EPA
United States
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Agency

Anaconda Smelter, Anaconda, Montana, Superfund Case Study

Revitalization of the Upland Areas

This is the story of ecological revitalization in the upland areas of the Anaconda Smelter Superfund site (the Site), where years of cleanup continue to transform contaminated lands into functional properties and support a sustainable environment. Located in southwest Montana, in and near the towns of Anaconda and Opportunity, the Site is part of the larger Upper Clark Fork Basin Superfund area. Contamination from nearly 100 years of copper smelter operations have affected the health and quality of the environment at the Site. Estimates indicate that more than a billion gallons of groundwater were contaminated and thousands of acres of soil were affected by fluvially-transported mine wastes and smelter emissions.

The massive 300-square-mile site area and variable, rugged terrain provided major remedial design challenges. This case study focuses on the upland areas of the Site, which include surface soil primarily contaminated by smelter emissions. Innovative assessment techniques, developed through years of studies and investigations, helped tailor remediation. Though originally designed for the Anaconda Smelter Superfund site, these evaluation and remedial processes may also be applicable at other contaminated sites across the country.

Smelter operations had immediate and long-term effects on the environment. Very little vegetation was able to survive on nearby properties or areas directly downwind. Smelting facilities released tons of arsenic, copper, sulfur, lead and zinc each day. A United States Department of Agriculture Technical Bulletin stated, "In 1910 and 1911, all of the major tree species were either dead or dying as far as 5 to 8 miles from the smelter." Local ecosystems worsened over the years. By the 1980s, forestry impacts were documented as far as 22 miles away. In addition to forests, impacted properties primarily include open grasslands and individually-owned ranches. These lands need to sustain area livelihood and local wildlife.

The innovative site evaluation and assessment techniques, paired with effective remedial processes such as tilling and adding soil amendments, have helped restore these vital grasslands and ranch areas. The uplands remediation and ecological revitalization efforts have served to provide key lessons and replicable assessment techniques for other sites with area-wide contamination.

This case study is part of a series focused on ecological revitalization as part of contaminated site remediation and reuse; these case studies are being compiled by the U.S. Environmental Protection Agency (EPA) Technology Innovation and Field Services Division (TIFSD). The purpose of these case studies is to provide site managers with ecological reuse information, including principles for implementation, recommendations based on personal experiences, a specific point of contact and a network of sites with an ecological reuse component.

Topics Highlighted in this Case Study:

- Soil Amendments
- Use of Native Plants
- Area-wide Remediation
- Wildlife Habitat
- New Evaluation Techniques
- Soil Reclamation

Ecological Revitalization

Ecological revitalization is the process of returning land from a contaminated state to one that supports functioning and sustainable habitat.

Background

The Site is located in the Upper Clark Fork River Basin in Anaconda Deer Lodge County. During almost 100 years of operation, the Anaconda smelters and mining at the nearby Butte site supplied enormous quantities of raw ore for material production across the country.

The Anaconda Copper Mining Company began large-scale copper smelting and concentrating activities outside the town of Anaconda in 1884. In 1902, additional smelting and processing operations began at a second smelter east of the town of Anaconda. Butte mining and Anaconda smelting activities provided most local jobs and revenue in the area; the industries were the cornerstone of the town and its economy. The Anaconda smelter had a national reputation as one of the leading producers of copper and boasted the largest free-standing smokestack in the world, standing over 580 feet. In 1977, Atlantic Richfield Company (ARCO) purchased Anaconda Copper Mining's holdings, which included the smelting site.

Figure 1: During their years of operation, the Butte mines and Anaconda smelters produced more than $300 billion worth of metal.

Milling and smelting operations released hazardous waste into the air and water.

- Records beginning in 1907 indicate that each day the smelter released over 30 tons of arsenic, copper, lead, sulfur and zinc into the environment.
- By 1978, the daily average of contaminants released into the surrounding communities and ecosystems had increased to 578 tons.
- Because of aerial emissions, contamination spread across 300 square miles around the Anaconda smelter.

When the smelter closed in 1980, it left the area's soil and water contaminated with heavy metals from almost a century of copper smelting. The shutdown quickly devastated the community and investigations revealed the degree to which the contamination had also damaged local vegetation and aquatic systems, threatening the nearby blue ribbon trout population.

