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State of Utah
Department of Natural Resources
Division of Oil, Gas and Mining
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REVEGETATION GUIDELINES
FOR UTAH COAL REGULATORY PROGRAM

Introduction

A permit application must contain plans for revegetation of all areas that have been or will be disturbed by the mining operation (UMC 817.100, SMC 816.100). Reclamation activities including revegetation must occur as contemporaneously as practicable with mining operations. Contemporaneous reclamation includes: (1) interim (temporary) revegetation necessary to stabilize areas until a permanent vegetative cover is established; and (2) permanent revegetation of deactivated portions of the mine, or the entire mine site.

Interim revegetation includes establishment of vegetation on topsoil stockpiles, waste banks, road cuts and fills, embankments, outcrops, nonriprapped temporary diversion ditches, drainage ways, etc. of an active mine, as well as during the period from mine closure until the final revegetation plan can be implemented. The principal objectives of temporary revegetation are erosion control and maintenance or enhancement of soil viability.

Permanent revegetation plans are required to establish a diverse, effective, and permanent vegetative cover on all disturbed lands except water areas and the surface of approved postmining roads. The goals of permanent revegetation are to control erosion, restore productivity of the land, and render the land capable of supporting the intended postmining land use. The postmining land use provides direction for permanent reclamation plans. Seed mixes, planting arrangements, as well as the selection of a reference area or other success standard, are all dependent on the postmining use (UMC 817.111, SMC 816.111).

These guidelines are intended to aid the applicant in formulating and/or modifying a revegetation plan which will meet the requirements and performance standards of UMC 784.13, 817.100, and 817.111-.117 (Underground Mining), and SMC 780.18, 816.100, and 816.111-.117 (Surface Mining).

While a specific revegetation plan is essential to a mine permit application, reclamation may not occur for several decades. The plan may be modified at any time to reflect new or improved revegetation techniques, or to incorporate results from monitoring interim revegetation or test plots. Test plots or field trials should be considered (and may be required) to determine the most effective way to revegetate problem areas or unique situations or to determine the effectiveness of the proposed permanent revegetation plans. If test plots are appropriate, the Division can assist with their design.

The revegetation plan must provide sufficient detail so that regulatory compliance can be ascertained. At a minimum (UMC 784.13, SMC 780.18), the plan shall include:

- A. A detailed schedule, including the anticipated starting and ending dates of each task;
- B. Seedbed preparation and fertilization plan, including methods, and types and rates of fertilizer;
- C. Species selection and the amounts per acre of seed or seedlings to be used;
- D. Methods to be used in planting and seeding, including type of equipment to be used;
- E. Mulching techniques, including type(s) of mulch, rate of application, and how it is to be applied and anchored;
- F. Irrigation techniques, including type of irrigation system, rate of water application and frequency of watering;
- G. A monitoring plan which includes proposed measures to determine the success of revegetation according to the postmining land use; and,
- H. A contingency or maintenance plan for problem areas.

Framework for Reclamation

The postmining land use provides the framework for the revegetation plan. Postmining land uses may be (a) those supported before mining or (b) higher or better uses (UMC 817.133 or SMC 816.133). The latter may be approved by the Division after consultation with the landowner or land managing agency, and if the criteria of UMC 817.133 or SMC 816.133 are met. After selecting a postmining land use, the typical vegetation needs or characteristics

of the proposed use (i.e. agriculture crops; timber stocking; wildlife cover, water and food; forage for livestock, etc.) must be determined. If prime farmlands are involved, the postmining land use must be croplands as per UMC 785.17(d)(1).

Reference areas or other success standards should be selected which reflect the intended postmining land use and, therefore, may be different from the premine vegetation. For example, the total number of woody plants to be established could be reduced from premining densities by demonstrating, through literature or field studies, that fewer woody plants would enhance the area for the proposed postmining land use. (See the Division's Vegetation Information Guidelines for details on establishing reference areas.)

Essentials of the Revegetation Plan

A. Revegetation Schedule

Revegetation, whether it is for temporary stabilization or as a part of permanent reclamation, must be as contemporaneous as practicable with the disturbance. The applicant must specify a schedule for both interim and permanent revegetation. The schedule should include the anticipated dates for beginning and ending each task of the revegetation plan and the expected time to complete the task. While exact dates are not expected, the general timeframe should be supplied (e.g. third week of May, late October (see Appendix A)). Several different tasks may be occurring simultaneously within the permit area. However, for any specific site, they will generally follow the order of seedbed preparation, seeding, mulching, planting, monitoring, and maintenance.

For successful revegetation, seeding and planting must be done such that weather and soil conditions are favorable for plant establishment. Seeding and planting must be accomplished during the first normal period of favorable conditions (UMC 817.113, SMC 817.113). For most areas in Utah, the best time to seed is late fall, just prior to snowfall, or early spring, immediately after snowmelt when soil moisture is optimum. Spring seeding may be limited to broadcast methods because of limited equipment access until optimum soil moisture conditions have passed. If seeding is to be done between mid-to-late May and late September, seeding only a cover crop (interim revegetation) or irrigation should be considered (see section F for details on irrigation).

Bare root or container stock should be planted in early spring. Success can be achieved with plantings as late as August if irrigation is used. Likelihood of success with planting after mid-August decreases rapidly because plants do not have sufficient time to become established prior to freezing conditions.

