RECLAMATION OF THE CARR FORK PROPERTY
TOOELE, UTAH

by

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Abstract. In 1986, reclamation of the 655 ac Carr Fork tailings and smelter complex was undertaken by the Anaconda Minerals Company in conformance with the Utah Mined Land Reclamation Act. The main reclamation objective was the mitigation of the detrimental effects of mining, allowing a safe return of the land to its pre-mining use of wildlife habitat. In achieving these objectives, activities included removal of structures, hydrologic controls, borrowing of topsoil, and revegetation. Reclamation activities were conducted in accordance with a Reclamation Plan approved by the Utah Division of Oil, Gas and Mining. Site studies contributing to the plan approval included surface and ground-water chemical characterization, design of surface-water diversions, geochemical characterization of soil borrow materials and impacted soils, and characterization of vegetation and wildlife communities. The following paper summarizes the history of the site, discusses development of the Reclamation Plan, and summarizes the reclamation methodology and results.

Additional Key Words: revegetation; topsoiling; water quality; heavy metals; Utah.

Introduction

The Carr Fork property began its mining history in 1910 when International Smelting and Refining Company (IS&R) commenced operations at its copper concentrator and smelter at the mouth of Pine Canyon, about 2.5 mi northeast of the town of Tooele, Utah (Figure 1). The facility processed ores transported over the crest of the Oquirrh Mountains via aerial tram from the rich underground copper mines in the Bingham Canyon mining district and later through the Elton Tunnel which was driven from a location northwest of the smelter to the copper deposits. Anaconda Copper Company purchased IS&R in 1915 and continued with the operations at the smelter. The facility was expanded from 1910 to 1941 with the addition of a lead smelter, lead/zinc flotation mill, and slag treatment plant. The expanded smelting complex had the capability to extract a wide variety of metals from various ore types and it processed ores arriving by rail from throughout the western United States.

The IS&R operations disturbed approximately 444 ac (Figure 2). The smelter/concentrator complex disturbed approximately 125 ac. Tailings from the concentrator operations were distributed over approximately 278 ac down the slope from the smelter/concentrator complex.

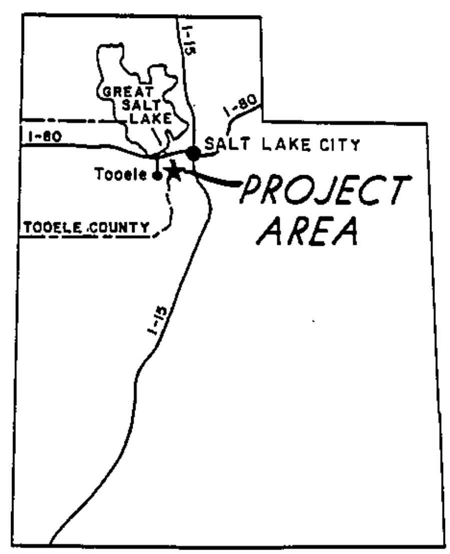

Figure 1 - Carr Fork Project location map.

In 1973, Anaconda began construction of a new copper mine and concentrator in Pine Canyon known as the