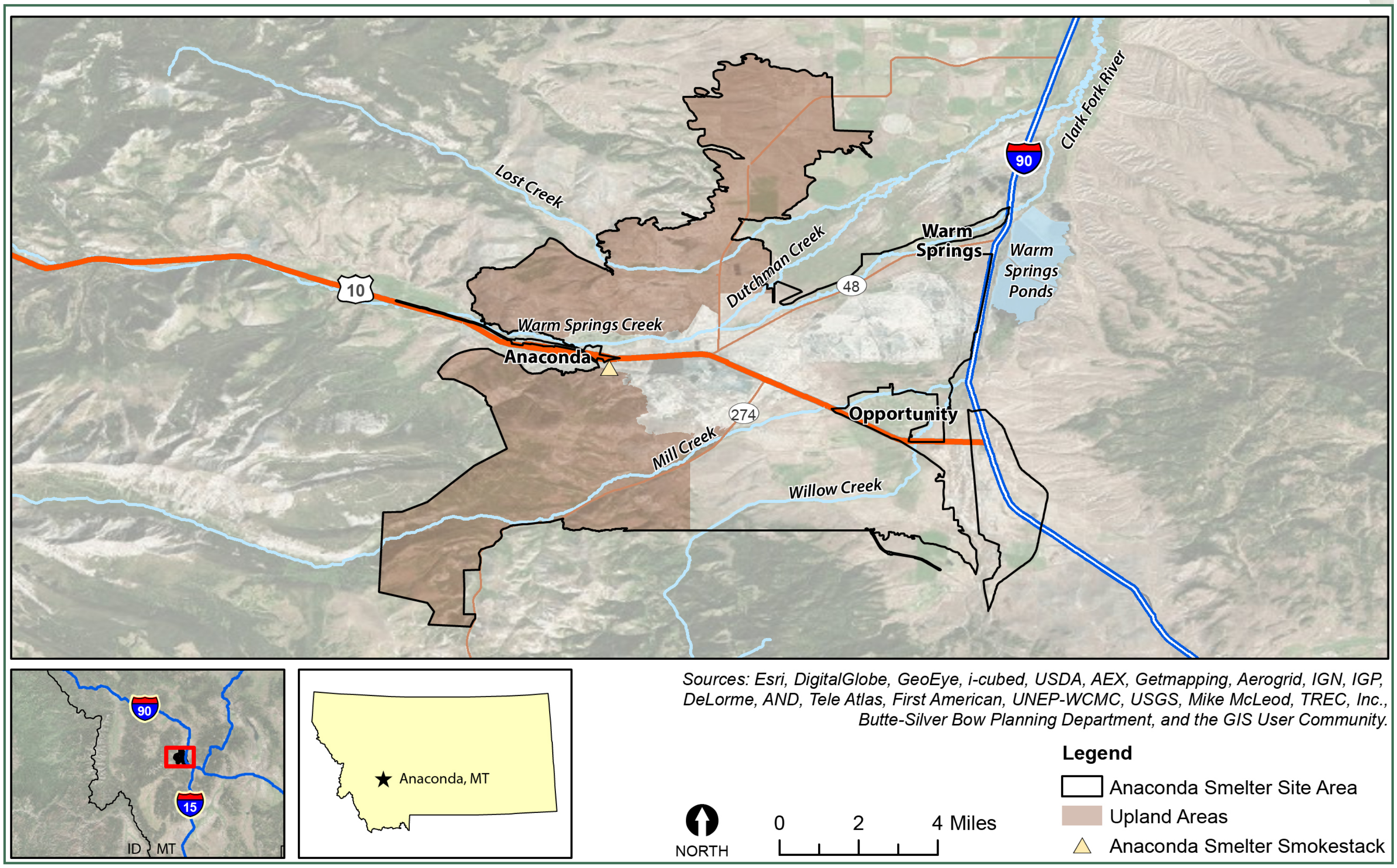
In 1983, EPA listed this 300-square-mile area as the Anaconda Smelter Superfund site on the Superfund program's National Priorities List (NPL). Terrain at the Site ranges from steep-slope uplands to level valley floors and includes a variety of creeks and drainages. The Site is bordered by the Clark Fork River and encompasses the towns of Anaconda and Opportunity (see Figure 3).

Millions of cubic yards of tailings, furnace slag and flue dust, and thousands of acres of soil contaminated by airborne emissions required remediation.

