# TECHNOLOGY OVERVIEW

# CAPPING/COVERS AND GRADING

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# CAPPING/COVERS AND GRADING

## 1. INTRODUCTION

Capping or covering of solid mining waste is an effective and proven treatment technology. It can be used as a short-term interim measure or as a long-term or final action. Installation of a cap or cover on solid mining waste can reduce or eliminate erosion, fugitive dust emissions, and infiltration of water to prevent the migration of contaminants. Caps or covers eliminate direct exposure to solid mining waste by creating a physical barrier that prevents direct contact with the contaminants. There are a variety of materials available, and this technology can be modified to adapt to site-specific conditions. However, the cap or cover must be maintained to ensure its effectiveness. Institutional controls may also be required. Caps and covers can be selected as the only treatment technology at a site or can be used in conjunction with other technologies.

## 2. APPLICABILITY

Capping/covers and grading are applicable to the following situations:

- solid waste
- high or low volume of material
- remote, rural, or urban areas
- solo technology or in conjunction with other remedies

Capping or covering of solid mining waste is an effective technology for isolating contaminants. This remedy reduces the mobility of the contamination but does not address contaminant toxicity or volume. This remedy is applicable to a variety of conditions and waste types. Caps and covers can be designed to address soil, sediment, or solid mining waste at remote, rural, and urban locations on- or off-site and can be used for small and large volumes of waste for any contaminant of concern. Caps and covers can be constructed in any climate; however, actual fieldwork may be dependent on weather conditions. Caps and covers can be used by themselves as an interim or final remedy or in conjunction with other technologies. The applicability of this technology depends on the availability of suitable land that may require institutional controls, access to the site, transportation of mining waste and capping and covering materials, and necessary equipment. The site needs to be accessible by the heavy equipment generally needed to conduct grading activities and to install a cap or cover. Typically, the solid mining waste needs to be graded prior to installation of the cap or cover.

“Grading” refers to the technique of stabilizing a pile of solid mining waste by reducing the slope or angle of repose generally to no steeper than three horizontal to one vertical (3:1) and adding storm-water control structures such as drainage channels and retention ponds. Slope stability analysis should be conducted when designing the construction of a cap or cover. Some piles may in fact be too large to cap or cover. Grading the existing material to stabilize the pile and reduce erosion may be an interim or perhaps a final remedy.

A variety of caps and covers designs can be used on everything from a chat, tailings, or slag pile to a contaminated residential yard. The following is a list of those designs:

- **Simple Soil Caps:** Simple soil caps involve placement of select fill to various depths to minimize erosion by deflecting runoff, encouraging evapotranspiration through vegetative cover growth, using the molecular affinity for water, and providing a physical barrier between potential receptors and waste material.
- **Drainage Layers:** Drainage layers serve as a capillary barrier through the creation of a difference in hydraulic conductivities between adjacent layers, effectively preventing percolation of precipitation to the waste material by promoting lateral drainage and increasing water storage of overlying layers. Options for drainage layers include gravel or geonets.
- **Geotextiles:** Geotextiles are permeable fabrics that allow passage of water through the material but prevent soil from moving through to lower layers.
- **Evapotranspiration Covers:** An evapotranspiration (ET) cover consists of a vegetated soil layer that has the advantages of being simple and potentially economical to construct and maintain and, in the appropriate setting and with an appropriate design, can be very effective. The principle upon which an ET cover works is that the soil layer holds incoming precipitation until it is removed by evapotranspiration. If the soil layer has sufficient storage capacity to hold the water until it can be removed by evapotranspiration, then no deep percolation penetrates past the cover. Despite the apparent simplicity of the design, proper performance of an ET cover depends on careful and robust analysis of the site variables and a thorough design procedure. Proper design of an ET cover depends on a thorough understanding of soil water storage, evapotranspiration, and climatic factors (ITRC 2003).
- **Impermeable Caps:** Engineered, impermeable barrier caps, like those used at a Resource Conservation and Recovery Act (RCRA) Subtitle D landfill, have an optimum permeability no greater than $1 \times 10^{-6}$ centimeters per second to prevent percolation into underlying layers. These layers are typically composed of clay, geosynthetic membranes, and geosynthetic clay liners or geoclays.
- **Hardened Cover:** Typically composed of rock, screened to an appropriate size to minimize infiltration.
- **Vegetative Cover:** Vegetative covers protect against gullying and scouring by surface water and wind, thereby minimizing erosion. A vegetative layer typically consists of soil sufficient for development of good root support and moisture storage and a vegetative layer consisting of growth media and soil amendments with the micro- and macro-nutrients necessary to sustain growth. It is highly desirable to establish native species on the cap that will not root deeply and eventually compromise the integrity of the cap (ITRC 2009).
- **Phytostabilization:** Phytostabilization is an in situ technology involving soil amendments and metals-tolerant plants to establish a ground cover. Under certain conditions, this containment technology can reduce migration of metals, reduce soil toxicity, and meet regulatory requirements. During phytostabilization, metals are chemically precipitated or sequestered by complexation and sorption mechanisms within the tailings or soils. Metal availability to plants is minimized, and metal leaching into ground water is reduced. Metals and arsenic that remain in soil solutions are demobilized via chemical reactions at plant root surfaces (ITRC 2009).