B. Seedbed Preparation

1. Physical Preparation. An adequate seedbed is firm but not compacted. Depending on the type of soils and history of the site, this may require ripping, discing, harrowing, etc. While a fairly uniform, level seedbed is suitable for agriculture crops or pasture, a rough surface is preferred for establishing a diverse native plant community. In arid environments, it may be necessary to gouge or pit the surface to aid in moisture retention. These practices are generally effective on areas of less than 15-20 percent slope. On steep slopes, contour furrowing or ditching can reduce erosion and aid in moisture retention.
2. Chemical Preparation. Chemical conditioning includes the addition of fertilizers or other soil amendments to improve soil conditions for plant growth. The rates of application should be based on a recent soil analysis of the redistributed surface soil layer. For replacement of native plant communities, the level of nutrients in adjacent undisturbed soils can be a target for supplementing basic plant nutrients (N, P, K, etc.). Soil amendments may include the addition of organic matter (i.e. rototilling hay into the top 6-8 inches), gypsum, etc. (See the Division's Topsoil and Overburden Guidelines for more information.)

C. Species Selection

For permanent revegetation, a diverse, effective vegetation cover that is capable of reproduction and plant succession is required (UMC 817.111, SMC 816.111). Species should be identified by both scientific and common name, including cultivar or variety where appropriate. Seeding rates for each species should be in terms of Pure Live Seed (PLS).

The use of native species is preferred. However, introduced species may be approved by the Division if desirable and necessary to achieve the approved postmining land use (UMC 817.111, SMC 816.111). All species must have

the same seasonal characteristics of growth as the original vegetation, be compatible with the plant and animal species of the area, and meet the requirements of federal and state laws and regulations on seed, poisonous and noxious plants and introduced species (UMC 817.112, SMC 816.112).

Exceptions to these requirements may be granted for species necessary to achieve a quick-growing, temporary, stabilizing cover in areas where erosion is an immediate concern and measures to establish permanent vegetation at a later time are included in the permit. These exceptions would apply to either cover crops (e.g. annual grass) for interim revegetation or nurse crops (e.g. alfalfa or yellow sweetclover) in permanent seed mixes.

The proposed postmining land use should be carefully considered when selecting species for permanent revegetation. For general rangeland or wildlife habitat restoration (i.e. returning the land to its premining condition or land use), primary consideration should be given to those species which are characteristic of the predisturbance land use or are adjacent to the site. Species that will improve cover and/or forage for local wildlife are encouraged whether or not the principal land use is wildlife habitat (UMC 817.97, SMC 816.97).

Other important considerations in species mix selection are adaptation to site conditions, species and life form diversity, dominance, seasonality characteristics, forage value, management requirements, seed availability and cost.

Generally, permanent reclamation seed mixes should include a minimum of four-to-eight species of each life form (grasses, forbs, and shrubs/trees), depending on the number of species in the premining community or the proposed postmining land use. For interim revegetation or stabilization, a seed mix of one or two species is usually adequate to provide erosion control. It is highly recommended, however, that temporary revegetation areas be used as field trials for the permanent revegetation plan. This will provide site-specific data to revise the final revegetation plan before large costs are incurred.

Appendix B includes a list of acceptable species for which seed is generally available from several seed suppliers, or can be obtained by ordering several months early. The general site characteristics of each species are listed to aid in developing a seed mix for a specific site.

The rate of seeding (Pure Live Seed (PLS)/unit area) or stocking (number of bare root or containerized stock/unit area) of each species must be provided in the plan (UMC 784.13, SMC 780.18). As a general rule, there should not be more than 20 PLS/ft² of any one species. The total PLS/ft² for all grasses and forbs should be between 50-80 for drill seeding or 100-150 for broadcast seeding methods. In general the broadcast seeding rate for a mix should be double the drill rate. When seeding woody plants in a mixture, consider seeding 1000 PLS for long-term establishment of one plant. For transplants, 60 percent survival for shrubs and 80 percent survival for trees can be expected.

D. Seeding and Planting Methods.

The revegetation plan must identify the methods and type of equipment to be used in seeding and planting (UMC 784.13, SMC 780.18). Drill seeding is preferred because it can place the seed at the optimum depth for germination. However, use of a drill is generally limited to slopes less than 20 percent. Use of a drill, with several seed boxes to handle a variety of seed sizes and shapes, will aid in the uniform distribution of the mix. Drill seeding should be done on the contour to limit erosion.

On steeper slopes, it is necessary to broadcast seed on the surface either by hand, with a whirly-bird-type seeder, or with a hydro-seeder. For best results, it is suggested that the areas that are broadcast seeded be lightly raked or dragged to cover the seed.

If more than one method is planned, the acreage of each method must be provided, as well as a map showing where each method is to be used.

The planting plan should identify whether cuttings, bare root or containerized stock will be used, and whether plants will be hand or mechanically planted. Since one of the major uses of woody plants is to provide browse or cover for wildlife. Wildlife habitat can usually be enhanced by planting clumps or groupings of plants. It is, therefore, necessary to include a narrative or map which describes the spatial arrangement of transplants.

E. Mulching and Moisture Retention

Mulches are used primarily for erosion control and moisture retention, which aids in vegetation establishment.

Mulching is required for all revegetation plans unless it is demonstrated that mulch is not necessary, or that other stabilizing practices will be used to control erosion and establish an effective vegetative cover (UMC 817.114, SMC 816.114).

All seeded areas should be mulched as soon after seeding as possible. The plan must identify the type of mulch to be used, the rate of application (usually between 2000 to 4000 pounds per acre, depending on site conditions such as type of soil, slope, etc.) and how it will be anchored (i.e. chemical tackifier, crimped, polypropylene netting, etc.). There are several types of mulches available, each with advantages and disadvantages. The more commonly accepted and used mulches include native hay, alfalfa hay, straw and wood fiber hydro-mulch. If hydro-mulch is used, seeding and mulching should be performed as two separate applications. Do not mix the seed with the mulch.