EPA, ARCO and the Montana Department of Environmental Quality (MDEQ) have coordinated cleanup efforts. EPA has divided the Site into a number of operable units (OUs). Remedial construction is ongoing at three OUs, including the Anaconda Regional Waste Water & Soil (ARWW&S) OU.

Figure 2: Environmental impacts from the smelter were documented as far as 22 miles away from the smokestack. Emissions caused short-term and long-term damage, including limited plant growth and inhibited forestation.

Figure 3: The massive Anaconda Smelter Superfund site includes 20,000 acres impacted by aerial emissions from the smelter. These areas are called uplands and are shaded in the map above.



The ARWW&S OU covers thousands of acres of land contaminated with arsenic and metals. Fifteen smaller remedial design units (RDUs) make up the OU, and these contaminated areas can be grouped into three larger land types, or units.

- The first land unit of the ARWW&S OU is the area that immediately surrounds the old smelters. Known as Waste Management Areas and Dedicated Development, this area includes tailings, slag and other smelting wastes. It also includes railroad bed built out of waste materials and the Anaconda Ponds and Opportunity Ponds tailings impoundments, in which contamination is about 100 feet deep.
- The second land unit of ARWW&S OU is the lowland areas. Creeks, streams and rivers contaminated with sulfidic mine tailings from the Site periodically flooded these lowlands and deposited contamination. In addition, polluted water used to irrigate lowland areas resulted in soil contamination. Contamination depth in this section ranges from less than an inch to several feet in historic stream channels. Despite metals contamination, vegetation typically grows in these areas due to the influence of groundwater and surface water.
- Upland areas furthest from the smelter make up the third land unit; this unit is the focus of this case study. Airborne smelter emissions reached soil in these upland areas and deposited arsenic, metal and sulphur compounds. Contaminants are most concentrated in the upper 2 inches of soil, but low pH and limited soil buffering capacity may leach copper and zinc up to 18 inches in some areas. Remedial efforts are taking place on about 20,000 acres impacted by smelter fallout.

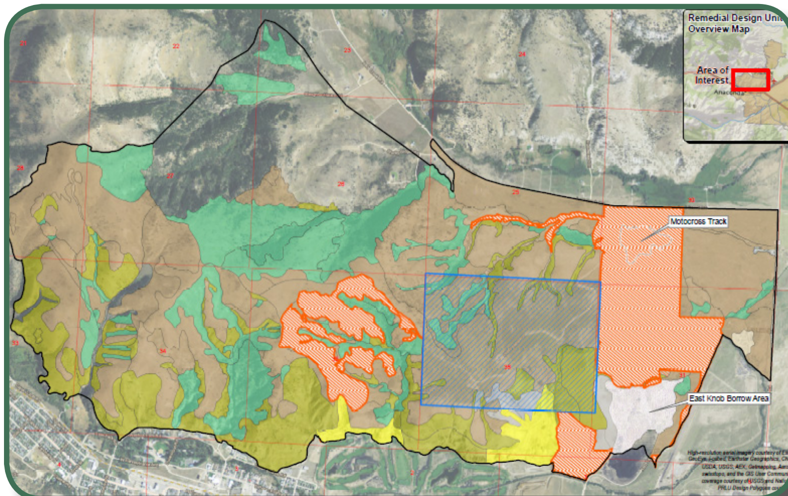


Figure 4: Varied topography, as indicated by the different colors on this aerial map of the Stucky Ridge uplands area, presented challenges for site remediation. The brown areas required tilling and chartreuse indicates steep slope reclamation areas. *(Source: EPA and CDM Smith)*

Learning from Site Investigations

Years of investigations and studies shaped cleanup efforts at the Site, and numerous on-site revegetation attempts informed the final strategies. As early as the 1950s, the Anaconda Copper Mining Company experimented with revegetating waste piles to abate fugitive dust emissions in the tailings impoundment. The Company also learned about the utility of amendments in greenhouse studies. In the early 1980s, the Company found that separating new plants from wastes using crushed limestone and clean soil, and using in-situ soil treatment could re-establish vegetation. These results were obtained from two demonstrations in the 1980s: the Streambank Tailing Revegetation Study (STARS) and the Governor’s Demonstration Study of in-situ treatment of tailings

During the remedial design phase for soil in the upland areas, site stakeholders faced a variety of challenges.