During site characterization, the following items should be addressed to provide adequate data for assisting in the determination of the applicability of this technology:

- Development of conceptual site modeling to identify the potential receptors and completed exposure pathways.
- Approximation of volume of the waste material.
- Mapping of the area to determine whether sufficient space is available in a suitable location with minimal slope.
- Addressing geologic conditions that may prohibit construction, such as active faults, underground workings near the surface, karst topography that is subject to subsidence, etc.
- Availability of on-site material borrow sources.
- Determination of physical parameters of available borrow material and the waste should include grain size, moisture content, permeability, Atterberg limits, and density. Proctor Tests (either ASTM D 698 or D 1557) should be run to determine the maximum dry density at optimum moisture content. Shear analyses may be required to determine whether the waste is stable in the current location. The nature of the waste materials to be stabilized has a significant effect on the stabilization area geometry.
- Determination of annual precipitation in the area.
- Evaluation of depth and direction of flow of groundwater in the area to evaluate the suitability of this remedy and for identifying the potential groundwater monitoring wells locations.
- Determination of the extent of 100-year flood plain and delineation of wetlands.
- Evaluation of any areas with cultural or historic significance.
- Evaluation of any on-site habitat for, or presence of, threatened and endangered species.
- Current and future land use should be considered to determine whether the location is amenable to keeping waste on site.

Examples of where caps or covers have been used include the Oronogo-Duenweg, Copper Basin, and Kerramerican sites.

At the Oronogo-Duenweg Mining Belt Superfund Site, in Jasper County, Missouri, lead contamination was deposited from smelting operations by wind dispersion onto residential yards in Joplin, Missouri and surrounding areas. A total of approximately 2,600 yards with lead contamination exceeding a risk-based cleanup level was excavated. The contaminated soil was transported to a soil repository, located on a mine waste area. The area is fenced, and the soil is maintained with a vegetative cover. Annual inspections of the repository are conducted to ensure the vegetative cover is preventing soil erosion. The soil will be maintained in the repository until final disposition can be determined.

At the Copper Basin of Tennessee site, 150 years of deep mining for copper, iron, and zinc was conducted on less than 2,000 acres of land. Over 30,000 acres have been impacted by acid fumes from processing. The primary contaminants are acidity, aluminum, copper, iron, manganese, and zinc. Impermeable caps have been used where residual materials represent a significant potential continuing source of acid and/or metals. Covering and grading has been used extensively in areas treated first with lime stabilization. Land use controls will be required upon the completion of remedial activities for those areas with waste materials that will remain in place. Numerous other technologies are being utilized at this site, such as anoxic limestone drain, backfilling/subaqueous disposal, chemical precipitation, in situ chemical stabilization, and constructed treatment wetlands.

At the Kerramerican Mine site in Blue Hill, Hancock County, Maine, a $7 million multicomponent geosynthetic cover system was installed on the 19-acre mill processing plant portion of the site. It was determined that exposed waste rock covering the 19-acre processing plant released 10,000–12,000 pounds per year of dissolved zinc and lesser amounts of copper and other metals to adjacent surface waters. Effectiveness of the geosynthetic cover system will be evaluated with a minimum five-year semiannual groundwater and surface water sampling program downgradient of the covered plant site, beginning in 2009.

