CHAPTER 23

REVETATION PLAN

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REVEGETATION PLAN
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CHAPTER 23
REVEGETATION PLAN

Introduction

The Revegetation Plan is designed to restore all lands affected by mining operations to a condition capable of supporting the postmining land uses of rangeland grazing, wildlife habitat, and cultural plants. The elements of the plan detailed in the following sections are those activities conducted on reclaimed lands following the completion of grading and minesoil reconstruction.

The Revegetation Plan will provide several inter-related vegetal and non-vegetal components in the reclaimed landscapes, each of which is designed to perform specific functions. These components include general purpose rangeland, shrubland and woodland habitat areas, cultural plant sites, and non-vegetal habitat enhancement. The rangeland component is intended primarily to support livestock grazing, while simultaneously providing utility for wildlife food and cover, and a potential source of culturally significant plant materials. Shrubland and woodland habitat areas are established around selected ponds and as islands interspersed within the rangeland component. These habitat areas are located primarily on north facing slopes but may also be located adjacent to ridgelines and along drainage bottoms. These areas are located to improve landscape and community diversity, develop diverse habitat features, establish travel corridors, improve the use of the larger and more open rangeland areas, diversify and increase the prey base for predatory mammals and raptors, provide a source of culturally significant plant materials, and provide sources of native plant propagules for migration into the surrounding rangeland vegetation. The non-vegetal component, consisting of rock features and raptor perches, is intended to further enhance the reclaimed landscape for wildlife. Culturally significant plant sites are normally collocated with habitat sites on upland, predominantly north facing slopes. Specifics of these components are discussed within the various sections of the Revegetation Plan.

The Revegetation Plan is designed to establish diverse, effective, and permanent vegetation that is similar in seasonal variety, diversity and plant composition when compared to the native vegetation on the leasehold. Habitat and culturally significant plant sites provide structural diversity and increased community diversity within the reclaimed landscape. However, the disturbances associated with surface mining, the inherent limitations in revegetation technology, and the lengthy successional

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timeframes in the arid southwest, preclude the reclaimed plant communities from completely mimicking the undisturbed sites. Ecological succession is encouraged using various reclamation procedures including minesoil reconstruction using soil or suitable plant growth substitutes, direct hauling of soiling materials, rapid soil stabilization, seeding and planting methods, planting arrangements, and the maximized use of primarily native plant materials that are adapted to Black Mesa site conditions.

Seed mixes, planting combinations, and revegetation techniques have been developed through various procedures and guidelines. First, the native vegetation communities were evaluated including species composition and the site characteristics influencing speciation and their functionality. From this information the feasibility of reestablishing similar vegetation communities or components in the reclaimed landscape was determined. Emphasis was placed on the dominant species in the various communities and what ecological factors contributed to their success. Second, the range of site characteristics that occur in reclaimed areas was examined to determine what species had the adaptive capacity to establish and be sustaining in the reclaimed environment. Species selection criteria (heavily influenced by autecological characteristics and synecological relationships) were then concentrated on maximizing native species in the mixes and planting combinations, returning a level of species diversity, controlling erosion, providing high utility for livestock, wildlife, and other land uses, and considering the commercial availability of plant materials. Since direct hauling of topsoil is practiced whenever feasible, it was also realized that viable plant propagules and soil microbial populations in "live" soiling materials would increase the potential for additional establishment of native species. In addition, salvaging residual soils and utilizing other suitable plant growth media where feasible would allow the creation of a wider range of plant growth media and site characteristics which in turn creates greater flexibility in species selection and eventual plant community diversity. Thus, creation of increased spatial variability of substrates and species selection provides opportunities for a greater presence of diverse organisms (WRDC and Bunin, 1985).

The Revegetation Plan reflects newly developed or existing best technology reclamation procedures. In addition, experience and in-house procedures have selected the most appropriate of these procedures to be used at any given time or under any field conditions.

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In summary, the objectives of the revegetation program are:

1. To establish on all lands that are disturbed by mining or related activities, except water areas, the surface area of roads, or under facilities that are approved for the postmining land use, a diverse, effective, and permanent vegetation that is compatible with postmining land use objectives, satisfy revegetation success criteria, and provide a mosaic of varying vegetal landscapes.
2. To achieve revegetation in a contemporaneous manner.
3. To stabilize and protect soil resources with respect to erosion.
4. To develop highly productive and nutritional grazing resources adaptive to grazing management systems.
5. To enhance wildlife habitat in the postmining landscape.
6. And to provide a source of culturally significant plant materials.