- It was impractical to completely excavate and replace contaminated soils at such a large site.
- It was difficult to use large equipment on the steep slopes of upland areas.
- Commercial alkaline amendments were expensive.

near the Clark Fork River. STARS also screened tolerant vegetation and preliminary liming rates to permanently maintain appropriate soil pH levels. These studies revegetated treated soils and wastes rather than using covers composed of clean off-site soil. This type of revegetation is more feasible over larger areas than excavation or surficial stripping.

Common Techniques for Soil Reclamation

Physical methods of soil reclamation can be divided into ex-situ and in-situ. Ex-situ methods include transportation of contaminated soil for cleaning, mechanical separation (using properties like density) or soil extraction and storage. In-situ methods can be applied on site, without removal, such as tilling and amendments. Common in-situ techniques used in Anaconda include soil mixing (i.e., tillage) to various depths for contaminant dilution and the addition of soil organic matter, lime and other amendments. Very highly contaminated material is often excavated/removed or a soil cover is applied. Information on other types of in-situ treatment can be found at: **Safe Management of Mining Waste and Waste Facilities**.

Lessons learned from those demonstration studies were used to develop remedial techniques for the specific conditions at the Site. This development process was known as the Anaconda Revegetation Treatability Studies (ARTS). These studies were conducted in the early 1990s, and were performed in four phases:

- Phase I evaluated site-specific experience with revegetation, worldwide revegetation literature and current site conditions to identify limiting factors for growth. This phase identified and sampled candidate plots for revegetation.
- Phase II included laboratory and greenhouse evaluations of soil treatments, soil amendments and related species-specific plant responses.
- Phase III documented five ARTS trial sites – three on tailing material and two on impacted soils.
- Phase IV presented the investigation results.

From information provided through ARTS, EPA and MDEQ selected in-situ reclamation as the remedy for much of the ARWW&S OU in a 1998 Record of Decision (ROD). Common in-situ reclamation techniques require some level of physical soil manipulation, amendment application, and revegetation based on site-specific conditions. However, large-scale remediation at the Site would require some changes to these common techniques. First, site stakeholders needed to develop a cost-effective and efficient way to systematically evaluate remedial needs for the 20,000-acre upland area. As noted in the ROD, the aim of remedial efforts would be to establish a self-sustaining collection of plant species to stabilize the soils against erosion and minimize contaminants reaching soil and groundwater; prevent human contact with contaminants; maximize water usage; re-establish wildlife habitat; and accelerate successional processes.

Remedial Team

ARCO, CDM Smith, EPA, MDEQ, and the MSU Reclamation Research Group

A New Tool: Land Reclamation Evaluation System (LRES)

Because the ARWW&S OU included such a large and varied landscape, it was important to efficiently determine the conditions of specific areas and appropriate remedies for each area. Site stakeholders needed a method that was precise and quantifiable and also incorporated non-scientific values, like the history or ownership of the area.

Montana State University's (MSU) Reclamation Research Group, local ecologists and reclamation scientists from CDM Smith developed a standardized decision-making tool called the Land Reclamation Evaluation System (LRES) to achieve the ROD's goals.

Steep Slope Reclamation

In the ARWW&S OU, some upland areas have slopes too steep for reclamation techniques like tilling or amendments. PRP contractors developed alternative methods to remediate these areas. These alternatives vary based on local conditions, such as the slope's steepness and degree of contamination. Alternatives include:

- Engineered stormwater controls so runoff will not contaminate streams.
- Herbicide aerial application to control weeds.
- Organic matter and fertilizer application for smaller slope areas.
- Rock check dams to stop erosion.
- Dozer basins to capture sediments.
- Grading steep gullies to establish vegetation at the bottom of gullies.
- Establishing trees, shrubs and grasses.

No one technique has proven successful for the upland slopes. Investigations and remedial efforts continue to vegetate slope areas and minimize erosion.

Figure 5: Aerial application of herbicide can help control weeds on steep slopes.

The LRES requires:

- Assessment of potential human and ecological risk.
- Quantitative scoring of the existing vegetation communities, soil stability attributes and the potential for contaminant transport.
- Identification of modifying factors that may impact the level and extent of land remediation.
- Use of decision diagrams to guide site decision makers in determining remedial actions and levels of reclamation intensity.