Physical manipulation of the ground surface can aid in moisture retention. Practices include land imprinting, gouging, pitting, contour furrowing, terracing and, possibly, ripping. In arid areas (less than 12 inches precipitation) success of revegetation may depend on the use of one or more of these manipulations to enhance moisture retention. The plan should identify proposed practices, justify their use on a site-specific basis, and delineate on a map or describe specific areas to be treated.

F. Irrigation

Irrigation is not generally necessary but may be needed for seeding in extremely arid areas during late spring and summer, or if mulch or other moisture retention practices are not used. Irrigation should only be used for vegetation establishment and is generally terminated after one or two growing seasons (unless it is required for the approved postmining land use).

If irrigation is used, it is better to infrequently apply quantities of water sufficient to recharge the root zone to field capacity than to apply minimal water on a frequent basis. Irrigation plans must identify the type of irrigation system (e.g. sprinkler, flood, furrow, etc.), the rate of application (dependent on soil and slope characteristics), and the frequency of application. It is as important to avoid over-irrigation as it is to supply sufficient water. Various soil moisture measuring devices (e.g. tensiometer, gypsum block, Coleman block, neutron

probe) can be used to guide the irrigation schedule. The plan should also indicate the last year of application since termination of irrigation can initiate the period of extended responsibility (UMC 817.116, SMC 816.116).

G. Monitoring

Revegetation sites are monitored for several reasons. These include: to determine initial species establishment and survival, to identify problem areas, to identify the need for maintenance or pest/disease control, to modify plans for future revegetation, and to determine success of revegetation efforts. The parameters selected and the sampling intensity depend on the purposes of monitoring. Frequency and density are measured to determine species establishment and survival, to determine the diversity of the stand and to identify problem areas. Cover is used for species establishment, diversity and determination of revegetation success. Productivity is used to determine revegetation success. Reconnaissance surveys are used to identify problem areas and the need for maintenance (i.e. repair of rills and gullies) or pest and/or disease control. All of these determinations can be used to reevaluate revegetation plans. (See regulation UMC 817.116 or SMC 816.116 for success standards specific to postmining land uses.)

All revegetated areas should be monitored. Detailed plans for monitoring of frequency, establishment and survival, cover, and diversity are needed for all final and interim revegetation. Reconnaissance surveys are usually sufficient for temporary revegetation that includes only one or two species. These plans must also identify the appropriate level of sampling to determine revegetation success. (See Appendix C for more detail on monitoring plans.)

H. Contingency and Maintenance Plans

Most major reclamation projects will have isolated areas of poor revegetation success. These may include erosion problems (rills and gullies that need repair); problems with weeds, disease or pests; small areas devoid of vegetation because of drought during the establishment period, over-grazing, etc. Monitoring will identify these problems should they develop. Repair and maintenance of these areas are usually labor-intensive because their small size may not warrant mobilization of large equipment, or because access may be restricted. Early detection (through monitoring) is important since any major maintenance will restart the liability period.

At best, it is difficult to predict what methods, seed mixes, weed/pest control, etc. will be needed until the problem is identified. Therefore, contingency and maintenance plans need only be discussed in general terms. At a minimum, the following items must be included:

1. Criteria for identifying problems;
2. A commitment to repair damage and control pests;
3. An outline and timeframe of how specific plans will be developed, approved, and implemented;
4. General plans for anticipated problem areas (e.g. repair of rills/gullies if steep slopes are involved in reclamation); and
5. A plan to manage grazing (e.g. fencing) until vegetation is established.

Test Plots and Field Trials

Most mine revegetation practices and plant materials used today were developed for range improvements on favorable areas. Unfortunately, many mines are located in areas generally considered unsuitable for improvement. While many of the conventional range improvement practices are applicable to mine reclamation, standard techniques may need modification and new techniques may be needed to reclaim many unique or difficult revegetation problems, including areas of low precipitation (less than 12 inches/year), poor soil conditions or limited quantities of acceptable soil, refuse piles and slurry ponds with potential toxic properties, and steep slopes.

For unique sites or problem situations, test plots or field trials are usually required to determine reclamation feasibility (UMC/SMC 786.19). The Division should be consulted in developing an adequate testing plan which may range from a field trial of the proposed permanent revegetation plan to formal test plots. Whether test plots or field trials are implemented usually depends on the amount and quality of data available for similar situations. Even if test plots or field trials are not required, the Division recommends that, where appropriate, the proposed permanent revegetation plan be used for interim revegetation. Field trials, coupled with a good monitoring plan, will help ensure final reclamation is successful the first time.

Maps

Unless specifically exempted by the Division, the following maps are to be included as part of the reclamation plan:

- A. Postmining land use map (if more than one land use is proposed for the permit area);
- B. Revegetation map showing the location of different seed mixes, mulches, seeding methods, etc. Total acreages should be indicated on the map or in the text;
- C. Transplanting map showing spatial arrangements, groupings, etc. of transplanted species;
- D. Special features map showing location of special features to enhance land use, such as guzzlers, ponds, rock piles, etc.

Conclusion

Detailed revegetation plans are required for all areas disturbed by the mining operation. Interim revegetation plans are needed for all areas that are not frequently recisturbed during mining operations, e.g. topsoil stockpiles, cut and fill areas, embankments, outslopes on sediment ponds, etc. Permanent revegetation plans are needed for the entire disturbed area, including areas of interim revegetation if these do not meet permanent reclamation plans. While the Division requires specific plans for seedbed preparation, seed mixes, mulches, methodology, etc. to determine the feasibility of reclamation before issuing a permit, plans can be modified with Division approval should conditions warrant.

