Geomorphic Reclamation in New Mexico: a Regulator's Perspective

Dave Clark
Mining and Minerals Division
Energy, Minerals and Natural Resources Department
Santa Fe, New Mexico

Abstract

Each of New Mexico's active coal mines has reclamation challenges that are being successfully resolved through the application of geomorphic grading methods. At the San Juan Mine, the soils and overburden material are of poor quality, and it is not uncommon for the mine to receive less than 6 inches of precipitation per year. Without irrigation, the San Juan Mine can expect successful revegetation establishment in only 1 of 5 years. Revegetation on uniformly flat or gently sloping regraded areas sometimes failed to persist after it had been established with irrigation. MMD had therefore been encouraging topographic diversity on reclamation to improve water harvesting and reduce the percentage of south aspect slopes. At La Plata Mine, steeply dipping, multiple coal seams were mined by open pit methods. It was recognized that the structurally-controlled trellis drainage pattern that existed premine would have to be replaced with a dendritic drainage pattern on reclamation where the overburden had been pulverized. At the McKinley Mine, sodic spoil material is prone to differential settling and the creation of piping features in areas where runoff ponds, which may lead to downslope instability. In each of these scenarios, the approximation of natural drainage patterns on the reclamation has reduced erosion and sedimentation by creating shorter slopes with correct profiles, and by improving conditions for revegetation establishment.

Introduction

The Mining and Minerals Division (MMD) is the coal regulatory authority in New Mexico. MMD also regulates hard rock mining, reclaims and safeguards abandoned mines, and maintains a database and registry of all mining activity within the state. MMD has been promoting the creation of topographic diversity on reclaimed lands for many years, in response to a number of different problems and limitations on our mines. Most New Mexico reclamation is conducted in arid or semi-arid climates. Revegetation typically takes at least three years to become fully established, and once established the density of plants is often low. We are seldom able to rely on dense vegetation cover to shield soils, or high root mass to bind soils. These same limitations exist in our undisturbed desert plant communities.

In New Mexico, erosion control on reclaimed lands must be achieved by careful management and use of materials excavated during the course of mining, and careful consideration of geomorphic principles to build stable post mine landscapes. Most native slopes in our region are armored by rock, in consequence of the erosion of soil particles by rain impact and runoff, or deflation of the soil by wind action. Valley soils, while they may be relatively deep, often are high in clay and salt content. The best root zone material is often found near the toes of slopes, on the downwind side of ridges and mesas, and similar "jackpot" scenarios. In

our experience, relatively high coarse fragment content in salvaged materials is a plus, so long as there are enough soil fines to hold moisture and support plant growth.

The bottom-line geomorphic principle is that watersheds on disturbed lands need to be constructed to simulate the relatively stable, equilibrium topography that the erosive forces of nature would eventually form over a very long time. Any other strategy amounts to the old-fashioned engineering maxim, "strive to conquer nature". MMD believes that emulating nature is a much better policy, and is arguably required by the Surface Mining Control and Reclamation Act of 1977 (SMCRA).

Problems with the traditional contour terrace and down drain method of slope construction include:

- continuing maintenance of terrace gradients and berms in consequence of differential settling, localized soil movement, extreme precipitation events, or burrowing activity;
- designs based solely on large storm events are subject to sediment deposition from smaller, more frequent events, resulting in flow blockage, diversion, and washouts;
- vegetation diversity is discouraged by uniformly graded, single aspect slopes, due to unvarying moisture harvest, wind exposure, and a lack of transition zones; and
- vegetation is particularly difficult to establish on south and west facing slopes in an arid climate due to high evaporation rates.

Geomorphic reclamation methods were developed to address the concerns outlined above, and promote the following goals:

- provide long-term drainage stabilization;
- meet runoff water quality criteria;
- reduce long-term maintenance costs;
- provide topographic diversity to enhance vegetation community development and wildlife habitat; and
- promote timely liability bond release.

Early in MMD's incitement of geomorphic reclamation methods, we heard a question from some of our mine operators: "When did the rules change to require this?" Our answer was that no change in the rules was required. We reminded these operators that: "BEST TECHNOLOGY CURRENTLY AVAILABLE [BTCA] means equipment, devices, systems, methods, or techniques which will (a) prevent, to the extent possible, additional contributions of suspended solids to stream flow or runoff outside the permit area, but in no event result in contributions of suspended solids in excess of requirements set by applicable State or Federal laws; and (b) minimize, to the extent possible, disturbances and adverse impacts on fish, wildlife and related environmental values, and achieve enhancement of those resources where practicable. The term includes equipment, devices, systems, methods, or techniques which are currently available anywhere as determined by the Director, even if they are not in routine use. The term includes, but is not limited to, construction practices, siting requirements, vegetative selection and planting requirements, animal stocking requirements, scheduling of activities and design of sedimentation ponds in accordance with 30 CFR parts 816 and 817. Within the constraints of the permanent program, the regulatory authority shall have the discretion to

determine the best technology currently available on a case-by-case basis, as authorized by the Act and this chapter" (30 CFR 701.5, in part).

