EPA Abandoned Mine Lands Innovative Technology Case Study

Palmerton Zinc Pile

Compost/Biosolids Application to Revegetate Defoliated Areas

ABSTRACT:

The Palmerton Zinc Pile Superfund Site is a former primary zinc smelter that operated from the late 1800s to 1980. Previous activities at the site created a more than 2,000-acre defoliated area on the adjacent Blue Mountain, a cinder bank composed of 33 million tons of material containing leachable metals, and additional defoliation along Stoney Ridge. As a result, there is heavy metal contamination in the surface soil, ground water, and stream sediments. In 1991, the responsible parties began applying biosolids to accelerate revegetation of the area. Through mid-2006, almost 1,300 acres of Blue Mountain, 220 acres of the cinder bank, and 40 acres of Stoney Ridge have been revegetated. Additional revegetation of Blue Mountain and Stoney Ridge will continue in the remainder of 2006 and in 2007. Revegetation has stabilized the treated area, reduced soil erosion, and improved water quality (i.e., decreased soluble metals contaminant concentration) associated with runoff from the site.

SITE BACKGROUND

CERCLIS ID: PA002395887

The Palmerton Zinc Superfund Site (the site) consists of several thousand acres in the Lehigh Gap area and is located off Route 248 in Palmerton, Carbon County, Pennsylvania. The Borough of Palmerton is positioned at the confluence of the Lehigh River and Aquashicola Creek in a valley bounded by Blue Mountain to the south and Stoney Ridge to the North. The area surrounding Palmerton is rural and consists of a series of deep, narrow valleys. Aquashicola Creek, a trout-stocked stream, runs the length of the valley and discharges into the Lehigh River. The area surrounding the site has a population of approximately 13,000 people with 5,393 residing in Palmerton itself.

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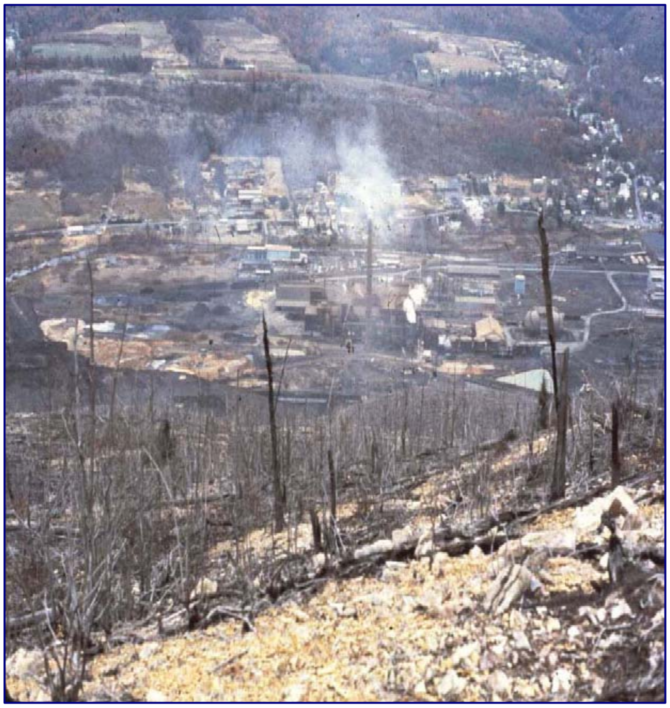


Figure 1: Palmerton, PA, 1980; Dead Ecosystem on Blue Mt.
(Source: Sprenger)

The site consists of two former zinc smelters—west plant operations began in 1898 and east plant operations in 1911. All primary zinc smelting operations ceased in December 1980. Smelting activities resulted in the emission of large quantities of zinc, lead, cadmium, and sulfur dioxide that caused the defoliation of more than 2,000 acres of vegetation in the vicinity of the east smelter on Blue Mountain. Process residue and other plant wastes were disposed of in a cinder bank—a 2.5-mile, 255-acre waste pile located behind the east plant at the base of Blue Mountain. The cinder bank contains approximately 33 million tons of material containing leachable metals, including lead, zinc, and cadmium. Portions of the cinder bank continue to smolder because residue was deposited in the pile before it was fully quenched. Additional defoliation has also occurred along Stoney Ridge.

To date, the responsible parties have revegetated approximately 1,300 acres of the defoliated acres on Blue Mountain, approximately 220 acres of the cinder bank, and 40 acres in the Stoney Ridge area of the site in order to control erosion. These areas were revegetated with compost or municipal sewage sludge, power plant fly and/or bottom ash, and/or agricultural limestone and seed mixtures.