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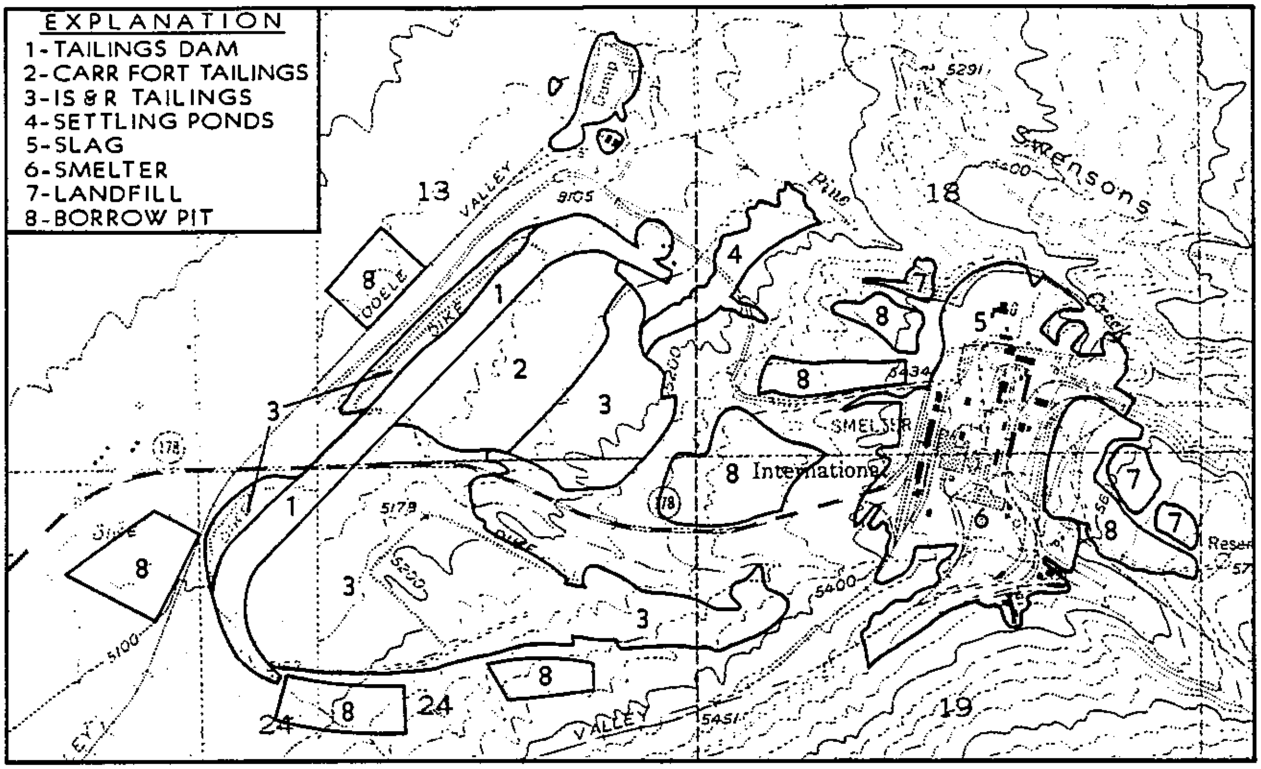

Figure 2.- General site map for the Carr Fork Project showing areas that were disturbed by previous mining and mineral processing operations (items 1-7) and the locations and sizes of the topsoil borrow pits that were developed for the reclamation project (item 8).

Carr Fork Project. Production at the new mine and mill commenced in 1979. Difficulties with the underground mining operations and the general decrease in copper prices caused Anaconda to suspend mining and milling in 1981 and to permanently terminate all operations, and begin reclamation activities in 1985.

The total disturbed area from the Carr Fork Project surface facilities was 130 ac. Tailings from the concentrator were piped down the canyon to a new tailings pond built on top of, and adjacent to, the old IS&R tailings. To contain the tailings, a new dam approximately 7,400 ft long and 80 ft high was built. The dam and the impounding area constructed during the Carr Fork operations re-disturbed approximately 68 ac of the previous IS&R tailings.

Regulatory Requirements

The Utah Mined Land Reclamation Act of 1975 (Title 40-8 as amended), provides the statutory framework for the reclamation of mined lands in Utah. The legislative findings portion of this act, 40-8-2 (3), drives the philosophy underlying rules that describe the intent of the reclamation program which is administered by the Division of Oil, Gas and Mining (DOGM):

"Mined land should be reclaimed so as to prevent conditions detrimental to the general safety and welfare of the citizens of the state and to provide for the subsequent use of the lands affected. Reclamation requirements must be adapted to the diversity of topographic, chemical, climatic, biologic, geologic, economic, and social conditions in the areas where mining takes place."

IS&R operations predated the Act and the resultant Mined Land Reclamation Regulations. Anaconda submitted a Notice of Intent to Conduct Mining Operations for the Carr Fork property in 1977 that described how reclamation and operations would conform with the act and regulations. A reclamation bond in the form of a Board Contract through the Board of Oil, Gas and Mining (DOGM) was established.

