated, a storm-water pollution prevention plan may need to be developed.

If an on-site repository is to be constructed, a state solid waste permit may be needed. If the material is being disposed of offsite, a RCRA Remedial Action Permit may be required.

Institutional controls may need to be placed on the property if concentrations of contaminants of concern at levels exceeding the cleanup level are left in place or to prevent certain future activities, such as digging near the repository or installing a drinking water well.

8. STAKEHOLDER CONSIDERATIONS

Excavation and disposal is generally accepted by the public. With on-site disposal, often additional information needs to be given regarding the future limitations and monitoring that will be needed. At the Shiny Rock Mine site in Oregon, 680 cubic yards of lead and cadmium contaminated soil was stabilized and placed in an on-site repository. The Oregon Department of Environmental Protection made the site Administrative Record available for review at the local public library, provided public notice of the selected remedial alternative, and held a public meeting to gather public comments. The majority of the public comments regarding excavation and on-site disposal were favorable; however, concerns were raised by the public regarding the on-site disposal and potential reuse of the soil.

If excavation is to be conducted near populated areas, there may be public concerns regarding increased vehicle traffic on private roads and in neighborhoods. The Lava Cap Mine in California is located in a semirural area of the Sierra Nevada foothills. In 1994, an estimated 1776 people lived within a 1-mile radius and over 24,000 in a 4-mile radius of the site. Prior to conducting the excavation activities, EPA mailed a newsletter about the cleanup to the community. In order to address neighborhood concerns about increased truck traffic and noise, the newsletter highlighted the truck traffic route that would be used and stated that work would be limited to 8 am to 5 pm Monday to Friday with work on Saturday conducted if necessary to meet the fall completion deadline. The newsletter also provided EPA contact names and phone numbers for the community to contact with complaints, concerns, or questions.

9. LESSONS LEARNED

Conducting a complete site characterization resulting in a fairly accurate estimation of the volume of material to be excavated is very important, especially if the site is located in a remote area. Without a fairly accurate volume estimate, there may not be adequate funding to address the contamination during the first removal action, and additional actions may be needed at a future date.

At the Mahoney Zinc Mine site in Alaska, the U.S. Forest Service originally estimated that 100 cubic yards of material was to be excavated and transported off site for disposal. Upon arrival at the remote site, the consultants realized that the volume of material to be removed was closer to 700 cubic yards. Additional funds were not available for the increased volume. A second removal had to be conducted in order to address the remaining 600 cubic yards, and due to federal funding cycles, the second removal was conducted five years after the first. Similarly, the volume of material to be excavated was underestimated at the Ore Hill site in New Hampshire as estimates of tailing depths were 4–6 feet as opposed to the 15-foot depth which were encountered. Fortunately, additional funds were obtained from the Department of Agriculture, and the fieldwork continued with minimal impact to the project.

The design of the on-site repository needs to include slopes that are as low as possible. Sheet-flow and runoff need to be taken into consideration to negate erosion of the cap material. At the Annapolis Lead Mine site in Missouri, the topsoil cap was eroding, and rock was placed around the perimeter of the on-site repository to slow the erosion. Also, a total of 1015 trees were planted at the site in 2008 in order to increase soil stability and reduce erosion.

10. CASE STUDIES

Table 10-1. Case studies using excavation and disposal

Annapolis Lead Mine, MO
Lava Cap Mine, NV
Shiny Rock Mine, OR
Valzinco Mine, VA
Washington County Lead District, Potosi, MO

11. REFERENCES

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