Appendix A

Example of Revegetation Schedule

TASK	MONTH:											
	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
Review revegetation plan	XX	X										
Order seed			X									
Order transplants				X								
Regrading						XXX	XXXX					
Spread topsoil								XXX				
Seedbed preparation									XX	X		
Apply fertilizer			XX*							XX		
Seeding											XX	X
Mulching											XX	X
Tasks to be done in subsequent years:												
Plant seedlings ¹			XX	X								
Monitor revegetation						XX	XXXX	XXX**		X***		
Submit monitoring report												X

Timeframes are approximate and will vary depending on site conditions and the acreage involved.

¹ Plant transplants the spring following seeding if used.

- * May need application of N the spring following seeding.
- ** Monitor during peak of growing season as per monitoring schedule.
- *** For survival of transplants.

APPENDIX B

SUGGESTED SPECIES FOR MINE RECLAMATION

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SPECIES	C/W	EXPOSURE ¹				SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		SEED ² SIZE
		N/E	S/W	LEV		SA	SI	CL	R	S	A	D	L	M	R		
GRASS & GRASSLIKE:																	
<i>AGROPYRON DASYSTACHYUM</i> THICKSPIKE WHEATGRASS	C	X	X	X		X	X	X	X			X	X	X	X	4000 - 10000	155
<i>AGROPYRON INERME</i> 'WHITMAR' BEARDLESS WHEATGRASS	C	X	X	X		X	X	X	X			X	X			4000 - 8000	117
<i>AGROPYRON RIPARIUM</i> 'SODAR' STREAMBANK WHEATGRASS	C	X	X	X		X	X	X	X	X		X	X	X	X	4000 - 10000	156
<i>AGROPYRON SMITHII</i> WESTERN WHEATGRASS	C	X	X	X		X	X	X				X	X	X	X	4500 - 8000	120
<i>AGROPYRON SPICATUM</i> BLUEBUNCH WHEATGRASS	C	X	X	X		X	X	X	X			X	X	X		4000 - 8500	125
<i>AGROPYRON TRACHYCAULUM</i> SLENDER WHEATGRASS	C	X	X	X		X	X	X	X			X	X	X		5000 - 10000	160
<i>ANDROPOGON GERARDI</i> BIG BLUESTEM	W		X	X		X	X	X				X	X			4000 - 7500	130
<i>ANDROPOGON HALILI</i> SAND BLUESTEM	W		X			X	X					X	X			4000 - 7000	113
<i>BOUTELOUA CURTIPENDULA</i> SIDEOTS GRAMA	W	X	X	X		X	X	X	X			X	X			4000 - 7000	190
<i>BOUTELOUA GRACILIS</i> BLUE GRAMA	W		X	X		X	X	X	X			X	X	X		4000 - 6500	750
<i>BROMUS MARGINATUS</i> MOUNTAIN BROME	C	X		X		X	X	X				X				6000 - 11000	80
<i>BUCHLOE BACTYLOIDES</i> BUFFALO GRASS	W		X			X	X	X				X	X	X		4000 - 6000	50
<i>DESCHAMPSIA CAESPITOSA</i> TUFFED HAIRGRASS	C	X		X		X	X	X				X	X			7500 - 12000	2500
<i>DISTICHLIS SPICATA</i> INLAND SALTGRASS		X	X	X		X	X	X	X	X		X	X	X		4000 - 8000	518

SPECIES	C/W	EXPOSURE			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 2
		N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	H	R		SEED ²
																SIZE
<i>ELYMUS CANADENSIS</i> CANADA WILD RYE	C			X	X	X	X	X			X	X	X	5000 - 8000		115
<i>ELYMUS CINEREUS</i> GREAT BASIN WILD RYE	C	X	X		X	X	X	X	X		X	X	X	4000 - 8000		105
<i>ELYMUS GIGANTEUS</i> MAMMOTH WILD RYE	C			X	X	X		X			X	X		4000 - 8000		175
<i>ELYMUS SALINUS</i> SALINA WILD RYE	C	X	X		X	X	X	X	X		X	X		5500 - 12000		380
<i>ELYMUS TRITICOIDES</i> CREEPING (BEARDLESS) WILD RYE	C			X		X	X	X	X		X			-		51
<i>ERAGROSTIS TRICHODES</i> SAND LOVEGRASS	W		X	X	X	X					X	X		4000 - 5500		1450
<i>FESTUCA ARIZONICA</i> ARIZONA FESCUE	C	X		X	X	X	X	X			X	X		7500 - 12000		550
<i>FESTUCA IDAHOENSIS</i> IDAHO FESCUE	C	X	X	X	X	X	X					X		5500 - 12000		450
<i>FESTUCA OVINA</i> SHEEP FESCUE	C	X		X	X	X	X				X	X	X	7500 - 12000		625
<i>FESTUCA THURBERI</i> THURBER FESCUE	C		X			X	X	X			X	X		8000 - 12000		995
<i>HILARIA JAMESII</i> 'VIVA' GALLETIA	W		X	X		X	X	X			X	X	X	4000 - 6000		155
<i>HORDIUM SP.</i> BARLEY "	C										X	X		5000 - 9000		14
<i>KOeleria cristata</i> JUNEGRASS	C	X	X	X	X	X					X	X		4000 - 8000		2315
<i>Lolium multiflorum</i> ANNUAL RYEGRASS "	C	X	X	X		X	X				X	X	X	5000 - 9000		227
<i>Muhlenbergia wrightii</i> SPIKE MUHLY	W	X	X	X	X	X					X	X		4000 - 9000		1600
<i>Oryzopsis hymenoides</i> INDIAN RICEGRASS	C		X	X	X	X	X	X			X	X	X	4000 - 7000		175
<i>Panicum obtusum</i> VINE-MESQUITE GRASS	W		X		X	X	X				X	X	X	4000 - 5500		143