## 3. ADVANTAGES

The advantages of capping/covers and grading include the following:

- immediate results
- easily implemented
- flexible
- permanent
- cost reduction

Caps and covers offer many advantages as a treatment technology. The main advantage is that it is a permanent remedy and exposure to the contamination is eliminated or reduced, thus addressing both acute and chronic risks to human and ecological receptors. When the solid mining waste is capped, there is an immediate break in the exposure pathway; i.e., there is not a period of time required for the technology to treat or break down the contamination. With an engineered cap for solid mining waste, the source is prevented from leaching or migrating contaminants to downgradient surface water or groundwater. Capping or covering provides a relatively rapid effect in the reduction of contamination in downgradient surface water bodies. Long-term monitoring of downgradient surface water or groundwater may be required.

Another advantage to capping or covering 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 but 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. If beneficial reuse of contaminated material is being considered, an ecological risk assessment should be conducted to ensure that the material does not pose undue risk to indigenous ecological receptors in addition to a human health risk assessment.

### 3.1 On-Site Disposal

On-site capping is generally more cost-effective than transporting contaminated solid mining waste off site for capping or covering. It is especially advantageous if the cap can be placed in an area previously impacted by mine activities and/or contaminated with solid mining waste requiring remediation. In addition, keeping the waste on site reduces potential for off-site incidents during waste transport, thereby reducing the risks to the public due to increased traffic or spills.

With the contamination covered and not available for exposure to the receptor, the area can often be reused as long as the cell is not disturbed and the reuse complies with other conditions of institutional or administrative controls. If site conditions allow, the cap can be designed and located in such a manner so that it blends with the site topography and is not visually apparent.

The Iron Mountain Mine operated in Shasta County, California from the 1860s through 1963. The 4,400-acre site was mined for iron, silver, gold, copper, zinc, and pyrite. Left behind after operations ceased were underground mine workings, waste rock dumps, piles of mine tailings, and an open mine pit. In addition, historic mining activity at the site fractured the mountain, exposing minerals in the mountain to surface water, rain water, and oxygen. When pyrite is exposed to moisture and oxygen sulfuric acid forms. In 1989, U. S. Environmental Protection Agency completed capping cracked and caved ground areas and the open pit mine on Iron Mountain.

## 3.2 Off-Site Disposal

Removing contaminated solid mining waste and capping or covering the waste off site is supported by the public as the risk of exposure to the contaminants has been removed. In addition, there are no restrictions on the property after the contaminated material has been removed. However, off-site disposal increases the cost compared to capping and covering material on site.

At the Magmont Mine in Iron County, Missouri, there was a combination of on- and off-site disposal. The Magmont Mine is a former lead mine that operated from 1968 to 1994 with over 290 acres of lead tailings deposited on site. Reclamation of the site is regulated under the Missouri Metallic Minerals Waste Management Act (MMWMA). As required by the MMWMA, a closure plan was developed that included reclamation through a combination of grading, capping, surface water control measures, and revegetation. As part of the reclamation, the tailings material in the impoundment on site was capped with 2–6 feet of clay material extracted from nearby hills.

During operation of the Magmont facility, a portion of the concentrated ore was shipped on trucks to various smelters located off site. Six spill sites were identified on highways where trucks carrying lead concentrate overturned. Those six sites were remediated by excavating the contaminated material and depositing it in a 2.5-acre repository located in a portion of the tailings impoundment area at the Magmont site. Once all the excavated material was placed in the repository, the material was graded to a maximum thickness of 2 feet, covered with stockpiled soil removed prior to the placement of the spill site material, covered with an additional 6 inches of topsoil, and contoured to provide positive drainage.

## 4. LIMITATIONS

Listed below are limitations to capping/covers and grading technology:

- long-term operation and maintenance
- administrative or engineering controls may be required
- security issues
- public acceptance

The main limitations with caps and covers technology, especially if used as a final remedy, is that it requires long-term operation and maintenance (O&M) and monitoring to ensure that the cap or cover remains effective and protective. Administrative or engineering controls may also be required, along with an ongoing source of funding for the site and insurance that future land use scenarios are limited. In some areas graded solid mining waste piles are attractive for unauthorized activities such as sledding, biking, or motorized vehicular use (ATVs, four-wheel drive).

