A REVIEW OF RECLAMATION AND ALTERNATE SEDIMENT CONTROL AT BRIDGER COAL COMPANY IN SOUTHWESTERN WYOMING[1]

Norman E. Hargis and Donald C. Hartley[2]

Abstract. Bridger Coal Company began coal production in 1974 and has reclaimed 630 ha of mined lands. The mine is in a northern cold desert at an elevation of 2,073 m. Annual precipitation is 15-20 cm, high winds are frequent, and evapotranspiration is high. Some soils and spoils are saline or sodic. Early publications predicted that revegetation of surface mines under these growing conditions would be problematic within acceptable time frames. Irrigation was initially required for a mining permit. Subsequent studies showed that irrigation was unnecessary. Live direct-haul soil is used when possible. Hay mulch is applied as needed for erosion control and moisture retention. Most seed is planted with a no-till drill after mulch has been crimped. A diverse seed mixture of native, locally adapted species and varieties is varied according to soil properties. Combinations of microrelief, broadcast seeding, shrub and forb seed mixtures, and snow fences have been used experimentally to improve moisture retention, shrub and forb establishment, and species diversity. Herbaceous production is usually greater on reclamation than on native land. Vegetative cover on reclamation is approximately equal to that on native land. Total cover, which includes litter and rock, is usually lower on reclaimed than on native land. Native shrub species have been successfully reestablished and are self-propagating. Alternate sediment control techniques are in use on mine disturbances. These are based on the following local natural conditions: semiarid climate, highly erosive geology, and ephemeral streams. Sediment control techniques are designed to reduce sediment levels in runoff from reclaimed lands to background levels. Runoff from reclaimed land that is at background sediment level has less impact downstream than water with too much or too little sediment. Monitoring by automatic pump samplers indicates that alternate sediment control techniques cause no additional contributions of sediment downstream.

Additional Key Words: Northern Cold Desert, Shrubs, Mined Land Reclamation, Alternate Sediment Control

Introduction

Jim Bridger Mine is operated by Bridger Coal Company, a joint venture of Interwest Mining Company (PacifiCorp) and Idaho Power Company. The mine produces approximately 7.0 x 10^6 Mg of subbituminous coal per year and delivers all of it to the nearby Jim Bridger Power Plant. Coal production began in 1974. Most overburden is removed by walking dragline.

An early review of mined land reclamation in the western United States questioned whether mined lands in areas receiving less than 250 mm of average annual precipitation could be adequately reclaimed without sustained inputs of irrigation and fertilizer and intensive management (National Academy of Sciences, 1974). Therefore, Bridger Coal Company's first permit issued under the Surface Mining Control and Reclamation Act of 1977 (SMCRA) required that irrigation be used. However, independent research conducted at the mine found that irrigation was not necessary for establishment of a satisfactory plant community (Powell et al., 1990). Irrigation was subsequently discontinued. Vegetation on reclaimed lands has been quantitatively monitored since cessation of irrigation to ensure that revegetation requirements are met. Life of mine disturbance will be approximately 4,050 ha and approximately 600 ha have been revegetated to date.

---

[1]Paper presented at the 1995 National Meeting of the American Society for Surface Mining and Reclamation, Gillette, Wyoming, June 5-8, 1995.

[2]Norman E. Hargis and Donald C. Hartley are Reclamation Coordinator and Manager, Environmental Affairs at Bridger Coal Company, P.O. Box 2068, Rock Springs, WY 82902.

Proceedings America Society of Mining and Reclamation, 1995 pp 409-415
DOI: 10.21000/JASMR95010409

https://doi.org/10.21000/JASMR95010409

Sediment ponds were believed to be best technology currently available (BTCA) under the regulations of the U.S. Office of Surface Mining. Bridger Coal Company might have been required to construct as many as 200 sediment ponds. An experimental practice was initiated in 1983 to test the effectiveness of alternative sediment control techniques compared to sediment ponds for the purpose of preventing additional contributions of sediment to receiving streams. Alternate sediment control became a standard practice in 1987. The effectiveness of alternate sediment control techniques continues to be quantitatively monitored.