SPECIES	C/W	EXPOSURE			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 3
		N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	H	R		SEED ²
<i>PAULICUM VIRGATUM</i> SWITCHGRASS	W	X	X	X	X	X	X	X	X			X	X	4000 - 8000	389	
<i>PHALARIS ARUNDINACEA</i> REED CANARYGRASS	C	X	X	X	X	X	X	X				X	X	4000 - 8000	510	
<i>PHLEUM ALPIMUM</i> ALPINE TIMOTHY	C	X		X	X	X	X					X	X	9000 - 12000	1300	
<i>POA AMPLA</i> BIG BLUEGRASS	C	X	X	X	X	X	X				X	X	X	5500 - 8000	885	
<i>POA CANBYI</i> CANBY BLUEGRASS	C				X	X					X	X		-	926	
<i>POA PRATENSIS</i> KENTUCKY BLUEGRASS	C	X	X	X	X	X	X				X	X	X	5500 - 12000	2150	
<i>POA SANDBERGII (SECUNDA)</i> SANDBERG BLUEGRASS	C		X		X	X	X	X	X	X	X	X	X	5500 - 12000	925	
<i>SCHIZACHYRIUM SCORARIUM</i> LITTLE BLUESTEM	W	X	X	X	X	X	X	X				X	X	5500 - 12000	260	
<i>SECALE CEREALE</i> CEREAL RYE *	C				X	X	X					X	X	-	18	
<i>SITANION HYSTRIX</i> BOTTLEBRUSH SQUIRRELTAIL	C	X	X	X	X	X	X	X	X	X		X	X	4000 - 12000	192	
<i>SPOROBOLUS AIROIDES</i> ALKALI SACATON	W		X		X	X	X	X	X	X		X	X	4000 - 6000	1775	
<i>SPOROBOLUS CRYPTANDRUS</i> SAND DROPSEED	W		X	X	X	X		X				X	X	4000 - 8000	5200	
<i>SPOROBOLUS GIGANTENS</i> GIANT DROPSEED	W		X	X	X	X						X	X	4000 - 6000	1725	
<i>STIPA COLUMBIANA</i> COLUMBIA NEEDLEGRASS	C		X	X	X	X						X	X	-	150	
<i>STIPA COMATA</i> NEEDLE AND THREAD GRASS	C	X	X	X	X	X	X					X	X	4000 - 7500	115	
<i>STIPA LETTERMANII</i> LETTERMAN NEEDLEGRASS	C				X		X					X		-	150	
<i>STIPA VIRIDULA</i> GREEN NEEDLE GRASS	C	X	X	X	X	X	X	X				X	X	4000 - 8000	181	
<i>TRISETUM SPICATUM</i> SPIKE TRISETUM	X	X			X							X		9000 - 12000	2500	

SPECIES	EXPOSURE ¹			SOIL TYPE					PRECIP RANGE			ELEVATION RANGE	PAGE 4	
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L		H	R
FORBS:														
<i>ACHILLEA MILLEFOLIUM</i> YARROW	X	X	X	X	X	X				X	X	X	5500 - 12000	2800
<i>ARTEMISIA LUDOVICIANA</i> LOUISIANA SAGEBRUSH		X		X	X	X				X	X		5500 - 12000	4500
<i>ASTER CHILENSIS</i> PACIFIC ASTER	X	X	X	X	X					X	X		4000 - 12000	2670
<i>ASTER GLAUCCODES</i> BLUELEAF ASTER	X	X			X					X	X		5500 - 12000	540
<i>ASTER TANACEIFOLIA</i> TAHOKA DAISY	X	X		X	X	X				X	X		6000 - 8000	496
<i>BALLEYA MULTIRADIATA</i> DESERT MARIGOLD		X			X					X	X		-	1060
<i>BALSAMORHIZA SAGITATA</i> ARROWLEAF BALSAMROOT		X		X	X	X				X	X	X	5500 - 8000	55
<i>CLEMATIS LIGUSTICIFOLIA</i> WESTERN VIRGINS BOWER	X		X		X	X					X	X	5500 - 8000	
<i>EPILORIUM ANGSTIFOLIUM</i> FIREWEED	X	X			X						X	X	5500 - 12000	8500
<i>ERIDGONUM UMBELLATUM</i> SULPHUR FLOWER	X	X		X	X	X				X	X		4000 - 12000	208
<i>GALLIARDIA ARISTATA</i> BLANKET FLOWER	X	X			X						X		-	132
<i>GALLIARDIA PULCHELLA</i> FIREWHEEL	X				X					X	X		-	153
<i>GERANIUM VISCOSISSIMUM</i> WILD GERANIUM	X	X	X	X	X						X	X	5500 - 12000	52
<i>HEMYSARUM BOREALE</i> NORTHERN SWEETVETCH	X	X		X	X					X	X		4500 - 8500	34
<i>HELANTHUS ANNUUS</i> ANNUAL SUNFLOWER	X	X		X	X	X				X	X		4000 - 7500	59
<i>LINUM LEWISII</i> LEWIS FLAX	X	X	X		X					X	X	X	5500 - 12000	280