To assess contamination so that remedial techniques could be considered, affected properties were divided into smaller polygon areas of similar vegetative status. Boundaries for the polygon parcels could be a body of water, a change in topography or other dividers that were already in place. Each parcel's LRES score included consideration of vegetation attributes, soil stability attributes and modifying criteria (such as land ownership). These scores informed decision makers about what to do with each parcel, making the LRES the primary basis for the remedial design. Parcels were given vegetation scores (0 to 100; these included cover and species richness) and soil scores (0 to 75; included water erosion and surficial tailings). Parcels with higher scores were less likely to need remedial action. For example, a parcel with a vegetation score of 73, a soil score of 69 and a total score of 142 was designated as needing no further action. However, a different parcel with a vegetation score of 7, a soil score of 19 and a total score of 26 needed deep plowing plus soil amendments. This conceptual design allowed for implementation of the remedial action work plan. Based upon validation-scoring, it was determined that the long-term compliance standard for the upland areas is a post-remediation score of 115 or greater.

Considering Soil Amendments

In addition to the LRES evaluations and data collection, other remedial design investigations were conducted to provide the basis for the in-situ treatment design. These investigations focused on surficial soils impacted by smelter emissions. Many surfaces with low LRES soil scores had poor buffering capacity due to low pH and high metal content. Soils with low pH are more acidic and are likely to allow contaminant mobilization and leaching into groundwater. Acidic soils can also inhibit seedling establishment and long-term plant growth, cause soil infertility, and limit microbial activity. Soil amendments can reduce bioavailability of contaminants while enhancing soil structure and revegetation.

Updating Application Rates

Studies in the early 1990s calculated a liming equation (alkaline amendment) based on the specifics of site contamination. Previous research had developed an amendment distribution equation based on the presence of sulfide minerals (often from tailings), rather than years of constant sulfur dioxide deposition and resulting depressed pH (from smelter emissions). Due to years of emissions exposure, the Site's soil had developed active acidity rather than the potential for acidity which is due to weathering or leaching of sulfide minerals. Between 1999 and 2002, ARCO's demonstration project updated application rates for active acidity. These updated area-specific considerations were able to reduce the selected lime amendment application rate by 25 percent, along with tests to ensure proper pH levels. Site stakeholders agreed to use spent lime as the lime amendment at this site.

The pre-ROD alkaline amendments considered were commercial lime, such as limestone and calcium oxide. These products are expensive and because the Site is so large, the potentially responsible party (PRP) hoped to find a more cost-effective alternative. Because the amendments would need to be applied over a vast area, the 2002 greenhouse studies (during Phase II of the ARTS) by ARCO and MSU assessed the effectiveness of alkaline industrial byproducts, such as lime kiln dust and cement kiln dust, as replacements for more expensive commercial products. Though PRP contractors found these byproducts to be effective, they were also hazardous due to elevated metal levels and high causticity, which could result in health risks during application.

Spent lime was chosen as the appropriate and non-hazardous lime amendment for the uplands. Spent lime is a byproduct of the beet sugar purification process.[1] During sugar beet processing, a precipitate of solid lime product forms that needs to be discarded, otherwise known as spent lime. Though spent lime is an inexpensive product, costs related to the transportation are significant as the closest sugar beet refinery is in Billings, Montana. Nonetheless, site stakeholders selected spent lime as the responsible choice for an alkaline amendment at the Site. It is effective, less toxic, and even contains some organic matter that further helps plant growth.

Remedial Action

The results of the site-specific evaluations, data collection and demonstrations formed the basis of design for the contaminated soil remedy in upland areas. The studies:

- Determined soil tillage would be an effective alternative to soil replacement to achieve metals dilution.
- Determined organic matter and alkaline amendments would promote plant growth.
- Found alternatives to expensive and hazardous commercial alkaline amendments.
- Suggested alternatives for difficult steep-slope reclamations (including planting trees, aerial application of herbicides, construction of rock check dams and dozer basins).
- Calculated a new liming equation based on site-specific conditions.

1 https://www.crystalsugar.com/media/19680/impact.pdf

Upland areas, with the exception of steep-slope areas, are remediated through a variety of techniques based on their LRES score. As of 2014, 11,500 acres have been remediated (8,300 acres remain to be addressed).