### 4.1 On Site

Design and construction of a cap or cover has physical site requirements and regulatory issues which must be considered. There must be sufficient space to construct a cap where it will not be adversely impacted by upgradient surface water sheet flow or the cap itself will not adversely impact downgradient surface water or groundwater resources. Surface water controls, such as upgradient channels or diversionary structures, can reduce the impacts of surface water runoff.

A nearby source of borrow material for the construction of the cap must be available. Limited on-site borrow materials can escalate costs; however, this remedy is typically much more cost-effective than off-site disposal or treatment alternatives. Cover material excavation, whether on or off site, may have adverse environmental impacts and require temporary and permanent mitigating measures unless acquired commercially. Other space considerations include those for equipment staging and material storage areas.

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 a impermeable liner to be part of the cap design to prevent migration of contamination from the solid mining waste. Long-term management of a cap includes operation and maintenance of the cap and also requires administrative or engineering controls so that the integrity of the cap is not compromised.

O&M activities include inspections and possible repair of the cap or cover. The interval for inspections of the cap depends on the type and design, as well as the risk to potential receptors if the integrity of the cap is breached. Generally, there are annual inspections for at least the first five years and less frequently in the years following. These inspections must be conducted for the life of the cap.

At the Annapolis Lead Mine in Missouri, a Time-Critical Removal Action was conducted in 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 on this land to prevent disturbance of the capped area and to prohibit the use of groundwater unless approved in advance by the state and the Environmental Protection Agency. Worker health and safety concerns with the construction of caps and covers are generally associated with the physical hazards of working around heavy equipment and potential exposure to contaminated material.

### 4.2 Off Site

The main limitation in capping or covering of the contaminated solid mining waste at an approved off-site location is the high cost generally associated with this alternative. The waste must be loaded into containers or another approved transportation mechanism and then transported to the off-site location. If the site is in a remote area, moving the solid mining waste off site could incur significant cost. If the waste exhibits hazardous waste characteristics, as determined by the Toxicity Characterization Leaching Procedure, the material would have to be treated before placement off site; otherwise, the waste will have to go to a licensed Subtitle C RCRA hazardous waste facility or possibly at an off-site repository authorized under a Remedial Action Permit. Nonhazardous waste materials can be capped or covered at an approved off-site location.

## 5. PERFORMANCE

Caps and covers are an effective, proven technology. Performance measures include the protection of human health and ecological environment in the reduction of contact with contamination and reduction of migration of contamination to downgradient water bodies. Revegetation success criteria should be established for vegetated covers. Reseeding may be required if a dense cover is not established or maintained. Additionally, the type of vegetation needs to be controlled. Deep rooting species (especially trees) may need to be pulled to prevent breaching of the layers. Burrowing animals also need to be discouraged. Diversionary structures such as run-on and runoff control ditches also need to be inspected and maintained. Careful design of the cap or cover and all associated features ensures long-term performance.

The Big River Mine Tailings/St. Joe Minerals Corp. site is located in a former mining region of southeast Missouri known as the "Old Lead Belt." This site is composed of six large areas of mine waste in this rural region, approximately 110 square miles in size. The areas included are the Bonne Terre Mine Tailings Site, the Leadwood Mine Tailings Site, the Elvins Mine Tailings Site, the Federal Mine Tailings Site, the Desloge Mine Tailings Site, and the National Mine Tailings Site. Also included are the surrounding residential and recreational areas. In 1977, heavy rains caused an estimated 50,000 cubic yards of tailings to slump into the Big River. The residual lead content in the tailings material is about 0.5%; other minerals such as cadmium and zinc are also present.

Since 1995, the Doe Run Company has been completing removal action activities at the piles. These include regrading and capping/covering with soil, rock, and/or direct vegetation of the

Desloge, Bonne Terre, and Elvins/Rivermines piles. These activities have prevented major releases of tailings such as the 1977 event. At the Elvins/Rivermines site, treatment ponds are being constructed to catch and treat water seeping out of the pile.