SPECIES	EXPOSURE ¹			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 5 SEED ² SIZE
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	H	R		
LUPINUS ALPESTRIS MOUNTAIN LUPINE	X	X	X	X	X	X					X	X		8000 - 12000	13
LUPINUS SERICEUS SILKY LUPINE	X	X	X	X	X	X					X	X	X	5500 - 12000	13
LUPINUS TEXENSIS BLUEBONNET				X	X	X				X	X	X		-	16
MEDICAGO SATIVA 'LADAK' ALFALFA	X	X	X	X	X	X	X	X			X	X		4000 - 10000	210
MEDICAGO SATIVA 'RANGER' ALFALFA	X	X	X	X	X	X				X	X	X		4000 - 8000	210
MELILOTHUS OFFICINALIS YELLOW SWEETCLOVER	X	X	X	X	X	X	X	X	X	X	X	X		4000 - 9000	260
DEMDIHERA CAESPITOSA WHITE TUFTED EVENING PRIMROSE		X		X	X		X			X	X	X		4000 - 8000	900
DEMDIHERA HOOKERI HOOKER EVENING PRIMROSE	X	X		X				X			X			8000 - 9000	866
DEMDIHERA PALLIDA WHITE EVENING PRIMROSE	X			X			X			X	X			4000 - 6000	512
OSMORHIZA OCCIDENTALIS SWEET ANISE	X		X		X						X	X		5500 - 9000	30
PENSTEMON CYANANTHUS WASATCH PENSTEMON	X	X		X	X					X	X			-	550
PENSTEMON EATONI EATON PENSTEMON	X			X	X		X			X	X	X		4000 - 8000	600
PENSTEMON PALMERI PALMER PENSTEMON	X	X	X	X	X	X	X			X	X	X		4000 - 8000	610
PENSTEMON STRICTUS 'BANDERA' ROCKY MTN. PENSTEMON	X	X	X	X	X		X			X	X			6000 - 11000	592
PEYALOSTEMUM PURPUREUM PURPLE PRAIRIE CLOVER	X	X	X	X	X	X				X	X	X		4000 - 7000	293
RHACELIA CAMPANULARIA BLUE BELLS	X			X		X				X	X			-	856

SPECIES	EXPOSURE ¹			SOIL TYPE						PRECIP RANGE				ELEVATION RANGE	PAGE 8
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	H	R		SEED ²
														SIZE	
<i>RUDBECKIA HIRTA</i> BLACK-EYED SUSAN	X	X	X		X						X	X		-	1710
<i>SPHAERALCEA AMBIGUA</i> DESERT GLOBEMALLOW		X	X		X	X					X	X		4000 - 5500	500
<i>SPHAERALCEA COCCINEA</i> SCARLET GLOBEMALLOW		X	X		X	X					X	X		4000 - 6000	500
<i>SPHAERALCEA GROSSULARIAEFOLIA</i> GOOSEBERRY LEAF GLOBEMALLOW	X	X	X		X						X	X		4000 - 8000	500
<i>SPHAERALCEA MUNROANA</i> MUNRO GLOBEMALLOW	X	X	X		X	X	X				X	X		4000 - 6000	500
<i>VICIA AMERICANA</i> AMERICAN VETCH	X		X		X	X	X				X	X	X	5500 - 10000	41
<i>VIGUIERA MULTIFLORA</i> SHOWY GOLDEN EYE	X	X	X		X	X						X		6000 - 12000	500
<i>ZINNIA GRANDIFLORA</i> ROCK MOUNTAIN ZINNIA		X	X		X						X	X		4000 - 6000	130

SPECIES	EXPOSURE ¹			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 7 SEED ² SIZE
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	H	R		
SHRUBS:															
AMELANCHIER ALNIFOLIA SERVICEBERRY	X	X	X		X	X	X					X	X	5500 - 10000	45
AMELANCHIER UTAHENSIS UTAH SERVICEBERRY		X			X	X	X					X	X	4000 - 8000	26
ARTEMISIA CANA SILVER SAGEBRUSH			X		X	X		X			X	X	X	5500 - 9000	850
ARTEMISIA ERIGIDA FRINGED SAGEBRUSH	X	X	X		X						X	X		4000 - 11000	4535
ARTEMISIA NOVA BLACK SAGEBRUSH	X	X	X		X	X	X	X			X	X	X	5000 - 8500	907
ARTEMISIA TRIDENTATA TRIDENTATA BASIN BIG SAGEBRUSH		X	X		X	X	X	X			X	X	X	4000 - 7000	2500
ARTEMISIA TRIDENTATA VASEYANA MOUNTAIN BIG SAGEBRUSH		X	X		X	X	X				X	X	X	6000 - 9000	2500
ARTEMISIA TRIDENTATA WYOMINGENSIS WYOMING BIG SAGEBRUSH		X	X		X	X	X	X			X	X		4000 - 8000	2500
ATRIPLEX CANESCENS FOURWING SALTBUH	X	X			X	X	X	X	X		X	X	X	4000 - 6000	60
ATRIPLEX CONFERTIFOLIA SHADSCALE			X		X	X		X	X		X	X		4000 - 7000	65
ATRIPLEX CORRUGATA MAT SALTBUH	X	X			X	X	X				X	X		4000 - 7000	60
ATRIPLEX CUNEATA CASTLE VALLEY CLOVER			X		X	X	X	X			X	X		4000 - 6000	30
ATRIPLEX GARDNERI GARDNER SALTBUH	X	X			X	X	X	X			X	X		4000 - 6000	112
ATRIPLEX TRIDENTATA TRIDENT SALTBUH			X		X		X				X	X		4000 - 6500	112
CEANOTHUS VELUTINUS SNOWBRUSH CEANOTHUS	X	X	X		X	X	X					X		6000 - 11000	94
CERATOLDES LAHATA WINTERFAT	X	X			X	X	X	X	X		X	X		4000 - 9000	70