Site Description

Jim Bridger Mine is 45 km northeast of Rock Springs in southwest Wyoming. The mine is immediately west of the great divide basin of the continental divide at an average elevation of 2,100 m in an area known as the Red Desert. Mean annual precipitation is 150-200 mm and the mean frost-free period is 100 days. Coal is mined from the Fort Union Formation. The local geology is an anticlinal structure known as the Rock Springs Uplift. Soils are Entisols and Aridisols derived from Cretaceous calcareous shale, Tertiary sandstone and shale, aeolian sand, and alluvium (Bridger Coal Company 1980)[3]. Soils have an average total thickness of 43 cm and A horizons that are only 8 cm thick. Numerous stream channels cross the pit. These are ephemeral, incised, and formed in sloping alluvium and sandstone which are highly erosive. Native sediment levels may exceed 60,000 mg/l.

Reclamation

Experts predicted that reclamation would be a difficult and lengthy process in surface-mined areas that receive less than 250 mm of annual precipitation (National Academy of Sciences 1974). However, research conducted by Powell et al. (1990) indicated that, while irrigation was helpful for establishment of a productive plant community, it was not essential. Bridger Coal Company, therefore, discontinued the irrigation which had been required under the first SMCRA permit.

Reclamation Methods

Regraded spoil is deep-ripped with the contour before soil is replaced. Soil is replaced to a total thickness of at least 30 cm. Typically, a 15-cm lower lift is taken from stockpile followed by a 15-cm top lift direct-hauled live (not stockpiled) from a soil stripping area. Direct-haul soil has produced more productive and diverse plant communities than soil taken from stockpile. However, even direct-haul soil can be difficult to revegetate if the soil is very dry and disaggregates when stripped.

Cultivation is done with a chisel plow with the contour. Newly respread soil is usually loose enough that cultivation is not necessary to eliminate compaction. However, cultivation is necessary to remove scraper tire ruts that go down hill and to smooth the soil surface enough so that mulching equipment can be operated. The soil surface is left moderately rough because microrelief enhances moisture retention and vegetation production.

The sequence of planting seed followed by mulching that is typically followed in revegetation and site stabilization projects has been reversed on Bridger's reclamation. Mulching is done first. Hay mulch is applied after cultivation at a rate of 734 kg/ha. Wheat hay or straw is avoided because volunteer wheat will competetively exclude perennial species. Mulch is crimped with the contour.

Most seed is planted with a Tye no-till drill. This drill has the capability to open a furrow through the mulch cover and place the seeds into the soil. The drill has three seed boxes. Most grass seed is fed

[3]Bridger Coal Company. 1980. Jim Bridger Mine Base Document, Wyoming Permit to Mine No. 338-C. Vol. 2: Mine Plan and Vol. 17: Soil Survey Report. Rock Springs, WY.

from the grass box through the double disk furrow openers. Very small or fluffy seed is fed from the bluestem box, through 10-cm tubes behind the double disk openers. Some of this seed is covered by the press wheels and some stays on or near the soil surface. This operating sequence makes drill seeding the last operation. Three basic seed mixes and a special shrub patch mix are used (Table 1). Most species

Table 1. Four basic seed mixes used by Bridger Coal Company.