WASTE STREAM CHARACTERISTICS

In the Borough of Palmerton and surrounding area, former smelting operations and other processes at the site resulted in soil and shallow ground water contamination of heavy metals, such as lead, cadmium, and zinc. Elevated levels of zinc and cadmium in the soil are responsible for the vegetation damage observed on Blue Mountain, the cinder bank and areas of Stoney Ridge. As a result of the defoliation, contaminated soil is more easily washed away, contributing to surface and ground water contamination.

During individual sampling events, concentrations of total metals and dissolved metals detected in each well were similar, which indicates that metals in the ground water at the site are present mainly in soluble form. The highest concentrations of zinc and cadmium (both total and dissolved) were consistently detected in wells at the eastern end of the cinder bank.

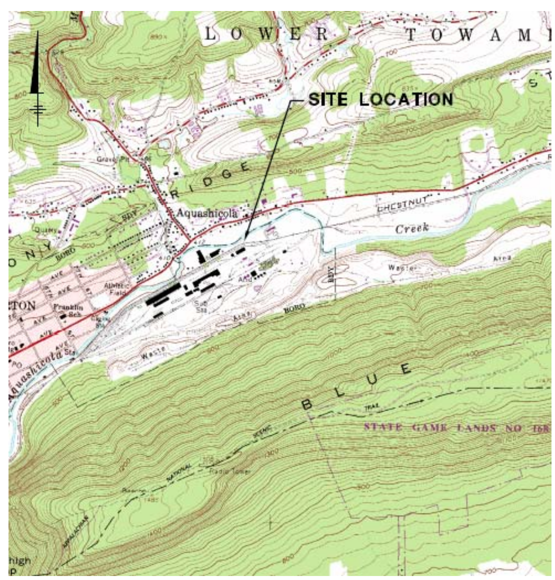


Figure 2: Location of Palmerton Zinc Site
(Source: Apollo, 2005)

Table 1. Metals Contamination Concentrations

Area	Media	Cadmium (parts per million ppm)	Lead (ppm)	Zinc (ppm)
Blue Mountain†	surface soil	364-1,300	1,200-6,475	13,000-35,000
Cinder Bank†	bank material	250	3,600	27,000
Stone Ridge‡	ground water	1-1,670	1-1,630	40-2,122,000

†Source: EPA 2002
‡Source: TT/B&V (Note that in some ground water samples the listed metals were not detected or were not significantly detected above the blank. Although listed under the Stoney Ridge RI, water samples were collected from all areas of the site–i.e., including Blue Mt. and the cinder bank).

Consequently, Aquashicola Creek is contaminated with zinc, copper and cadmium with elevated levels of cadmium, lead and zinc found in fish near the site and elevated cadmium levels found in fish taken 27 km downstream (as reported in TT/B&V, 2002). Bioaccumulation of these contaminants in fish may pose a health threat if consumed by people.

Treatment Technology

Revegetation is the main treatment technology selected to address the heavy metal soil contamination at and surrounding the site. Revegetation is expected to produce the following results:

Figure 3: Palmerton Zinc Superfund Site Aerial View
(Source: Sprenger, Undated)

- Stop or greatly reduce wind erosion, which will remove air-borne heavy metals from the site;
- Stop or greatly reduce surface erosion by water, thus preventing the placement of heavy metals in the surface waters that flow from the site; and
- Increase evapotranspiration by establishing a permanent vegetative cover on the site, which will prevent significant quantities of water from percolating through the soil profile. This technology is expected to prevent water from picking up heavy metals and delivering them to the ground water (HRD, April 1991).

Blue Mountain Revegetation

Following several years of pilot testing, full-scale implementation of the revegetation of Blue Mountain began in 1991. Between 1991 and 1995, approximately 850 acres were revegetated using a spreader truck (as shown on page 1) to apply lime, potash, sludge, and fly ash (see Table 2 for specific amounts).

