USE OF AN ALTERNATIVES ANALYSIS TO DETERMINE THE RECLAMATION APPROACH FOR HEAP LEACH PADS[1]

by

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Abstract: Cyanide heap leach pad operations present challenging conditions for reestablishment of vegetation. Heap leach material at the Santa Fe/Calvada Mine was generally unsuitable for plant growth, and topsoil resources salvaged during mining were limited. A multidisciplinary project team developed a process to identify and evaluate a range of realistic reclamation approaches. The range in alternatives considered environmental, regulatory, and financial aspects. Five alternatives were evaluated against the criteria most critical to determining reclamation success and bond release: regulatory compliance, conservation objectives, and management considerations. The result of the analysis provided Homestake with a technical basis for management decisions regarding the reclamation approach for the heap leach pads.

Introduction

Corona Gold, Inc., a subsidiary of Homestake Mining Company, commenced mining operations in 1988 at the Santa Fe/Calvada Mine, located in central Nevada, approximately 25 miles East of Hawthorne. Cyanide leaching was used to process 17.6 million tons of ore over the life of the project. Four leach pads were constructed on approximately 135 acres within the mine permit area.

The heap leach operation at the Santa Fe/Calvada Mine was recently decommissioned and reclamation activities were begun to revegetate and stabilize the leach pad areas. Leach pads have been regraded to slopes of 3:1 (horizontal to vertical) steepness, which range from approximately 240-430 feet in length. The Santa Fe/Calvada Mine represents one of the first attempts to revegetate leach pads in this extreme arid region of Nevada.

Homestake Mining Company has established policies that dictate very high internal reclamation standards for all company mining projects worldwide. Regulatory reclamation success standards for the Santa Fe/Calvada Mine in Nevada consist of the "Interim Standards" jointly approved by the Nevada Division of Environmental Protection (NDEP) and the Bureau of Land Management (BLM). An evaluation of reclamation Success according to the Interim Standards requires that mines take every prudent step possible, based upon current technology, to reestablish 100 percent of the pre-mine vegetation cover. If such steps are taken and well documented NDEP and BLM will consider the mine to be in compliance with regulatory requirements regardless of the degree of success of the revegetation effort. However, Homestake Mining Company would not be satisfied with the reclamation effort unless revegetation was successful in establishing an ecologically functioning plant community capable of supporting the designated post-mining land uses.

Background

During operation of the Santa Fe/Calvada Mine, Corona Gold, Inc. had conducted concurrent reclamation of waste rock dumps which provided good evidence of regional reclamation potential. However, revegetation potential of the dumps varied significantly from the potential of the heap leach pads. Homestake recognized that reclamation of the leach pads would take significantly different measures and extended effort to accomplish successful revegetation.

Among the factors that constrained the reclamation potential of the heap leach pads were:

1. Poor Suitability as a Plant Growth Medium initial soil suitability analysis by Fruit Growers Laboratory, Inc.[3] indicated saline-sodic affected leach pad material, excessively high pH conditions, void of organic matter, lack of fine soil particles, and high nitrate concentrations.

2. Extreme Surface Temperatures - on-sight measurements of surface temperatures showed that dark

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[3]Fruit Growers Laboratory, Inc. Santa Paula California.

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colored (black) leach pad material increased the seedling microenvironment temperature by 20°F on approximately half of the heap leach pad area;

3. Shortage of Available Topsoil[4] Salvaged During Mine Construction - only enough topsoil was stockpiled to cover one-half of the leach pad area with a eight-inch application;

4. Harsh Climatic Conditions - average annual precipitation of 4-5 inches per year; and

5. Limited availability of supplemental water for irrigation.

Homestake realized that a site specific reclamation plan including grading, soil amendment, seedmix, horticultural practices, and maintenance procedures would be needed to overcome reclamation difficulties. Homestake also required additional information on cost, timeframe, and predicted results in order to develop a defensible reclamation plan.

Homestake and RCI designed a test plot program, constructed by Nielsons, Inc.[5] and Kelley Erosion Control, Inc.[6] in 1996, to evaluate the potential for improving reclamation success on the heap leach pads. Direct seeding into leach pad material without topsoil application is a new approach that requires improving the plant growth suitability of the leach pad material.

The two primary treatments evaluated at the Santa Fe/Calvada test plots were:

1. Gypsum application to exchange calcium and magnesium for sodium, lower pH, and improve nutrient cycling; and

2. Incorporation of green manure to improve organic matter content, increase infiltration and water holding capacity, and enhance surface aeration.