It is unfortunate, and we believe in error, when the requirement to use the BTCA is interpreted as synonymous with requiring best management practices (BMPs) or similar sediment control measures. The term BTCA is clearly much broader in scope, and it conveys much more authority and responsibility to the SMCRA regulatory authority than do standard sediment control practices.

Challenges

Thirty years ago, many experts thought that reclaiming mines to meet SMCRA standards would be impossible in the San Juan Basin. They had good reason to be concerned. Large scale erosional processes have created the most sublime and characteristic aspects of New Mexico's landscape. The dry climate requires careful management strategies for harvesting moisture. Shallow and poor quality soil, or no soil development at all, is a common challenge. Seed production in perennial desert vegetation may be low, episodic and difficult to harvest. Very real problems needed to be solved, but the coal industry and its consultants and suppliers responded with innovation, and today coal operators in the Southwest are winning national reclamation awards.

A number of specific challenges needed to be addressed with respect to geomorphic reclamation. Acceptance of the concept by mine management was among the first issues. Mine managers tend to be engineers, and engineers tend to be cautious and conservative by nature, much more comfortable with standardized and proven construction methods than with untried solutions. That is exactly how we want and expect engineers to think, because they design and build the infrastructure that the rest of us unthinkingly depend upon. Generally, regulators are not much different than engineers in their affinity for standard and proven practices. Clear performance standards are much easier to enforce than conceptual goals and visions.

As we began to discuss implementing geomorphic designs with San Juan Coal Company, a means to address these conservative construction inclinations happened to be at hand. La Plata Mine had an out of pit spoil dump that was approved to be reclaimed in place. In fact, the east aspect of the McDermott Dump had already been reclaimed with a gradient terrace and riprapped down drain. About 52 acres were available as a test case on which to build meandering channels, "scalloped" watersheds, a talus slope, rim rock features of varying design, slopes armored with suitable spoil, and an artificial aquifer to feed a wildlife watering hole. The idea was to learn how difficult such features were to build and how well they functioned. Features that proved to be undesirable would not be used in future reclamation, and if any features were considered outright failures, they could be removed without too much trouble. A considerable degree of confidence and buy-in from management and regulators was generated as McDermott Dump was reclaimed, and as it weathered storms. In contrast to having to re-construct any of the reclamation, the operator received an excellence in reclamation award for the project from MMD's parent organization, the Energy, Minerals and Natural Resources Department.

Mitigation of unsuitable spoil, generally on account of high clay or salt content, is often an issue on New Mexico coal mines. The more complex the post mine topography, the more difficult it is to apply uniform mitigation treatments to ensure that a quality root zone has been built. This is one concern that arose during the McDermott reclamation project. We negotiated a solution to address the potentially acid or toxic forming material rule by a commitment to monitor revegetation establishment, ascertain the most likely cause of failure, and apply mitigation material if unsuitable root zone material was the most likely cause of failure. Thus far, a cyclic peak in the rabbit population has had the most significant impact on revegetation establishment at La Plata Mine.

Both topsoil lay down and seeding are more difficult on undulating terrain. Tie-in with undisturbed drainages requires an extremely good survey of the disturbance edge. Sometimes it is necessary to extend drainage channels into previous reclamation, in order to ensure capture of runoff from older areas by the new stream channels.

Geomorphic grading is dozer intensive, and mining equipment is typically larger than optimal for constructing drainage channels. The work requires enhanced equipment operator skills and better communication and feedback from the designers, especially during the first few months of construction. Operators incorporating GPS machine control on their dozers report improved efficiencies, once proficiency with the guidance tools is attained.

If the errors were not fatal, MMD accepted some features that we didn't think were ideal in the early stages of development, so that operators and managers wouldn't get discouraged or frustrated. We offered constructive criticism for the next opportunity, rather than demand a redo. MMD also learned that moving less spoil is not inherently bad, if it results in a better final product. If properly shaped, steeper slopes may be built in the heads of watersheds, which means that less material has to be moved. Moving less material is often the most attractive short-term result of geomorphic grading from the operator's perspective.

Case Study: San Juan Mine

MMD has long been concerned with a lack of revegetation success at the San Juan Mine. The soils and overburden material are uniformly of poor quality, and it's not uncommon for the mine to receive less than 6 inches of precipitation per year. Los Lunas Plant Material Center has estimated that without irrigation, the San Juan Mine could expect successful revegetation in only 1 of 5 years. True to predictions, establishing revegetation without irrigation has rarely been successful. Water pumped from the San Juan River has therefore been used to irrigate revegetation during the first year after seeding, and sometimes early in the spring of the second year.