The Horse Heaven Mine is an abandoned mercury mine located on approximately 40 acres near Ashwood, Oregon. In 2006 and 2007, remedial action at the site consisted of excavation and on-site entombment and capping of furnace area soils; collection, entombment and capping of solid waste mining debris on site, and regrading of calcine tailings to mitigate mass wasting and off-site migration. The first annual inspection report, performed and submitted in 2008, documented that the remedy, as constructed, was protective as intended.

In addition, institutional controls were imposed through recordation with Jefferson County. Restrictive covenants govern future redevelopment capacity and requirements to maintain engineering control (fencing, signing). In addition, there are prohibitions on removal of calcine and/or other site material containing mercury.

## 6. COSTS

The main cost component in the use of caps and covers is the cost of construction materials and the cost for the use of heavy equipment during waste placement and cover construction. Various capping options can be used for on-site repositories. Caps and covers can be relatively inexpensive technologies to implement in comparison to excavation in the short term but require long-term cost for maintenance and monitoring. For those sites with high volumes of waste to be capped, the need for multiple pieces of equipment over a longer duration of time causes the cost to be greater. Also, site location plays a role in the cost to mobilize the equipment and other necessary materials to the site; i.e., it will be more costly for remote sites as opposed to urban sites. The distance required to transport cap or cover materials can also affect the cost. Limited on-site borrow materials can escalate costs; however, on-site waste containment is still much more cost effective than off-site alternatives.

At the Big River Mine Tailings Site in southeast Missouri, the Doe Run Company opened on-site quarries to produce the required cover rock and further reduce the cost of construction and transportation.

At the Dunka Mine site in Minnesota, a former taconite (iron-bearing rock) mine, closure included capping and regrading just over 190 acres of waste rock for a total cost of $3.9 million dollars. Costs ranged from $79,000/acre for a soil cover to $304,000/acre for flexible membrane liners. These costs included some reshaping of the waste piles. Covering the piles with 2 feet of native soil, as required by Minnesota Mine Land Reclamation laws, generally costs about $49,000 to $61,000/acre (Eger, Melchert, and Wagner 2000).

## 7. REGULATORY CONSIDERATIONS

The design and construction of a cap may fall under regulations of the state solid waste or hazardous waste regulatory agency governing nonhazardous waste landfills or remedial action plan permits. These regulations may require a solid waste construction permit and public comment period as well as specific design criteria and maintenance requirements for the cover and leachate-control measures.

Depending on the size of the area to be capped or covered, a storm-water discharge permit may need to be obtained during the land disturbance/construction phase at the site, especially if cover materials are stockpiled for a period of time. A pollution prevention plan may need to be developed as a requirement of a storm-water discharge permit. See the Valzinco Mine Case Study.

The National Contingency Plan and the Comprehensive Environmental Response, Compensation, and Liability Act require that on-site remedial actions comply with federal and more stringent state applicable or relevant and appropriate requirements of environmental laws.

The Gribbons Basin Mine Site in Marquette County, Michigan is an active iron mine where composted municipal solid waste and paper mill sludge are being used to supply organic matter and establish vegetation on tailings to control dust emissions. The sludge application is active but has developed selenium issues. In addition, there are regulatory issues associated with this new technology in that Michigan currently has no standards for the use of composted solid waste.

Table 7-1 is intended as only a beginning reference for evaluation of the federal regulations that may be applicable to capping or covers. Regulations that are specific for the location are not included, nor are state and local (county or city) specific requirements.