The first year results of the test plots indicated that additional treatment of the heap pads was necessary to ameliorate saline-sodic conditions. RCI McClelland Laboratory, Inc.[7] column test program to evaluate gypsum/leaching and topsoil and application treatments in a condensed timeframe. The objectives of the laboratory analyses were:

1. To quantify the water application necessary to leach salts and sodium below the 12 inch rooting depth; and

2. determine if salts would be drawn upward and contaminate an applied topsoil layer under normal climatic conditions.

The results of the laboratory analysis showed that a treatment of gypsum with a five-inch application of clean water was necessary to leach salts and sodium from the upper 12 inches of the leach pad material. Additionally, the lab concluded that under a compressed two-year climatic cycle of normal precipitation and drying, topsoil did not become contaminated with salts.

Reclamation Alternatives

The results of initial test plot work on the heap leach pads and laboratory analyses completed in 1996 provided valuable insights for developing treatments to address reclamation limitations. The remaining task was to assimilate the existing data and identify the optimum combination of leach pad material amendment, topsoil application, and irrigation treatments that would result in meeting Homestake's reclamation standard. The preferred treatment would have to address growth medium limitations, unpredictable precipitation during the plant germination and establishment period, and the temperature extremes from the black colored heap leach material.

Homestake Mining Company and RCI developed an approach to analyze a spectrum of reclamation alternatives representing incremental increases of supplemental treatments. The objective of the alternatives analysis was to determine the best option for lessening reclamation risks and increasing successful reclamation potential. Homestake required that each alternative portray realistic and feasible procedures that could be accomplished on the relatively steep slopes of the heap leach pads at the remote mine location. Various combinations of gypsum amendment with leaching, topsoil application, and temporary irrigation were used to define the following reclamation alternatives.

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[4]NOTE: The term "topsoil" is used in this paper to denote the solum (A and B horizons) of an undisturbed native soil. In the desert environment, these soils are typically shallow, low in nutrients and organic matter, and not comparable to "topsoil" in terms of agricultural applications.

[5]Nielsons, Inc., Cortez, CO.

[6]Kelley Erosion Control, Inc., Sparks, NV.

[7]McClelland Laboratory Inc., Sparks, NV

Alternative 1. Partial topsoil application/ leaching. Apply an eight inch layer of topsoil to all black surface areas to alleviate temperature restrictions and to provide a suitable plant growth medium. Apply gypsum to light colored heap material and leach with five inches of clean water to overcome saline-sodic constraints and improve plant growth suitability.

Alternative 2. Partial topsoil application/ leaching/supplemental irrigation. Supply supplemental irrigation during the seedling establishment period in addition to the treatment called for in Alternative 1.

Alternative 3. Full topsoil application. Apply an eight inch layer of topsoil uniformly over the entire surface of the heap leach pads. This alternative requires that a topsoil source be identified from within a 10 mile radius of the mine.

Alternative 4. Full topsoil application/ temporary irrigation. Supply supplemental irrigation during the seedling establishment period in addition to the treatment called for in Alternative 3.

Alternative 5. Approximate pre-disturbance conditions. Apply gypsum to heap material and leach with 5 inches of clean water to a depth of 12 inches. Follow with a 12 inch application of local topsoil to establish optimum conditions for deep rooting plants. Include native seed collected from undisturbed areas adjacent to the mine as a significant portion of the seedmix. Supply irrigation in a manner conducive to encourage native plant establishment. Control invasion of undesirable weeds as necessary to promote establishment of the desired reclamation plant community. Retreat as necessary over a five year period to achieve desired results. Consider additional reclamation amenity options such as:

1. Creating planting pockets with containerized plants.

2. Establishing colonies of transplanted native plants and soils.

3. Conducting landscape analyses designed to promote blending and transition through regrading and selective placement of rocks and boulders.

4. Incorporating aspect variability and visual quality into design factors.

Evaluation Criteria

The comparison of alternatives was based upon their potential for reclamation success. "Success" was defined within the bounds of Homestake's internal reclamation standards and current requirements for regulatory compliance. RCI considered success from two primary perspectives; first from a conservation view, and secondly from a management framework.

The conservation view of success was based upon the following definition of reclamation by Dr. Ed DePuitt:

> Reclamation is the process of returning a drastically disturbed site to a self-sustaining condition equal to or better than occurred prior to disturbance in terms of biological organisms, ecological functions, and physical processes.

Plants are important biological organisms that can be readily observed as indicators of reclamation success. An internal threshold for the reclaimed desired plant community was set at four percent perennial cover. This factor was based upon previous sampling of successful seedings on waste rock dumps at the Santa Fe/Calvada Mine. A second biological indicator of success is regeneration of seeded species.