Reclamation Objectives

When the decision to reclaim was reached by Anaconda, the company and its reclamation contractor, JBR Consultants Group, Salt Lake City, Utah, began detailed design of the reclamation plan. Objectives of the reclamation program were to mitigate detrimental effects of the mining operations, including visual impacts and blowing dust, allowing for safe return to the pre-mining land use of wildlife habitat. The specific reclamation activities were generally proposed as:

- o Removal of all structures, buildings, equipment and trash from the site,
- o Regrading of slopes,
- o Sealing of all mine portals,
- o Redistribution of topsoil over the tailings,
- o Revegetation using grasses, shrubs, and forbs.

Anaconda and DOGM employed a multi-disciplinary study of the site to establish pre-reclamation site conditions, and to direct how to best achieve the desired post-mining land use.

Site Studies

Baseline environmental studies of the pre-disturbance conditions had not been required of either IS&R or Anaconda prior to facility construction. Therefore, the natural site-specific conditions needed to be established to develop an optimal proposed vegetative cover and suitable species diversification standard for the revegetation efforts. It was also necessary to determine environmental impacts that had occurred from the combined operations to assure that the reclamation plan mitigated these impacts to the extent possible. To satisfy these information needs, baseline data were collected from the site in the following areas: surface- and ground-water hydrology, soils, vegetation, wildlife habitat, and detailed characterization of the site disturbances (JBR, 1986).

Surface-water investigations provided data on the flow quantity and quality of the Pine Canyon drainage from 14 locations throughout the canyon. This channel bordered the site on its north side, and particular attention was paid to determining any water chemistry impacts that might be attributed to the slag dump and a solid waste dump which were located adjacent to the stream. Samples were analyzed for a complete suite of dissolved metals, physical water parameters, nutrients, alpha and beta radiation, oil and grease, total organic carbon, cyanide, and sulfide. The water sample analyses indicated that surface waters did not exceed water quality standards and indicated that there were no mining-related impacts to water quality.

Ground-water quality was investigated through the sampling of four monitor wells that had been previously installed by Anaconda and one spring in the vicinity of the slag pile. All samples were analyzed for the same parameters as the surface-water samples. Water samples from the four wells met drinking water quality standards. However, the spring discharging from the slag was found to contain cadmium and zinc concentrations in excess of drinking water standards. Review of the potential for leaching of the slag and tailings by natural waters indicated that it was highly unlikely that there could be any metals leaching or impact to ground-water quality through this pathway. The reason for the elevated metals concentrations in the spring was never positively identified. (Since the reclamation was completed in 1987, the water quality from this spring has consistently met drinking water standards.)

Soils on the site were investigated to determine the metals content and to locate suitable quantities of topsoil substitute material for use in reclamation. A total of 150 soil samples were obtained from the site and at various soil horizons to depths of as much as 17 ft. The results of the metals and sulfate analyses demonstrated that there were elevated concentrations of metals within the confines of the smelter site and downwind (east) for approximately 1,000 ft. Metals were generally concentrated within 12 in of the ground surface. Analyses of the soils to determine the mobility of metals indicated that less than 1 percent of the contained metals were water soluble. Moreover, analyses showed that the primary impact on plant growth was not the metals concentrations, but rather the effects of pH values of 6.6 or less and the presence of elevated sulfate concentrations.

The identification of the required topsoil substitute material used standard soils classification procedures. The parameters that were recorded included (Table 1):

- o Texture
- o pH
- o EC
- o Cation Exchange Capacity
- o Percentage of Organic Matter
- o Nitrogen and Nitrate
- o Sulfate
- o P, K, Ca, Mg, Na, Zn, Cu, Fe, Al, As, Cd, Mn, Pb

Table 1 Range of Consolidated Substitute Soil Material Parameters

Soil Depth	pH	μmohs/ cm EC	meq/100 CEC	%O.M.	mg/kg SO_4
0-24"	5.22-8.10	136-416	8-18	0.99-2.28	67-1700
24-48"	7.33-9.07	74-277	10-23	0.52-0.84	91-282
48-72"	8.59-9.73	147-366	3-18	0.20-0.98	6-91
72-96"	8.89-9.73	147-277	2-9	0.08-0.84	6-144
96"-	8.89-9.23	124-215	2-3	.008-0.12	2-112

The topsoil substitute exploration program was also heavily influenced by geological considerations because the potential substitute materials were Quaternary alluvium and lake sediments, the distribution of which could be studied by standard geologic and geomorphic investigation techniques. Particular attention was directed toward correlation of the various stratigraphic horizons in order to predict their distribution across the dimensions of each borrow pit.