The sludge application rate was adjusted, as necessary, to provide up to 2,000 pounds/acre of organic nitrogen. The fly ash amount was then adjusted to provide a 2:1 sludge:fly ash ratio. The other amendments remained constant. Tree and grass seeds were also applied. (HRD, 1991)

While revegetation of the initial 850 acres was highly successful in establishing grass cover, fungal disease, competition with plants, and foraging animals hindered tree seed growth. Additionally, limited sampling data indicated that translocation of contaminants may have been occurring through plant uptake. As a result, additional test plots were planted in 1995 and 1999 (approximately 100 acres), and based on the results, EPA adopted the following approach for the revegetation of the remaining denuded acreage (EPA, 2002):

- Utilize a self-sustaining meadowland revegetation approach that has minimum metal uptake;
- Sample and analyze appropriate indicator plant species for metals to determine if any uptake is occurring; and
- Periodically remove volunteer tree species with high metal uptake (e.g., birch, or poplar), if necessary.

After the initial 850 acres, the application of sewage sludge was replaced with mushroom and leaf-litter compost due to the negative public perception of sewage sludge application. During the first half of 2006, the responsible parties applied amendments, fertilizer, lime and warm season grasses to approximately 200 acres on Blue Mountain with an agricultural tractor and spreader, and an additional approximately 150 acres on Blue Mountain with a fixed wing crop-duster (Root, 2006).

Table 2. Biosolids Application in Three Areas at the Palmerton Site

Area	Lime (tons/acre)	Sludge or Compost (wet tons/acre)	Fly Ash (tons/acre)	Potash (pounds/acre)
Blue Mountain (first 850 acres)	10	105[1]	57.5[2]	132
Cinder Bank	10	270	138[3]	–
Stone Ridge (and remaining Blue Mt.)	Varied[4]	20[5]	–	160/130/290[6]

Notes:
[1] 20% solids
[2] 15% moisture
[3] Includes power plant fly and/or bottom ash.
[4] Sufficient amount to raise the soil pH to 6.5 base on soil tests.
[5] Consists of a mixture of Lehigh County and mushroom organic compost.
[6] Consists of commercial fertilizer containing 160/130/290 pounds per acre N/P/K (Nitrogen increased to 250 lbs/acre where leaves were located or used.)

All work to date on Blue Mountain has been conducted on private land. The remaining ~700 acres to be revegetated are located on land owned by the State of Pennsylvania or U.S. National Park Service and operated under a cooperative agreement. EPA is working with the State and Park Service to remediate the remaining portion of Blue Mountain.

Cinder Bank Revegetation

Municipal sewage sludge, power plant fly and/or bottom ash, agricultural limestone (together known as "Ecoloam") and select seed mixtures were combined in a vegetation mixture and then applied to the cinder bank using a spreader truck (similar to that used for the Blue Mountain revegetation). The ratio of sludge to ash was 2:1 by volume. The Ecoloam was applied at a rate of approximately 60 dry tons of sludge per acre.

The seed mixture included grasses that establish themselves quickly, perennial grasses for long-term erosion control, and birdsfoot trefoil, a nitrogen-fixing legume, to maintain nitrogen fertility without the need for supplementary fertilization. The material specification ceiling concentrations of metals and other constituents in the sludge and ash used in the Ecoloam were based on Pennsylvania Department of Environmental Protection (PADEP) maximum allowable concentrations in sludge and cumulative metal loading rates and adjusted down to ensure that no combination of sludge and ash meeting the specified limits could ever exceed the PADEP lifetime metals loading limits. (ZCA 1999)

Stoney Ridge Revegetation

To help minimize erosion and sediment transport, the responsible parties revegetated approximately 40 acres along Stoney Ridge in 2005 using a mixture of mushroom compost, lime, and fertilizer (see Table 2). Further, the responsible parties were planning to revegetate another 15 acres in the fall of 2006.

Table 3. Acres Revegetated

Area	Ecoloam	Mushroom/Leaf-Litter Compost	Total Reclaimed	Remaining
Blue Mountain	850	350	1,200	600
Cinder Bank	220	—	220	25
Stone Ridge	—	40	40	15
TOTAL	1070	390	1,460	640

Challenges, Adjustments, and Solutions

Establishing forestland at the site proved to be extremely challenging and was ultimately abandoned in favor of meadowland. Problems and change in strategy follow.