SPECIES	EXPOSURE ¹			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 8
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	M	R		SEED ² SIZE
<i>CERCOCARPUS LEDIFOLIUS</i> CURLLEAF MOUNTAIN MAHOGANY		X		X	X	X				X	X			5000 - 8000	52
<i>CERCOCARPUS MONTANUS</i> TRUE MOUNTAIN MAHOGANY	X		X	X	X	X				X	X			4000 - 8500	59
<i>CHRYSOTHAMMUS NAUSEOSUS ALBICAULIS</i> WHITESTEM RUBBER RABBITBRUSH		X	X	X	X	X	X	X		X	X	X		4000 - 8000	400
<i>CORNUS STOLONIFERA</i> RED-OSIER DOGWOOD	X	X	X	X	X	X	X					X	X	5500 - 10000	17
<i>COWANIA MEXICANA</i> CLIFFROSE		X		X	X	X	X			X	X	X		4000 - 8000	64
<i>EPHEDRA NEVADENSIS</i> NEVADA MORMON TEA	X	X	X	X	X		X			X	X			4000 - 7000	20
<i>EPHEDRA VIRIDIS</i> GREEN MORMON TEA		X		X	X		X	X	X	X	X			4000 - 7500	25
<i>GRAYIA SPINOSA</i> SPINY HOPSAGE		X		X			X	X		X	X			4000 - 7000	167
<i>HOLODISCUS DUMOSUS</i> ROCK SPIREA	X	X	X	X	X		X			X	X	X		4000 - 9500	
<i>MAHONIA REPENS</i> CREEPING OREGON GRAPE	X		X	X	X						X			5500 - 11000	60
<i>PACHYSTIMA MYRSINITES</i> MOUNTAIN LOVER	X		X	X						X				6000 - 9000	0
<i>PRUNUS VIRGINIANA</i> CHOKECHERRY	X	X	X	X	X	X				X	X			5500 - 8500	5
<i>BURSHIA TRIDENTATA</i> BITTERBRUSH		X	X	X	X	X	X			X	X			4000 - 9000	15
<i>RHUS GLABRA</i> SMOOTH SUMAC		X		X						X	X			5500 - 8500	49
<i>RHUS TRILOBATA</i> SQUAWBUSH	X	X	X	X	X	X				X	X	X	X	4200 - 11000	21
<i>ROSA WOODSII</i> WOODS ROSE	X	X	X	X	X	X	X			X	X	X		4000 - 11000	45
<i>SALIX</i> SPP. WILLOWS	X	X	X	X	X	X				X	X			4000 - 11000	0

SPECIES	EXPOSURE ¹			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 8
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	H	R		SEED ² SIZE
SAMBUCUS CERULEA BLUE ELDERBERRY	X	X	X				X					X	X	6000 - 8500	217
SAMBUCUS RACEMOSA RED ELDERBERRY	X	X	X				X					X	X	7500 - 11000	286
SHEPHERDIA ARGENTEA SILVERLEAF BUFFALOBERRY	X		X	X	X	X						X	X	4000 - 7500	45
SYMPHORICARPOS ALBUS COMMON SNOWBERRY							X					X		4000 - 8000	76
SYMPHORICARPOS LONGIFLORUS LONGFLOWER SNOWBERRY		X					X					X	X	4000 - 6000	0
SYMPHORICARPOS DREOPHILLUS MOUNTAIN SNOWBERRY	X	X					X					X	X	4800 - 9000	75

SPECIES	EXPOSURE ¹			SOIL TYPE					PRECIP RANGE				ELEVATION RANGE		PAGE 10 SEED ² SIZE
	N/E	S/W	LEV	SA	SI	CL	R	S	A	D	L	M	R		
TREES:															
<i>ABIES CONCOLOR</i> WHITE FIR	X	X		X						X	X			5000 - 9500	0
<i>ACER GLABRUM</i> ROCKY MOUNTAIN MAPLE	X	X		X						X	X			6000 - 9000	14
<i>ACER GRANDIDENTATUM</i> BIGTOOTH MAPLE	X	X	X	X	X					X	X			4500 - 7500	0
<i>BETULA OCCIDENTALIS</i> WATER BIRCH			X	X	X	X	X			X				5000 - 8000	0
<i>JUNIPERUS SCOPULARIUM</i> ROCKY MOUNTAIN JUNIPER		X	X	X	X	X				X	X			6000 - 9000	0
<i>PICEA ENGELMANNI</i> ENGLEMAN SPRUCE	X		X	X						X	X			7000 - 12000	135
<i>PICEA BUNGENS</i> BLUE SPRUCE		X		X						X				6500 - 8000	106
<i>PINUS ARISTATA</i> BRISTLEcone PINE	X	X	X	X						X	X			6500 - 10000	18
<i>PINUS CONTORA</i> LODGEPOLE PINE	X	X		X						X				6500 - 10000	94
<i>PINUS EDULIS</i> PYNION PINE		X	X	X	X					X	X			5000 - 7500	0
<i>PINUS PONDEROSA</i> PONDEROSA PINE		X	X	X	X					X	X			5000 - 8000	12
<i>POPULUS ANGUSTIFOLIA</i> NARROWLEAF COTTONWOOD			X	X	X	X	X			X				4000 - 8000	0
<i>POPULUS TREMULOIDES</i> QUAKING ASPEN	X	X	X	X	X					X	X			5500 - 10000	0
<i>PSEUDOTSUGA MENZIESII</i> DOUGLAS FIR	X		X	X	X					X				5000 - 8000	38

* ANNUAL GRASSES TO BE USED AS COVER CROPS.