Vegetation investigations included review of past revegetation test plots installed by Anaconda and identifying native vegetation at transect stations and spot observation sites. The objectives of these investigations were to determine the baseline vegetative parameters for selection of the proper revegetation seed mix and also to determine, through the vegetative patterns, the level of impacts caused by the past operations. Data indicated that a significant change in vegetation was due to the smelter emissions which caused elevated sulfate levels in the top 0-12 in of soil lowering the pH to 5-6, and resulting in decreased plant cover densities. The lack of cover had a secondary impact of causing the sheet erosion of the soil surface which had resulted in a "desert pavement" effect of closely spaced pebbles covering the ground surface. This retarded the potential for natural revegetation.

Wildlife observations indicated that the species and relative populations were typical of the Basin and Range Province. Scrub oak stands located around the margins of the site and in gullies within the site provided habitat for deer and birds. A riparian community was present along the Pine Canyon channel but the stream did not support a fishery.

The site was investigated to identify the locations and characteristics of all remaining waste materials and to record the dimensions of walls and buildings for design of the regrading program. A total of 96 samples from remaining smelter feedstock and waste material were analyzed for total metals, Extraction Procedure (EP) toxicity, water-soluble metals by saturated paste extract, and acid-generating and neutralization potential. Wastes were categorized as to their potential for releasing metals to the environment. Few of the wastes were leachable under the EP toxicity test or the saturated paste procedure. A number of the wastes were found to have net acid-generating potentials as high as 44 T/1000 T which indicates that these could become acid over time and release soluble forms of the contained metals. These wastes were targeted for special disposal on site while the other wastes were considered inert enough to reclaim in-situ.

The smelter site contained numerous walls, basements, foundations, and rail yards which all needed to be addressed in the regrading plans. All of these features were measured and mapped. Cross sections were then prepared to aid in the design of the regrading plans.

Reclamation Designs

The above-referenced studies of post operational baseline conditions were verified by a DOGM permit review team. The approved reclamation design for the Carr Fork site included 5 elements: site clean-up, surface-water control, regrading, topsoil placement, and establishment of vegetation.

Site Cleanup

With the exception of access roads required for routine maintenance, all other roads were destined for scarification and revegetation. Trash and demolition debris were buried in a permitted landfill adjacent to the smelter site. Foundations were backfilled at an angle of 3 horizontal:1 vertical from the wall tops. Certain concrete pads were covered with 12 in of fill. Wastes were categorized into two groups: those containing metallic elements deemed noncontributory under post-reclamation site conditions, and those capable of generating acids with concomitant release of metals. The later were managed by encapsulation in a designed pit located in the Carr Fork Project tailings. Site studies had verified the acid-neutralizing potential of the Carr Fork Project tailings with respect to the acid-generating capacity of the encapsulated materials.

Surface-water Control

The objective underlying the design of drainage-control structures was limiting erosion and minimization of off-site sediment transport. Runoff volumes were determined using the Curve Number method (Soil Conservation Service, 1972). The 100 yr, 6 hr storm event was utilized as was the Farmer-Fletcher storm distribution. These data were utilized in the design of a surface-water management system including runoff control dikes, sediment ponds, and engineered channels. Open channels were generally designed at gradients where the native soil would be non-erosive during the 100 yr flow event. Steeper gradients were stabilized with rip rap combined with energy dissipating boulders or large concrete blocks.