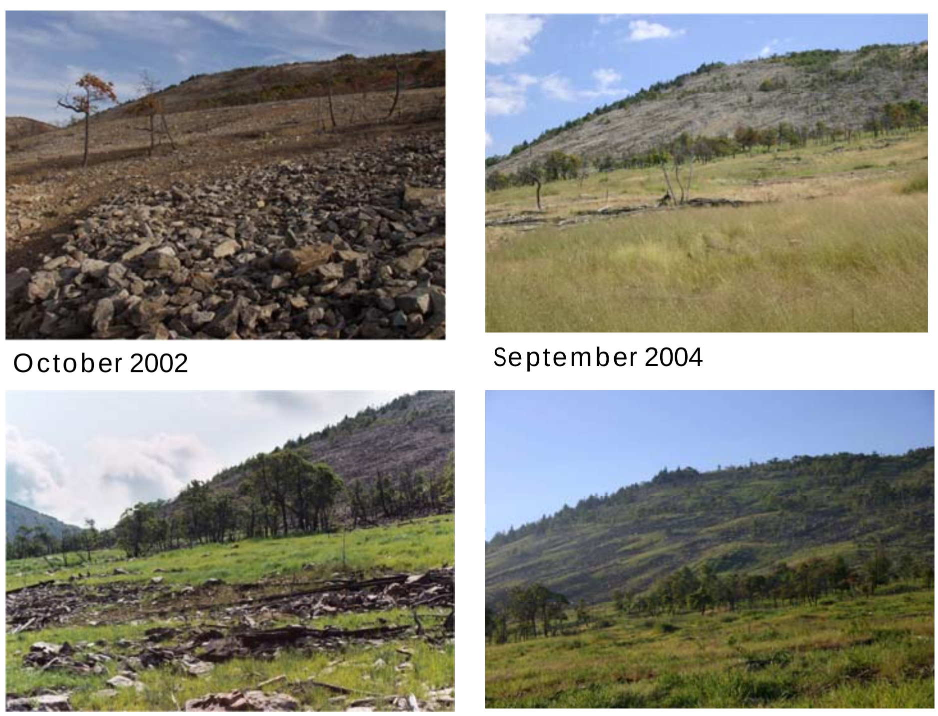
In 1995, USACE, on behalf of EPA took the following actions to attempt to achieve the tree seedlings' successful maturation in the test plots planted on Blue Mountain:

- Cut all grass in a 3.3 ft. area with a weed-whacker prior to dibble barring the seedling into the ground, in an attempt to minimize competition from grass;
- Inoculated the seedlings with a microrhizium developed for contaminated soils prior to planting;
- Applied an animal repellant and an iron chelate (FeEDDHA) to seedlings; and
- Used insect control as needed.

In the spring of 1998, a ground weed control mat (3x3 ft.) or other control was applied around the seedlings. A plastic protective tube was placed around the seedlings at planting in November 1997 to protect from animal grazing. The plastic tube was ineffective because windy conditions on the mountain caused massive wind damage to the seedlings. A netting type of seedling protector was applied in March 1998. Despite these extensive efforts, the 1995 tree seedling planting performed poorly. An additional round of tree seedlings were planted in November 1999 in the plots that had the fewest surviving seedlings from the 1995 planting. In response to the difficulty in creating successful forestland through either seeding or seedling planting, EPA requested a cost analysis of establishing meadowland versus forestland. This cost comparison estimated meadowland establishment at $1,125/acre versus $6,125/acre for forestland via tree seedling planting and intensive seedling maintenance. In light of the cost and difficulties in establishing trees on this site, EPA allowed the responsible parties to modify the remediation to exclude tree seeds/seedlings (EPA, 2002). These modifications were also applied to the cinder bank and Stoney Ridge revegetation areas.

PERFORMANCE OF SYSTEM

During the past 10 years, the 850 acres reclaimed on Blue Mountain have maintained more than 70 percent vegetative cover with increasing emergence of volunteer tree species. As can be seen in Figure 5, vegetation on the west side of Lehigh Gap has increased dramatically in the past 4 years.



October 2002 | September 2004 | August 2003 | August 2006

FIGURE 5: PALMERTON ZINC SUPERFUND SITE PROGRESSION OF REVEGETATION ACTIVITIES (SOURCE: ROOT, 2006)

Other Technologies Used for Wastestream

In association with revegetation and cleanup of the cinder bank, the responsible parties built a system to divert surface water around the cinder bank and is treating contaminated leachate before it is discharged to the nearby Aquashicola Creek.

In addition to revegetation, other erosion control activities conducted in the Stoney Ridge area include the installation of rock/stone check dams, diversion berms, and sedimentation basins in and around the erosion channels.

COST

Prior to beginning revegetation activities, it was determined that removal of contaminated soil and associated smelting residue would cost more than $4 billion and take up to 45 years.