Common name	Scientific name	Loamy	Sandy	Shrub	Saline
Thickspike wheatgrass	*Elymus lanceolatus* Critana	2.24	2.24		2.24
Bluebunch wheatgrass	*Pseudoroegneria spicata* Secar	2.24	1.12		2.24
Slender wheatgrass	*Elymus trachycaulus* Pryor	2.24	2.24		
Streambank wheatgrass	*Elymus lanceolatus* Sodar	1.12	2.24		1.12
Western wheatgrass	*Pascopyrum smithii* Rosana	1.12			2.24
Pubescent wheatgrass	*Elytrigia intermedia* Luna		1.12		
Sandberg bluegrass	*Poa sandbergii*	0.22		0.22	
Canby bluegrass	*Poa canbyi*		1.12	0.22	
Needleandthread	*Stipa comata*		0.56		
Indian ricegrass	*Oryzopsis hymenoides* Nezpar	1.12	2.24		
Bottlebrush squirreltail	*Sitanion hystrix*	1.12			1.12
Sheep fescue	*Festuca ovina* Covar	2.24	2.24		1.12
Basin wildrye	*Leymus cinereus* Magnar	1.12	2.24	0.56	
Russian wildrye	*Psathyrostachys juncea*				2.24
Lewis flax	*Linum lewisii* Apar	1.12	1.12	0.11	1.12
Cicer milkvetch	*Astragalus cicer* Monarch	1.12	1.12		1.12
Munro globemallow	*Sphaeralcea munroana*	0.56	0.56		
Western yarrow	*Achillea millefolium*	1.12	1.12	0.11	1.12
Rocky Mtn. penstemon	*Penstemon strictus* Bandar	0.56	0.11		
Big sagebrush	*Artemisia tridentata*	1.12	1.12	4.48	1.12
Rubber rabbitbrush	*Chrysothamnus nauseosus*	0.56	0.56	0.34	0.56
Douglas rabbitbrush	*Chrysothamnus viscidiflorus*		0.11	0.22	
Winterfat	*Kreschenenikovia lanata*	0.56	0.56	0.22	
Gardner's saltbush	*Atriplex gardneri*	3.36	0.56		4.48
Shadscale saltbush	*Atriplex confertifolia*	1.12			
Fourwing saltbush	*Atriplex canescens*	1.12			
Greasewood	*Sarcobatus vermiculatus*		0.56		0.56
Spiny hopsage	*Grayia spinosa*		0.11	0.22	

are native, drought tolerant, and salt tolerant. The core seed mix is the loamy seed mix. It is modified slightly according to soil texture or salinity. Seed mixes are modified slightly from year to year depending on seed availability and success had with a species in previous years. Other varieties are also used on a trial basis. For example, Trailhead variety basin wildrye may be better adapted to Southwestern Wyoming than Magnar variety. The shrub patch mix was developed in 1993. It is planted in depressions, swales, and drainages. Its purpose is to enhance the vegetative mosaic of reclamation by creating small islands of forbs and full shrubs and to imitate the vegetative structure of similar landscape positions on native rangeland. Very rocky soils are planted with a rangeland drill. The rangeland drill is very durable but will not plant fluffy or very small seed such as sagebrush.

Trial Methods

Several alternatives to Bridger Coal's standard reclamation methods have been tried. Dozer and scraper basins have been formed in regraded spoil before soil replacement. Dozer basins were described by Sindelar et al. (1973). At first, scraper and dozer operators who were accustomed to regrading spoils to a smooth surface were told to roughen the surface up again. Now, the location and size of most microtopographic features is determined by equipment operators. Basins must be deep enough so that a depression will still exist after soil is replaced. Basins are usually 15-60 cm deep after soil replacement, although they may be twice that deep before soil replacement. Vegetation productivity is higher inside than outside the basins because the basins retain water.

In recent years basins have been planted with the special shrub patch seed mix. This mix was formulated so that high-density stands of full shrubs in the Asteraceae family could be established (Table 1). Basin wildrye is included because it adds structural diversity and is a component of the native loamy range site which occurs in depressions on hillslopes and in ephemeral stream beds. The mix also includes small seeded and low-growing forbs and grasses for diversity. Grass and forb seed is used in small quantity so that these lifeforms will not significantly compete with shrub seedlings. The entire mix is planted from the bluestem box on the no-till drill. Shrub establishment is usually improved inside basins because of enhanced snowpack and moisture retention. Since the mix is new, no performance data are available yet.

Temporary cover crops were tested as an alternative to mulching. Regreen, a wheatgrass x winter wheat hybrid, and oats *(Avena sativa)* were drill seeded with a rangeland drill during the first planting season after soil replacement. The regular seed mix was interseeded with a no-till drill into the stubble, without further tillage, approximately one year later. This practice has not been as successful as drill seeding into crimped hay mulch. The annual precipitation at the mine is apparently insuffìcent for vigorous cover crops.