**Table 7-1. Federal regulations potentially applicable to mining site contamination**

| Federal statutes | Citation | Description |
|---|---|---|
| Solid Waste Disposal Act as amended by the Resource Conservation and Recovery Act of 1976 (RCRA Subtitle D) | 40 CFR Part 257, Subpart A: §257.3-1 Floodplains, paragraph (a); §257.3-7 Air, paragraph (b) and Part 258 sections §258.11–258.15 location restrictions, §258.40 design criteria, and Subpart E §258.50–258.59 groundwater monitoring and corrective action | Regulates the generation, storage, handling, and disposal of solid waste. |
| RCRA Subtitle C | 40 CFR Part 264 (TSDF) | Regulates the generation, treatment, storage, and disposal of hazardous wastes. |
| National Emission Standards for Hazardous Air Pollutants | 40 CFR Part 61, Subparts N, O, P, pursuant to 42 USC §7412 | Regulates emission of hazardous chemicals to the atmosphere. |
| Clean Air Act (CAA), National Primary and Secondary Ambient Air Quality Standards | 40 CFR Part 50, pursuant to 42 USC §7409 | Sets standards for air emissions. |
| Executive Order No. 11988 Floodplain Management | 40 CFR §6.302 and Appendix A | Regulates construction in floodplains. |
| Bevill Exclusion | 40 CFR Part 261.4(b)(7) and RCRA Section 3001(b) (Bevill Amendment) | Excludes solid waste from the extraction, beneficiation and processing of ores and minerals from regulation as hazardous waste under Subtitle C of RCRA. |

| Federal statutes | Citation | Description |
|---|---|---|
| Section 404, Clean Water Act (CWA) | 33 USC 1251 et seq., 33 CFR Part 330 | Regulates discharge of dredge or fill materials into water of the United States. |
| Safe Drinking Water Act (SDWA) | 42 USC §300, 40 CFR Part 141–143 | Regulates the nation's public drinking water supply by setting national health-based standards for drinking water to protect against both naturally occurring and man-made contaminants that may be found in drinking water. |
| Surface Mining Control and Reclamation Act (SMCRA) | 30 U.S.C. §1234–1328, 30 CFR Part 700 et seq. | Regulates the environmental effects of coal mining in the United States by setting environmental standards that mines must follow while operating and achieve when reclaiming mined land. |

## 8. STAKEHOLDER CONSIDERATIONS

Caps and covers are generally accepted by the public. With caps or covers additional information often needs to be offered regarding the future land use limitations and monitoring and maintenance that will be needed.

At the Big River Mine Tailings Site, the Bonne Terre Pile has several acres of grass on the flat-top pile which is being considered for use as a city park. Special consideration must be taken to ensure that the integrity of the cap remains during construction and use of the park.

## 9. LESSONS LEARNED

It is very important to conduct a complete site characterization resulting in a fairly accurate estimation of the volume of material. The design of the on-site cap needs to include slopes that are as low as possible when addressing solid mining waste piles. Sheet-flow and runoff need to be taken into consideration to negate erosion of the cap material with implementation of runoff controls. At the Annapolis Lead Mine site in Missouri, excessive erosion occurred on portions of the cap created during the 2004 removal action due to a cap design that included overly steep sides. During the site remedial action, a rock blanket was placed around the edges of the cap to hold soil in place so that vegetation had an opportunity to establish itself on the capped area. In addition, a total of 1015 trees has been planted at the site to increase soil stability and further reduce erosion in areas adjacent to the cap.

At the Big River Mine Tailings Site, off-road vehicle traffic on the Bonne Terre Pile has compromised the integrity of the cap. The cap currently requires repairs and some form of barrier will need to be added to prevent future damage to the cap.

To allow for maximum land reuse, it is good to reduce the footprint of the solid mining waste contamination as much as possible. However, more engineering analysis and design will be needed to ensure slope and cap or cover stability. Consideration may be given to construction of a partially subgrade on-site repository to reduce the overall footprint of the waste site.

## 10. CASE STUDIES

**Table 10-1. Case studies using capping/covers and grading**

| |
|---|
| Annapolis Lead Mine Site, MO |
| Bark Camp, PA |
| Big River Mine Site, MO |
| Copper Basin, TN |
| Cottonwood Creek Mine, MO |
| Dunka Mine, MN |
| Ely Copper Mine, VT |
| Gribbons Basin, MT |
| Horse Heaven, OR |
| Hume Mine, MO |
| I-99 Remediation, PA |
| Iron Mountain Mine, CA |
| Kerramerican, ME |
| Lava Cap Mine, NV |
| Magmont Mine |
| McNeely Green Reclamation at Tar Creek Superfund Site, OK |
| Ohio/numerous sites, SE OH |
| Oronogo-Duenweg,MO |
| Potosi Area, MO |
| Stull Yard, ID |
| Tecumseh – AML Site 262, IN |
| Valzinco Mine, VA |

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