Although costs are not available for all of the revegetation activities, the responsible parties estimate that it cost approximately $9 million to reclaim the initial 850 acres of Blue Mountain. A significant portion of the cost can be attributed to the construction of more than 60 miles of switchback roads to accommodate the application truck's need for a relatively level road surface. Subsequent revegetation activities (e.g., the remaining portion of Blue Mountain, the cinder bank, and Stoney Ridge) did not require construction of roads and, therefore, are anticipated to cost less per acre than the initial 850 acres.

Based on the initial estimates for removal of contaminates soil, it is clear that the chosen remediation method is significantly less expensive.

LESSONS LEARNED AND CONCLUSIONS

The method of application and the types of biosolids and seeds used for revegetation were all modified after the initial revegetation of the 850 acres on Blue Mountain.

- Because trees could not be easily established, tree seeds were replaced with grass seeds.
- Due to metals uptake, the types of grass seeds were replaced with those having minimal metals uptake.
- As a result of negative public perception, sludge application was replaced with mushroom compost.
- To decrease costs, application methods were modified to eliminate the need for roadway construction.

EPA CONTACTS

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KEY DATES

1898 – 1967	New Jersey Zinc Company operates the zinc smelters.
1967 – 1981	Gulf & Western Corporation operates the zinc smelters.
1981	Horsehead Industries, Incorporated, purchases the smelters and begins operating the facility as a hazardous waste recycling plant.
Sept. 1983	Site is listed on the NPL
Sept. 1985	EPA enters into an Administrative Order on Consent (AO) with Horsehead Industries, Incorporated (HII), and the current owner/operator of the site, The New Jersey Zinc Company, a division of HII. Under the terms of this AO, HII agrees to conduct a Remedial Investigation/Feasibility Study (RI/FS) for the Cinder Bank.
Sept. 4, 1987	Record of Decision (ROD) is issued, which calls for the revegetation of 2,000 acres on Blue Mountain.
June 29, 1988	ROD is issued for remediation of the Cinder Bank.
Early 1980s	Revegetation of cinder bank begins.
1991 – 1995	850 acres of Blue Mt. is revegetated using municipal sewage sludge.
1995	Tree seedling pilot test is conducted on Blue Mountain.
Dec. 22, 1995	EPA sends Special Notice Letters to the potentially responsible parties (PRPs), which contained an offer for them to perform the RI/FS for the ground and surface waters potentially impacted by the site (i.e., Stoney Ridge area). After the PRPs decline this offer, EPA performs the RI/FS using Superfund monies.
1997 & 1998	EPA conducts fieldwork associated with the ecological aspects of the contaminated ground and surface waters impacted by the site.
Nov. 1999	Additional round of tree seedling pilot tests are conducted on Blue Mountain.
April 2000	Cinder bank Leachate collection and treatment and surface water diversion work begins in conjunction with revegetation activities.
Fall 2002	Revegetation of cinder bank is complete.
July 2005	*Stoney Ridge Erosion and Revegetation Activities Workplan* is submitted.
April 2006	EPA approves second preliminary design for revegetation of the remaining non-publicly-owned land in the Blue Mt. area.
2006	Amendments, fertilizer, lime, and warm season grasses are applied to more than 200 acres of Blue Mt. with agricultural tractor and spreader and an additional approximately 150 acres of Blue Mt. with fixed wing crop-duster type aircraft.

REFERENCES

Apollo® Environmental Strategies, Inc. (for Viacom International, Inc.). July 1, 2005. "Palmerton Zinc Superfund Site – Stoney Ridge Erosion and Revegetation Activities Workplan."

Horsehead Redevelopment Co., Inc. (HRD). April 1991. "Blue Mountain Project Palmerton Zinc Superfund Site Remedial Design."

Jenness, Nathan. University of Arizona (for USEPA). August 2001. "*Mine Reclamation Using Biosolids*."

Sprenger, Mark. USEPA-OSWER-OSRTI-ERT. Undated. "Effectiveness of BiosolidsApplication for Remediating Metals Mining Sites."

Tetra Tech/Black & Veatch (TT/B&V). June 2002. "Remedial Investigation Palmerton Zinc Pile – Operable Unit 4."

U.S. Environmental Protection Agency. February 2002. (Signed July 2002) "Second Five-Year Review Report Palmerton Zinc Pile."

U.S. Environmental Protection Agency Region 3 (Mid-Atlantic). June 2006 (last updated). Current Site Information. http://www.epa.gov/reg3hwmd/npl/PAD002395887.htm.

Zinc Corporation of America (ZCA). March 1999. "Cinder Bank Revegetation Plan."