Rangeland Revegetation Methods and Materials

Site Preparation. Upon completion of final grading and minesoil reconstruction, reclaimed areas are contour ripped with multi-shanked, deep rippers using dozers, graders, or farm equipment. Following ripping, reclaimed lands with replaced soils are contour furrowed using a modified offset disk. This large offset disk has a standard front gang retained and the rear gang modified to include 36-inch diameter disks spaced 36 inches apart. The modified rear disk gang creates furrows on the reclaimed landscape that are 9 to 18 inches deep with 36-inch spacing. The front unmodified disk gang aids in seedbed preparation by loosening and breaking up the soil. This disk is also used to control heavy annual weed infestations that have established prior to seeding operations. The disking operation reduces compaction, improves permeability and infiltration, increases rooting depths potential, retards and retains overland surface water flow, decreases runoff, and reduces erosion. While ripping operations are conducted approximately on the contour, disking operations are conducted strictly on the contour which necessarily keeps all subsequent operations on the contour. Refer to Chapters 22 and 26 for a complete discussion of minesoil reconstruction and surface stabilization.

Fertilization. PWCC does not add fertilizer amendments to reclaimed areas as normal practice. The perennial species contained in the permanent seed mixes are adapted to low fertility environments. This improves the seeded perennial species advantage since annual weedy plants and volunteer grains from mulch can quickly and significantly

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increase in stand density and biomass under enhanced soil nutrient regimes resulting from fertilizer applications.

Specific revegetation goals may require fertilizer amendments. If a reclaimed unit is to receive a fertilizer application, it will be based on technical literature recommendations or evaluation of soil tests or soils information contained in Chapter 8, Soil Resources and Overburden.

Plant Material Lists. PWCC will use the rangeland seed mix presented in Table 1 for lands reclaimed primarily as grazing land and to establish high density shrublands. The rangeland mix includes warm and cool season components as well as forbs and shrubs. The mix may also be used to interseed existing revegetated lands. A range of seeding rates are presented in Table 1 to compensate for seed availability and variability in application rates or methods (drilled versus broadcast rates) and to achieve varying revegetation goals. This range allows for adjusting mixtures to a specific reclamation requirement. As an example, interseeding may require a lighter application rate or a higher shrub component may be desired in the reclaimed landscape.

The rangeland seed mix contains a minimum of nine warm season species and eight cool season species, three cool-warm species, eleven perennial grasses, five perennial forbs, and four subshrubs/shrubs. Five of the grasses are warm season species (blue grama, sideoats grama, sand dropseed, galleta, and alkali sacaton). The remaining six grasses are cool season species (thickspike wheatgrass, western wheatgrass, pubescent wheatgrass, beardless bluebunch wheatgrass, Russian wildrye, and Indian ricegrass). All of the warm season grasses are native. Four of the cool season grasses are native (thickspike wheatgrass, western wheatgrass, beardless bluebunch wheatgrass, and Indian ricegrass), and two are introduced (pubescent wheatgrass and Russian wildrye). Two of the cool season forbs are introduced (sainfoin and small burnet). Lewis flax, prairie coneflower, and Palmer penstemon are native forbs with cool season growth characteristics. The shrub component consists of four warm season chenopod shrubs, including the natives fourwing saltbush, shadscale, and winter fat, and the introduced subshrub prostrate kochia. Shrub seeding rates are high to aid in establishing high density shrubland.

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Selections of grass, forb, and shrub species from Appendix A, Table A-1 may be added or substituted for species in the rangeland seed mix based upon primary species availability

TABLE 1. Rangeland Seed Mix[1]