Methods included:

- In-situ soil tillage to dilute metals concentrations, which is generally limited to the upper 2 inches of the soil profile, but could include tilling up to 18 inches.
- Application of soil amendments.
- Application of organic matter; top 6 inches should include at least 1.5 percent organic matter.
- Application of native seed mixes for revegetation.

These techniques can be altered for the varied topography of the upland areas and can allow for reuse. The ecological risk assessments did not predict that metal uptake in the revegetated areas would negatively impact livestock or wildlife consuming the plants. Site stakeholders have not seen any impacts on livestock or wildlife from metal uptake.[2]

Steep-slope remedial techniques are still being investigated and tested.

Development of Seed Mixtures and Adapted Varieties

Eight seed mixes have been developed for lands being remediated at the ARWW&S OU. The mixes are based on the environment to be remediated: general grassland areas, drainageway/wet areas, bottomlands, waste management areas, landowner-specific mixtures, steep slope/dozer basin areas, saline areas, and areas with particularly high soil metal concentrations. These mixtures are dominated by wheatgrass, fescue and poa species that have proven hardy in the semi-arid climate and soils of Anaconda. These soils have residual metal contamination, low fertility and damaged microorganism communities.

The Role of Organic Matter

Organic matter is especially helpful for promoting early plant growth. For successful remediation and revegetation, it was determined that the top 6 inches of soil should have at least 1.5 percent organic matter. Remediation contractors account for existing organic matter in the soil and use composted manure from local cattle ranches, making this a green, cost-effective part of the remedial effort.

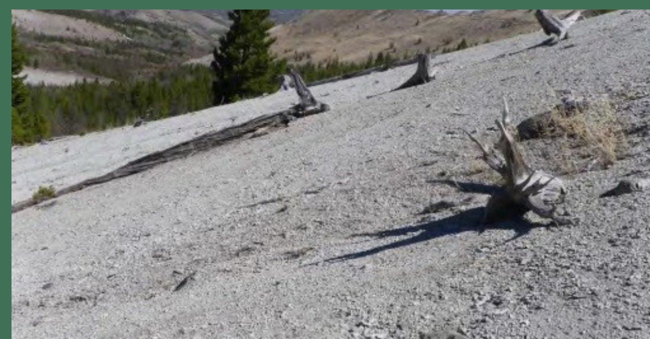


Figure 6: On-site plot in May 2012.

Figure 7: The same on-site plot with organic matter applied.

Figure 8: The same on-site plot in July 2014.

2 Potential wildlife bioaccumulation of contaminants were assessed by Dr. Dale Hoff of EPA in consultation with the USFWS and Texas Tech University. Their findings indicated that wildlife risks through direct exposure or through bioaccumulation were not significant.

Remediation Milestones Timeline

- 1884-1980: The Anaconda Copper Mining Company conducted copper smelting, processing and mining activities.
- Early 1950s: The Anaconda Company used revegetation to abate fugitive dust emissions.
- Early 1980s: The Anaconda Company experimented with in-situ remediation of treated soils and wastes.
- 1983: EPA listed the Site on the National Priorities List (NPL).
- Early 1990s: Anaconda Revegetation Treatability Studies (ARTS) were conducted; these studies informed the Land Reclamation Evaluation System (LRES), which was developed concurrently.
- 1998: EPA and MDEQ selected in-situ reclamation as the remedy for the ARWW&S OU with assessment using LRES.
- 1999-2002: ARCO's demonstration projects informed decisions on alkaline amendments.
- 2003-2009: CDM Smith developed the Vegetation Management Plan to manage vegetation on reclaimed areas.
- 2005-2006: LRES was used to prepare remedial action work plans and designs.
- 2006-ongoing: Large scale in-situ soil remediation was performed. Steep slope reclamation was also conducted.
- 2010-2014: The Montana NRDP performed remediation on Stucky Ridge (within the ARWW&S OU) using new varieties of metal-tolerant species.
- 2010: EPA's Five-Year Review of the Site found that some treated areas remained poorly vegetated.
- 2011: CDM Smith conducted a Vegetation Response Investigation to further study poor plant establishment.
- 2012: Total Metal Index (TMI) was developed based on the findings of the 2011 investigation.
- 2013: The Vegetation Management Plan updated to acknowledge different kinds of land uses and to identify vegetation performance compliance standards.