Revegetation on uniformly flat or gently sloping regraded areas sometimes failed to persist for long after it had been established with irrigation. When the revegetation did survive, it was predominantly made up of 2 native grass species and one shrub species. That limited array of species is not likely to provide very much resilience in a harsh environment, and represented only a small fraction of the species being seeded. MMD had therefore been

encouraging topographic diversity on reclamation to improve water harvesting, reduce the percent of south aspect slopes and achieve a better expression of the seeded species.

The Cottonwood Pit reclamation, for which San Juan Coal Company won the 2004 Best of the Best National Reclamation Award, has demonstrated that adding topographic diversity through geomorphic grading does indeed increase revegetation diversity. Cottonwood is supporting the highest species richness of any San Juan Mine reclamation. It is hard to imagine that this would be true if conventional grading methods had been used to construct the predominantly south-aspect slopes in this area (Figure 1).

Figure 1. Cottonwood Pit reclamation at the San Juan Mine in 2004, three years after seeding.

Case Study: La Plata Mine

At La Plata Mine, steeply dipping, multiple coal seams had to be mined by open pit methods. The structurally controlled trellis drainage pattern that existed premine would have to be replaced with a dendritic drainage pattern on reclamation where the overburden had been

pulverized. When the operator (again, San Juan Coal Company) committed to a minimum drainage density (feet of drainage bottom per acre of watershed) and the replacement of premine watersheds, MMD considered those to be acceptable sideboards for a workable hydrologic reclamation plan. The operator proposed a drainage density standard that exceeded the premine drainage density because of the loss of bedrock control in stream channels on reclaimed land. This helped MMD to recognize that we were negotiating with people who "get it".

We accepted a narrative, conceptual permit commitment to construct drainages, rather than requiring up-front certified designs for each feature. The operator was moving toward a new approach and needed to know that there was an allowable margin of error. RUSLE and SedCAD runs that were conducted on earlier-permitted post mine topography designs demonstrated that post mine erosion rates and sediment yields wouldn't exceed the premine condition. The extra drainage density produced when the geofluvial designs were draped over those basic watershed designs was clearly more conservative, because slopes were shortened (Figure 2). The proof was provided when large storms (including a 200 year – 2 hour event) on freshly soiled reclamation did not result in more erosion than would be expected on undisturbed land.

Figure 2. Reclamation that has been seeded and mulched at La Plata Mine.

Case Study: McKinley Mine

The use of terraces and riprapped down drains had become a standard reclamation practice at McKinley Mine, operated by Chevron Mining, Inc. Continuing maintenance on the terraces and repair of down drains throughout the minimum 10-year liability period was causing concern within MMD, as we considered whether we could, in good conscience, release the operator from liability on reclaimed areas that were not proving capable of withstanding routine summer storms. Sodic spoil material at McKinley Mine also had the potential to form large subsidence piping holes that represented a hazard to post mine land users. The operator agreed to remove a number of terraces that were causing chronic problems. Although terrace removal was very successful on older reclamation, both MMD and the operator wanted to adopt grading methods that would reduce the need for future repairs. Geomorphic grading is being used to complete the reclamation of the final pits and address these issues (Figure 3).

It is unlikely that geomorphic reclamation can completely remove the risk of differential settling or piping in sodic spoils. However, the number and size of these types of problems has been drastically reduced on areas where geomorphic grading has been completed. The need for riprap is far less than in prior years, and this is likely to result in considerable savings to the operator as mining ends and riprap would need to be purchased from off-site sources.

Figure 3. Southwest end of Area 11 pit reclamation at the McKinley Mine.

Conclusion

MMD has no regrets concerning the implementation of geomorphic reclamation on New Mexico's coal mines. We believe that the stability and productivity of our reclaimed areas has been greatly improved by creating more natural landscapes. Our concerns regarding release of liability have been alleviated by observing reclaimed lands stand up to large precipitation events without damage. Continuing improvements in geomorphic grading software allow the operators to produce complex post mine topography designs more efficiently, and submit those designs for review and approval by MMD. GPS machine control is also becoming a common tool on our mines and provides assurance that complex geomorphic designs can actually be constructed.

Perhaps the most surprising and gratifying result of giving our operators a little more flexibility, though, has been the ownership that they are showing in their reclamation product. After a bit of skepticism in the beginning, the operators soon realized that they had been empowered to create something special. The sense of inventiveness in the reclamation process has become evident across all of our mines, from the managers to the equipment operators. Dozer operators don't want any other operators mucking around in "their" watersheds. Artificial rock outcrops are built in near perfect replication of natural features. At our mines that are in full closure after decades of operation, with layoffs coming soon, employees can take pride in their final efforts. At La Plata Mine, the operator contracted with a professional filmmaker to depict the history of the mine from start to finish, as a thank-you gift to everyone who contributed.

Monthly inspections have become an opportunity to look at what's been done since the last visit, to discuss creative opportunities in specific areas, and to give and get feedback on how different approaches and types of equipment are working out. It is hard to imagine a better environment in which to practice the science and art of mined land reclamation.