Reclamation Results

Annual reclaimed vegetation monitoring was initiated when irrigation ended as a reclamation practice. The initial purpose was to demonstrate that the reclamation practices in use, which no longer included irrigation, were sufficient to establish a cover of native perennial species. Monitoring is now also used to measure the parameters by which the reclaimed land will be evaluated for final bond release. Comprehensive, low intensity sampling of all lands reclaimed for more than 5 years was performed in 1991 (Table 2). Vegetative basal cover was as high on 4 of the reclaimed areas as it was on nearby native rangeland. Total cover, which includes vegetative basal cover, litter, and rock was lower on all reclaimed areas than it was on native rangeland. This was because reclaimed land has much less litter and rock than native rangeland. The litter and rock components will be problematic parameters in final bond release determinations. Biomass was higher on all reclaimed areas, except one, than on native rangeland. One explanation for this could be that grasses and forbs on reclamation have less competition from mature shrubs than they have on native rangeland. Also, reclamation soils are much less variable relative to quality, thickness, and topographic position than are native soils.

Table 2. Summary of 1991 vegetation data for reclaimed and native land. Values for cover and biomass are means and standard deviations of 10 observations. Total cover consists of litter, rock, and vegetation.

Area	Hectares	Total cover (%)	Vegetative basal cover (%)	Biomass (g/m2)
R4-4-1	19	18.8+/-6.9	1.0+/-1.2	4.7+/-2.7
R5-4	29	16.0+/-6.1	1.8+/-1.2	3.6+/-2.3
R6-3	8	9.0+/-2.4	2.4+/-0.7	17.9+/-8.7
R6-4-2	11	13.0+/-5.5	2.6+/-1.3	17.5+/-7.9
R7-4	15	19.0+/-8.7	2.4+/-3.2	1.3+/-1.0
R8-4a	14	13.6+/-5.2	1.0+/-0.8	8.3+/-7.4
R8-4b	10	23.1+/-11.7	3.1+/-2.1	23.4+/-10.8
R9-4	33	23.1+/-26.8	2.1+/-1.9	23.0+/-14.4
R11-4	94	15.8+/-8.7	4.1+/-2.4	21.0+/-10.5
R12-3	18	18.1+/-6.4	3.5+/-4.3	7.6+/-5.3
R13	31	8.9+/-3.0	2.2+/-1.9	10.3+/-11.4
R15-4	33	17.9+/-20.5	1.6+/-1.5	—
R15-3	14	16.7+/-7.5	5.3+/-4.5	12.2+/-6.7
R17-3	19	21.0+/-5.5	6.3+/-4.7	40.6+/-19.1
R17-4	21	14.4+/-7.1	2.2+/-1.0	28.0+/-13.0
Native	—	34.3+/-28.9	3.5+/-1.3	2.5+/-2.2

Alternate Sediment Control

Alternate sediment control techniques were tested under an experimental practice between 1983 and 1987 and became a standard practice in 1987. Sediment yield from lands affected by the pit, spoils, and reclamation is controlled by alternate sediment control techniques, not by sediment ponds. However, facilities areas have sediment ponds. Foundational concepts, justification, development, experimental design, and results of the experimental practice are described in Bergstrom (1987). Alternate sediment control techniques must prevent additional contributions of sediment to runoff outside the affected land (WDEQ-LQD, 1994).

Alternate Sediment Control Techniques

Several techniques are used to limit sediment discharge from mined land to background levels. One group of techniques involves preventing runoff from leaving disturbed areas. These techniques include berms, diversion ditches, toe ditches, small catchments, and drainage via haulroads and ramps to the pit floor. Most of these techniques are appropriate for very small drainage areas because the volume of water diverted or retained must be small. Drainage from larger areas can be diverted by haul roads and ramps into the pit. Water stored on the pit floor is used for road watering.