Three grass varieties have been developed by the United States Department of Agriculture Natural Resources Conservation Service from germplasm from smelter-impacted land near Anaconda. These varieties, Copperhead slender wheatgrass (Elymus trachycaulus), Washoe Great Basin wildrye (Leymus cinereus), and Opportunity big bluegrass (Poa secunda), were tested on Stucky Ridge (Anaconda) by the Montana Natural Resource Damage Program (NRDP). NRDP found the grasses performed well. As a result, they are being incorporated into the seed mixtures used in the upland areas of the ARWW&S OU.

Making Adjustments: Total Metal Index (TMI)

EPA's 2010 Five-Year Review found that some in-situ treated areas remained poorly vegetated. Based on this, the Five-Year Review recommended further investigations.

- In 2011, site contractor CDM Smith conducted a Vegetation Response Investigation to further study poor plant establishment, particularly related to residual metals concentrations.
- The site team revisited the 2002 greenhouse studies to assess metal impacts on growth during these studies.
- The 2011 Vegetation Response Investigation found many areas where soil pH was neutral, but remaining contaminant levels (mainly metals) were negatively impacting plants.

The need to determine an in-situ threshold for residual contamination that would allow for successful vegetation spurred development of the Total Metal Index (TMI) in 2012. The TMI correlates metal and metalloid concentrations (either the sum of total arsenic [As], copper [Cu], and zinc [Zn], or only arsenic) with qualitative plant stress levels. Arsenic is useful as an indicator contaminant both because increases and decreases in arsenic concentrations were consistent with other combined metal concentrations and because EPA used it at the Site to determine human health risks for different land uses.

Soil Metal Index (Sum of Total As+Cu+Zn in mg/kg*)	Soil Arsenic Index (mg/kg)	General Plant Stress Level Due to Soil Contaminants
700-	*166-*	*Very Low*
1,200	*245*	*Low*
1,450	*290*	*Low-Moderate*
1,700	*330*	*Moderate*
2,300	*430*	*Moderate-High*
2,900	*530*	*High*
3,500+	*630+*	*Very High*
*milligrams per kilogram		

The TMI is being used to determine if in-situ remediation is likely to be successful based on the degree of contaminant-related phytotoxicity. If the post-remediation plant stress level is likely to be moderate or higher (>1,700 TMI), then enhanced remediation, such as deeper tillage or more amendments, needs to be considered. Cleanup techniques used at high and very high TMI areas include stripping and removal of the very contaminated surface soil layer, or applying cover soil and then seeding.

Figure 9: Performing soil tilling on the Site.

Land Management

Initial remedial work focused on contaminated areas owned by the PRP. As work shifted more to private property, the remedial approach also shifted to better incorporate private property owners' needs. Many landowners desired efficient reclamation without long-term management or property restrictions. As a result, EPA and ARCO revised the Vegetation Management Plan in 2013 to acknowledge different kinds of land uses and allow the cleanup to accommodate individual landowners' needs, if feasible. Results from the Vegetation Response Investigation informed development of six land management categories:

- Category 1. Unrestricted Use Properties

  The soil has less than 250 mg/kg arsenic according to the TMI, which is the approved level for residential use. This is primarily used at private properties. No long-term operation and maintenance is required.

- Category 2. Upland Properties

  The TMI is low to moderate (up to 1,700 mg/kg). These properties have limited long-term operation and maintenance responsibilities.

- Category 3. Upland Properties

  The TMI is moderate to high (>1,701 mg/kg). These areas may have enhanced reclamation and require future assessments.

- Category 4. Upland Properties

  The TMI is moderate to high (>1,701 mg/kg). These properties are similar to Category 3 and require a land management plan.

- Category 5. High Arsenic Areas

  These have restricted uses and more long-term responsibilities; they require a land management plan.

- Category 6. Waste Management Areas

  These have restricted uses and long-term responsibilities.

On-site seed mixes are primarily native and naturalized grasses. Several mixes have been distributed on the Site depending on topography (e.g., different species are used on wetlands versus dry uplands). One plant, called Redtop, is found throughout the Site even though it was not in seed mixes. Redtop is aggressive, grows naturally in the area and performs well in acidic soils. Seed mixes are often applied based on landowner preference and projected future land use.

Figure 10: Perennial grasses cover the Site.