Ecological functions are more difficult to observe and include such things as nutrient cycling, successional replacement of plant communities, and plant/wildlife/insect interactions. In short time frames, evaluation of ecological functions is primarily based upon professional interpretation.

The most important factor in terms of physical processes as they relate to reclamation success is erosional stability of reclaimed soils. Other physical processes that can be observed are plant litter accumulation and reinvasion of local native species.

The two most important management considerations are time and money. Reclamation of the heap leach pads necessarily occurs following the production phase of the mine. Therefore minimizing the time for reclamation closure and minimizing costs when the mine is no longer producing income becomes the driving force when making reclamation decisions.

Comparison of Alternatives

Reclamation conditions, predicted for a six year period (to year 2003) were analyzed for each alternative, as shown in Table 1.0. Vegetation establishment under Alternatives 1 and 3 was predicted to range between fair and good depending upon the prevailing climatic conditions during the initial growing season. The risk of requiring retreatment was greater for Alternatives 1 and 3 due to the possibility of drought and seeding failure. Supplemental irrigation during the establishment period (Alternatives 2 and 4) would increase vegetation cover and diversity, expedite

vegetation community development, and reduce the risk for seeding failure. The greatest contribution to enhanced ecological function within the evaluation timeframe would result from introduction of soil biota, insects, seeds, and plants from local sources (Alternative 5). Fully topsoiled pads (Alternatives 3 and 4) would be more conducive to plant regeneration and reinvasion of local species. Soil stability was expected to be good when plant establishment was rapid and vegetation cover increased under temporary irrigation.

Overall, Alternative 5 was anticipated to rank the highest of all alternatives in terms of the reclamation success criteria used in this report. However, the inherent requirement for maintenance over a five-year period, and additional amenities would result in infeasible micro-management of the reclaimed area.

Costs varied between alternatives due to the cost for providing water for leach treatments, importation of topsoil, the need for reseeding if adequate moisture conditions did not prevail, and the need for local seed collection. Alternative 5 differed significantly from the other four alternatives with regard to construction time and money.

Conclusions and Recommendation

The Homestake/RCI project team concluded that each alternative would meet regulatory compliance. Each alternative would produce different resulting plant communities. There was no expectation however, that the leach pads would ever be directly comparable to the undisturbed native range sites. The history of the leach pads will render them ecologically unique with regard to successional development. The risk of not meeting reclamation success was higher without irrigation. Reclamation costs increased with additional inputs of topsoil and irrigation, and were significantly higher for Alternative 5. However, no alternative was far superior as compared to the other alternatives based upon the success criteria in this analysis.

As a result of irrigation, Alternatives 2 and 4 represented the best potential for species diversity and initial productivity relative to the array of species expected. However, if the seeding establishment years had favorable spring precipitation, they may not differ significantly from the expectations for Alternative 3. Alternatives 1 and 3 have higher risks for requiring retreatment if adequate moisture conditions do not prevail during the establishment period. However, retreatment would not prolong the reclamation period outside of the six year analytical time frame, assuming that retreatment would only occur one time.

The alternatives analysis was based upon the combined results of previous field and laboratory testing, and professional advise sought by Homestake throughout the reclamation planning process. In the end, Homestake is developing a reclamation plan for the heap leach pads that will minimize the risk of reclamation failure, and maximize the potential for revegetation success by meeting the Homestake standards within allowable time and budget demands.

Table 1. Evaluation of Reclamation Alternatives for Heap Leach Pads

	Potential for Reclamation Success				
Description of Alternative	Revegetation Success	Ecological Functions	Soil Stability	Risk of Retreatment	Relative Cost
1. Apply growth meduim to cover dark colored surfaces; apply gypsum and leach light colored surfaces.	Fair	Fair	Good	Possible	1 *(low)*
2. Apply growth medium to cover dark colored surfaces; apply gypsum and leach light colored surfaces; irrigate for establishment.	Good	Good	Good	Unlikely	2
3. Apply growth medium to cover entire surface of heap leach pads.	Good	Good	Good	Possible	3
4. Apply growth medium to cover entire surfaces of heap leach pads; irrigate for establishment.	Very Good	Good to Very Good	Good	Unlikely	4
5. Apply gypsum and leach the heap pad material to 12 inches; apply topsoil; incorporate local seed into seedmix; irrigate for establishment; selectively fertilize, weed, retreat as needed.	Very Good	Very Good	Good	Included in Task Description	5 *(high)*