Many of the slopes within the property fall in the 8-10 percent range, implying a need for design and construction of expensive sediment ponds and diversion ditches. Containment of runoff close to the source was considered to be a preferred alternative. At the smelter site, a series of 6 ft high dikes were constructed along the contours of the slope reducing overland flow velocities, mitigating erosion, facilitating sediment containment in disturbed areas, and enhancing water infiltration. In other areas, topsoil borrow pits in conjunction with a designed diversion ditch system were used to collect runoff from disturbed areas. Thc pits served as sumps for locally derived sediment, and facilitated water infiltration. Both of these examples illustratc the use of site-specific field configurations to obviate the need for additional sediment pond design and construction.

Regrading

The objective of the regrading plan was reduction of all man-made walls and slopes to a maximum slope angle of 3h:1v. This angle is less than the angle of reposc of site materials, and facilitated subsequent topsoil placement and reseeding operations by tracked machinery. Exception to this slope angle included the 2.5h:1v downstream face of the Carr Fork Project tailings dam the stability of which was documented in an engineering report (Bechtel, 1977), and the outslopes of the Pine Canyon slag pile. A total of approximately 200,000 yd^3 of regrading were required in the entire project.

Topsoil Placement

A total of 655 ac of disturbed ground were included in the reclamation project. Approximately 495 ac of this total could not be revegetated without placement of nearly 800,000 yd^3 of topsoil, averaging 12 in thick. As is typical of sites developed prior to enactment of reclamation laws, no topsoil was salvaged in conjunction with the construction of the Carr Fork Project and IS&R facilities. Therefore, site studies were conducted to delineate borrow areas for a topsoil substitute to be obtained from the alluvial subsoil material. A total of 8 borrow pits were selected around the margins of the disturbed area to provide the required soil material. Basic selection criteria for the locations of these pits included short hauls between the pits and the topsoil locations, location of the pits on Anaconda property, minimization of uphill hauls, and eventual use of some of the pits for surface-water control.

Depth cutoff in the borrow pits was established at the point where soil texture indicated poor soil quality. Soil was deemed to be unacceptable when the texture was clay or sand. Borrow depths varied from 3-10 ft in consolidated alluvial materials and old Lake Bonneville sediments. Textures ranged from clay loams to gravelly sandy loams. Generally, soil materials from the deeper layers had high pH values (8.6-9.2) and low cation exchange capacities (2-6 meq/100). Most of the substitute soil materials were horizontal depositional beds and not developed soil horizons.

Revegetation

Revegetation efforts were designed to establish a diverse and self-sustaining ground cover of plant species which would stabilize the disturbed surfaces and provide food and cover for wildlife. The reclamation standard was the respective ground cover percentages for the plant communities at established locations. The standards for diversity would be the species composition typified in a given plant community. The selection of species for seeding and planting was based on the performance of plants and seed used in the test plot program, the role of indigenous species in the successional plant communities, and the performance of some species in similar environments. Two basic seed mixtures were utilized, one for the lower elevations on topsoils borrowed from lake sediments and a second on the higher elevations where topsoils were borrowed from alluvial deposits.

Cool and warm season grasses were used to lengthen the growing period for grasses, legumes were used to fix nitrogen, forbs for diversity and planted shrubs were selected to establish pioneer islands of enhanced plant growth. In areas where waste material indicated a potential for development of a pH of less than 6, lime was placed prior to substitute soil distribution at the rate of 30,000 lb per acre with a goal of buffering to pH of 6 to 7. The lime material used was sugar beet plant lime precipitate. In these areas, deep rooted plant species were avoided to preclude root penetrations below the neutralized zones and the resultant shock to plant growth.

To overcome the low inherent fertility of the borrowed soil materials, especially the lack of nitrogen and phosphorus, a diammonium phosphate fertilizer (16-48-0) was applied at the rate of 484 lb per acre. This application provided 77 lb of nitrogen and 100 lb of phosphorous per acre.

To provide more organic matter in the soil, a green alfalfa hay mulch was used at 1 ton per acre. The green alfalfa hay provides 50 lb of nitrogen, 10 lb of phosphorus, and 42 lb of potassium per acre. The green hay also has a narrow carbon-to-nitrogen ratio which facilitates microbial growth by providing sufficient nitrogen for the microbial population to digest the mulch.