Depending on the property and desired use, long-term responsibilities can include monitoring and Five-Year Reviews, and implementing institutional controls to restrict the disturbance of soil. The updated Vegetation Management Plan for the Site allows for the restoration of private properties faster while supporting future use. This plan marks the culmination of many different remedial efforts and innovative assessment techniques. EPA continuously monitors the ARWW&S OU to ensure that the remedial actions continue to be effective and that remedial action objectives and remedial action goals are being met.

Current Land Use

Though remediation continues on much of the Site, there have been many developments on the site already. Developers turned 250 acres of the Site into a 21-hole golf course. Designed by golf legend Jack Nicklaus, the course combines historic mining artifacts with beautiful landscaping. Maintenance of the golf course serves the dual purpose of providing recreation and keeping the Site vegetated for remedial purposes.

In addition to recreational reuse, the Site also supports residential and public service developments. Dozens of homes have been built next to the course, and the community has plans for a recreational vehicle (RV) park. Community, Counseling and Correctional Services, Inc. (CCCS) developed a regional prison facility on remediated property in 2008. AWARE, Inc., a private, non-profit corporation that provides community-based services to people with mental, emotional and physical needs, also developed and operates a campus on site. In 2009, a contaminated abandoned railroad bed was removed west of Anaconda to make way for future highway, sewer and multi-use trail expansion to the West Valley.

Native Pollinators

Not only do native pollinators provide us with a significant amount of the food we eat and contribute to the economy, they also perform key roles in natural ecosystems. By helping to keep plant communities healthy and able to reproduce naturally, native pollinators assist plants in providing food and cover for wildlife, preventing erosion, and keeping waterways clean. Source: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_014931.pdf

There are several commercial companies at the Site. NorthWestern Energy began operating an on-site natural gas-fired electric generation facility, Mill Creek Generating Station, in 2011. U.S. Mineral, an industrial supplier of coal slag and roofing granules, also operates on a portion of the Site.

Lessons Learned/Next Steps

Remedial action to address site contamination has been implemented at more than 340 residential properties and more than 11,500 acres of open space. Of the almost 12,000 acres remediated so far, more than 93 percent are considered successfully reclaimed and thereby protective of human health and the environment. The remaining areas are being monitored and are anticipated to be successful or will have additional remedial action performed.

Key lessons learned include:

- Changes in topography required customized remedial techniques. To keep costs low, several techniques were applied during trials to assess which would have the highest success rates.
- Cost-effective remedial actions for impacted soils over a large area required a new evaluation tool, LRES, that was easily replicable and based on quantitative values.
- Using alternative alkaline amendments can be cost-effective and safe.
- Evaluating areas with low vegetative success after remediation assisted with long-term solutions and adjustments to land management plans. It is important to evaluate the amount of metals in the soil, rather than focusing only on pH.
- Earlier studies and recently-collected data helped inform the development of compliance standards and dictate future land management practices.
- Cooperation between the stakeholders (PRP, county and private landowners) was essential to the ensuring that remediation would align with future land use goals.
- Collaboration of oversight agencies, like EPA and MDEQ, allowed efficient development and approval of innovative techniques to evaluate and remediate impacted lands and to perform long-term land management.

Additional Information

Websites to obtain additional information on the Anaconda Smelter Superfund site and ecological revitalization include:

EPA Region 8 Site Profile
www2.epa.gov/region8/anaconda-co-smelter

EPA's Eco Tools
www.clu-in.org/ecotools/

Mine Tailings Fundamentals: Current Technology and Practice for Mine Tailings Facilities Operation and Closure Webinar
https://clu-in.org/conf/tio/mining_052015/

ASMR Paper, Land Reclamation Performance Evaluation Process and Standards Used at the Anaconda Smelter Site, Montana
www.asmr.us/Publications/Conference%20Proceedings/2009/1129-Rennick-MT.pdf

Frequently Asked Questions About Ecological Revitalization of Superfund Sites
www.clu-in.org/download/remed/542f06002.pdf

Remedial Action, Remedy Performance, and Long-Term Land Management at the Anaconda Smelter NPL site Webinar
https://clu-in.org/conf/tio/mining2_060415/

The Use of Soil Amendments for Remediation, Revitalization, and Reuse
https://clu-in.org/download/remed/epa-542-r-07-013.pdf

Contact Information

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