¹ EXPOSURE - N/E = NORTH TO EAST, S/W = SOUTH TO WEST, LEV = LEVEL

SOIL TYPE (TEXTURE) - SA = SANDY, SI = SILTY, CL = CLAY, R = ROCKY, S = SALT TOLERANT, A = ALKALINE TOLERANT

² PRECIPITATION RANGE - D = DROUGHT TOLERANT (<10"), L = 10"-16", M = >16", R = WETLAND/RIPARIAN AREAS

SEED SIZE IN 1,000S. IF = TO 0 THEN TRANSPLANTS SHOULD BE USED OR DATA NOT AVAILABLE.

Appendix C

REVEGETATION MONITORING GUIDELINES

Introduction

These guidelines are intended to aid the applicant in formulating a monitoring plan, an essential part of a complete revegetation plan, which will meet the requirements and performance standards of UMC 784.13 (SMC 780.18) and UMC 817.116 (SMC 816.116.)

All revegetated areas, whether they are interim or permanent revegetation efforts, should be monitored. The frequency and type of sampling will depend on the purpose of the revegetation. For example, reconnaissance sampling may be sufficient for an interim reclamation project implemented solely for temporary land stabilization. Frequent, quantitative sampling may be desirable for test plots or an interim reclamation area being used to test the permanent reclamation seed mix.

Essential Elements of a Monitoring Plan

A. Schedule

The monitoring schedule should include frequency and season of monitoring. In general, monitoring should be conducted at least once during the growing season, preferably when the vegetation stand is at its peak which is usually during late June to August. In order to compare results between years, monitoring should occur on approximately the same dates each year. See Table 1 for recommended monitoring schedule.

B. Monitoring Methods and Parameters

Methods employed should be consistent from year to year. Plots or transects can be either randomly located each year, or randomly located and permanently marked with rebar or roof bolts to ensure that the same plots are measured each year. Individual plants can be permanently tagged and checked yearly to determine survival rate. Permanent plots are particularly useful for species composition and shrub survival data.

Two types of monitoring should occur, those being 'qualitative' or 'reconnaissance' surveys and 'quantitative' sampling. These are discussed in detail below.

1. Reconnaissance Survey. Visit each reclamation site and qualitatively record observations. No formal sampling or statistical analysis is necessary. However, the following observations are to be made:
 - a. Note all species which are growing on the site, whether seeded (planted) or invading from surrounding areas. For years of quantitative sampling, this would also include all species observed outside of sample plots.
 - b. Note whether or not grazing or browsing has occurred by wildlife or domestic animals and, if so, which species are being utilized.
 - c. Note wind, water and mechanical (e.g. trampling) erosion.
 - d. Record any special problem areas or unusual plant development as a result of disease, insect or pest infestations, etc. or areas of poor vegetation, due to toxic or acidic materials, lack or excess of fertilizer, etc.
 - e. Note special conditions or circumstances, e.g. sampling conducted during drought year or during unusually wet year, plot disturbance by off road vehicles, etc.
2. Quantitative Sampling. Measure each specific parameter to be tested for the given year. Parameters sampled (cover, frequency, woody plant density, survival, etc.) depend on both the objective of a specific sampling period and the postmining land use of the revegetated area. See UMC 817.116 (SMC 816.116) for success standard parameters specific to postmining land uses and the Division's Vegetation Information Guidelines for descriptions of acceptable sampling methods.

C. Evaluation of Data

The monitoring plan must indicate the level at which revegetation would be deemed unsuccessful during early monitoring and would, therefore, prompt remedial action. The plan should refer to contingency or maintenance plans to correct problem areas.

The plan should describe reference areas or other standards to be used to determine revegetation success and indicate the level of statistical confidence which will be met (see the Division's Vegetation Information Guidelines).

D. Monitoring Report

The operator must include a summary of all reclamation activities as part of the annual report. This includes a monitoring report for all revegetated areas. The monitoring report should include at a minimum:

1. A map showing revegetated areas and test plots;
2. A table which identifies each revegetated area, the year it was seeded, and the seed mix, mulch, methods used, etc.;
3. An analysis of the data collected or the results of the reconnaissance survey; and
4. Recommendations to correct any problem areas.

Table 1. Recommended Monitoring Schedule.

QUALITATIVE OBSERVATIONS:

<u>Reclamation type</u>	YEAR									
	1	2	3	4	5	6	7	8	9	10
Permanent Reclamation	X	X	X	X	X	X	X	X	X	X
Trial Plantings	X	X	X	X	X	X	X	X	X	X
Test Plots	X	X	X	X	X	X	X	X	X	X
Interim Stabilization	X	X	X	X	X	X	X	X	X	X

QUANTITATIVE OBSERVATIONS:

<u>Parameter</u>	YEAR									
	1	2	3	4	5	6	7	8	9	10
Cover		X	X		X				X	X
Frequency		X	X		X				X	X
Woody Plant Density		X	X		X				X	X
Transplant Survival	X*	X	X							
Productivity:										
Test plots			X		X				X	X
All Other Revegetation**									X	X

* For spring planting, "year 1" sampling would occur in the fall of the planting year.

** For croplands, submit actual crop production each year (1-10).

Note: This schedule is for a mine with a 10-year extended liability period. For a mine with a 5-year period, years 9 and 10 sampling would occur during years 4 and 5 respectively.