A second group of techniques involves the placement of rock check dams or hay bales or other suitable material for the purpose of filtering and temporarily detaining runoff water so that some of its sediment load settles. Check dam size is determined by using the SEDIMOT II computer program (Wilson et al., 1982). These materials are used a short distance down stream from disturbed land. Their purpose is temporary. They are installed before soil removal and maintained while the disturbed drainage area is erosionally unstable. When the disturbed area is recontoured and revegetated the check dams start to become obsolete. As the reclaimed plant community becomes well established and increases ground cover, the sediment storage function is performed to a greater degree by the reclaimed landscape and to a steadily decreasing degree by the check dam. As this shift in sediment storage function occurs the check dams are, with state regulatory authority approval, dismantled and allowed to blend into the stream bed. A system of automatic pump samplers (discussed later) is in place to quantitatively monitor the effectiveness of sediment control as this process occurs.

A third group of techniques is the most enduring in its effects. These techniques involve good mined land reclamation practices and include prudent geomorphic design, reconstruction of complex slopes, restoraton of drainage density, roughening of the soil surface, mulching, contour farming, and timely establishment of permanent vegetative cover. These will be the elements of erosion control and sediment storage for the long term. The more quickly and effectively this third group of techniques is implemented, the more assurance one has that the temporary techniques will, in time, become redundant.

Sediment Monitoring

Alternate sediment control techniques were originally tested and determined to be best technology currently available by a statistically based paired watershed experiment (Bergstrom, 1987). Monitoring has continued since the techniques became standard practice in 1987. Automatic stage recorders and pump samplers remain in use. However, the PS-69 pump samplers are being replaced with the more modern priority contaminant-type samplers. Since 1983, the sediment yield of 122 runoff events has been monitored. Sediment yield is expressed as quantity of sediment per unit area of watershed. Unit water yield and unit sediment yield for each event are plotted on a graph which displays 95% prediction bands for these variables. The graphical presentation accounts for the fact that the monitored watersheds are unequal in size and that storm events are not equivalent in antecedent conditions, intensity, or size. Analysis of monitoring results to date has shown that background sediment levels have not been exceeded in disturbed watersheds and correspondingly, that disturbed watersheds are in phase with receiving watersheds relative to sediment storage and release.

Conclusion

Revegetation and alternate sediment control are allied objectives in that both ultimately depend on implementation of good land reclamation practices for their success. The present application of these technologies came about after earlier paradigms were questioned and alternative technologies were studied through scientific investigations that involved hypothesis testing. Subsequent revegetation monitoring shows that reclaimed vegetation biomass greatly exceeds that on native rangeland but reclaimed vegetation cover is approximately equal to that on native rangeland. Experience is showing that direct-haul live soil is usually superior to soil taken from stockpile as a plant growth medium. Revegetation objectives are being achieved without irrigation. Alternate sediment control techniques are preventing the contribution of additional sediment from mined lands to receiving waters. The application of alternate sediment control techniques and then monitoring their effectiveness focuses sediment control efforts where they are ultimately most effective: on the reclaimed landscape.

References

Bergstrom, F. W. 1987. The impact of sediment control measures on ephemeral semiarid stream water quality, Bridger Coal Company, Southwestern Wyoming. Pages G91-G914 in Fourth Biennial

Billings Symposium on Mining and Reclamation in the West and the National Meeting of the American Society for Surface Mining and Reclamation. March 17-19, 1987. Billings, MT.
http://dx.doi.org/10.21000/JASMR87010209

National Academy of Sciences. 1974. Rehabilitation potential of western coal lands. Ballinger Publishing Co. Cambridge, MA. 198 pp.

Powell, K. B., R. B. Vincent, E. J. DePuit, J. L. Smith, and F. E. Parady. 1990. Role of irrigation and fertilization in revegetation of cold desert mined lands. J. Range Manage. 43:449-455.
http://dx.doi.org/10.2307/3899011

Sindelar, B. W., R. L. Hodder, and M. E. Majerus. 1973. Surface mined land reclamation research in Montana. Montana Agric. Exper. Sta. Research Rep. 40. Bozeman, MT. pp. 11-31.

WDEQ-LQD. 1994. Wyoming Department of Environmental Quality Land Quality Division 1994 Rules and Regulations. Cheyenne, WY.

Wilson, B. N., B. J. Barfield, and I. D. Moore. 1982. A hydrology and sedimentology watershed model. I. Modeling technique. Dept. of Agric. Engr., Univ. of Kentucky, Lexington, KY.