The enhancement of microbial populations to establish nutrient cycling was considered critical for sustained plant growth on the borrowed topsoil substitute materials. The sandy loam materials had a low fertility capacity due to the lack of organic matter and low clay contents. It was assumed that the sandy loams also lacked the microbial populations needed for nutrient cycling.

In the following spring, urea (46-0-0) was applied at 109 lb per acre to provide an additional 50 lb of nitrogen per acre. This application was timed to overcome the expected nitrogen depletion that occurs when the soil warms and accelerated plant growth and active microbial populations compete for the available soil nitrogen.

Construction Description

The project plans were approved by the Division of Oil, Gas and Mining in June 1986. Construction plans and bid documents were completed in July and the project was awarded.

The contractor decided to use a truck-loader combination for mining and hauling topsoil substitute. A fleet of end-dump haul trucks were loaded with front-end loaders. The soil was dumped at specific locations selected by a worker at each dumping area. The piles were then graded out with bulldozers to uniform depths as required by the design plans.

At the soil borrow pits, an inspector monitored the texture and pH of the soil being loaded into the trucks. This prevented the inadvertent removal of unsuitable soil from the borrow sites. The inspector also monitored the soil application areas to determine if the proper thickness of soil was being applied. The application of lime, fertilizer, mulch, and seed was also inspected for the proper application rates and coverage.

A fertilizer-spreader truck then spread the recommended amount of dry fertilizer over all areas to be revegetated. Following the fertilizer application, the soil surface was disked to scarify compaction caused by the truck traffic. After the disking, only agricultural tractors were allowed on the soil surface. Hay mulch was applied with cyclone-type mulching machines towed behind tractors. The hay was then crimped into the soil during the application of seed by the action of the rangeland seed drill. The regrading, topsoiling, and seeding of the entire project area was completed in November 1987.

In March 1988, the urea pellet fertilizer was applied by helicopter spreader because the ground was still saturated. During this time, approximately 20,700 container plants of various species were hand planted across the site. These plants were clumped in low areas and on slope aspects which were expected to enhance their chances for survival.

Finally, the entire site was fenced with a 5-strand barbed-wire fence to exclude off-road vehicles and livestock. Site inspections of the vegetation were also conducted by JBR to track the progress of the revegetation and identify any problems early enough to rectify them. These inspections occurred monthly during 1988 and continued on a quarterly basis until bond release in the first quarter of 1990.

Results and Conclusions

The winter of 1987-88 was wet and there were a number of large rainstorms in March 1988. The high amounts of runoff produced some erosion damage on the bare regraded surfaces. A number of deep gullies were formed where the runoff collected on large, flat surfaces and ran over the regraded slopes. However, this wet period was also ideal for germination and early growth of grasses and plants which flourished in response to the nutrients supplied by the fertilizer applications and the abundant soil moisture. The vegetative cover increased rapidly and quickly stabilized the disturbed surfaces with a vigorous growth of forbs and grasses.

By the summer of 1988, and through to the present, drought conditions have prevailed at the site. Grasses have become dominant in the seeded community, with a fair understory of legumes. Shrubs have suffered in the competition with grasses for moisture during the drought, so mortality has reduced the shrub population. However, the surface of the ground has been stabilized by the dense ground cover and further erosion has been minimal. The seeded vegetation cover exceeds that indigenous to the Yeates Hollow soils (30%) and the Pleasant Grove soils (42%). The major erosion damage features were repaired and small areas where the revegetation was not satisfactory were reseeded in the fall of 1989.

Both Anaconda and the State of Utah are very pleased with the results of reclaiming the Carr Fork Project. The previous blowing dust problem from exposed tailings, visual impacts related to the site and contaminated soil surfaces at the smelter have been completely eliminated. Continued monitoring of surface-water quality in Pine Creek shows that there have been no impacts on the creek due to the reclamation activities. Revegetation efforts have successfully covered the site with a self-sustaining cover of perennial plant species. The revegetated site has also become somewhat of a wildlife preserve, providing food and cover for a wide variety of wildlife.

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Footnotes

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