Common Name	Scientific Name	Drilled Rate PLS Lbs/Acre	PLS Seeds per Ft^2	Seasonality[2]	Lifeform[3]
1. Thickspike wheatgrass	Agropyron dasystachyum	1.0 - 2.0	3.5 - 7.0	C	G
2. Western wheatgrass	Agropyron smithii	2.0 - 3.0	5.0 - 7.5	C	G
3. Pubescent wheatgrass	Agropyron trichophorum	0.5 - 1.0	1.1 - 2.2	C	G
4. Beardless bluebunch wheatgrass	Agropyron inerme	0.5 - 1.0	1.3 - 2.7	C	G
5. Russian wildrye	Elymus junceus	0.5 - 1.0	2.0 - 4.0	C	G
6. Indian ricegrass	Oryzopsis hymenoides	1.0 - 2.0	3.2 - 6.4	C-W	G
7. Sainfoin	Onobrychis viciaefolia	1.0 - 3.0	0.7 - 2.1	C-W	F
8. Prostrate kochia*	Kochia prostrata	0.25 - 0.5	2.3 - 4.6	W	S
9. Fourwing saltbush	Atriplex canescens	2.0 - 5.0	2.4 - 6.0	W	S
10. Winterfat*	Eurotia lanata	1.0 - 2.0	2.5 - 5.0	W	S
11. Shadscale	Atriplex confertifolia	1.0 - 2.0	1.5 - 3.0	W	S
12. Blue grama*	Bouteloua gracilis	0.5 - 1.0	9.8 - 19.5	W	G
13. Sideoats grama	Bouteloua curtipendula	1.0 - 2.0	4.5 - 9.0	W	G
14. Sand dropseed*	Sporobolus cryptandrus	0.05 - 0.1	6.0 - 12.1	W	G
15. Galleta (florets)	Hilaria jamesii	1.0 - 2.0	3.9 - 7.8	W	G
16. Alkali sacaton*	Sporobolus airoides	0.25 - 0.5	10.0 - 20.0	W	G
17. Lewis flax	Linum lewisii	0.5 - 1.0	3.3 - 6.6	C	F
18. Prairie coneflower*	Ratibida columnaris	0.1 - 0.3	2.1 - 6.2	C-W	F
19. Small burnet	Sanquisorba minor	1.0 - 2.0	1.3 - 2.6	C	F
20. Palmer penstemon*	Penstemon palmeri	0.1 - 0.2	1.4 - 2.8	C	F
	Total	15.25 - 31.6	67.8 - 137.1		

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[1] Also used to establish high density shrubland.

[2] Seasonality: C = cool, W = warm.

[3] Lifeform: G = grass, F = forb, S = shrub.

NOTE: Species identified with an asterisk will be broadcast seeded.

or desired stand composition. Substitutions will generally be made with species of comparable seasonality and life form to those in the standard mix being substituted. Any grass, forb, or shrub species found in Appendix A, Table A-1 may be added to the rangeland seed mix. The majority of species in Table A-1 are native.

The approximate composition of the various growth forms in the Rangeland Seed Mix (based on PLS seeds/square foot) is as follows: 1) cool season grasses (23 percent); 2) warm season grasses (50 percent); 3) forbs (13 percent); and 4) shrubs (14 percent). The seed mix is designed to achieve a diverse composition of warm and cool season grasses, forbs, and shrubs. The warm season grass seeding rates are increased in the composition of the mix to compensate for their difficulty in establishment. The forb and shrub components represent nearly 30 percent of the seed mix composition. The high seeding rates for woody plants aid in establishment of high density shrubland areas within the overall rangeland revegetation.

The Drainage Channel/Small Depression Seed Mix is detailed in Table 1A. It is used for permanent seeding of drainages, downdrains, and small depressions. The selection criteria for the mix includes species that can establish under dry conditions, are drought tolerant after establishment but can also tolerate periodic flows or inundation, tolerate alkaline and saline soils, can grow on a range of soil textures, and are particularly adapted to fine textured soils. Further consideration included use of sod forming grasses, large bunchgrasses to provide increased stature and surface roughness, and woody plants to enhance surface roughness and channel stability while providing more structural diversity and wildlife habitat potential. Once established, the seeded stand will provide good channel stability.

The 11 species in this mix include six warm season species (two grasses and four shrubs), four cool season grasses, and one cool season forb. Eight of the eleven species are native.

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Reclamation Sequencing and Seeding Methods. The seeding methods described in the following paragraphs are dependent on the sequence of reclamation activities and variations within those activities. The variation is required for operational flexibility, consideration of different physiological requirements for germination and establishment of the many species included in the standard mix, consideration of varying

TABLE 1A. Drainage Channel/Small Depression Seed Mix

Common Name	Scientific Name	Drilled Rate PLS Lbs/Acre	PLS Seeds per Ft^2	Seasonality[1]	Lifeform[2]
1. Western wheatgrass	Agropyron smithii	2.0 - 3.0	5.1 - 7.7	C	G
2. Streambank wheatgrass	Agropyron riparium	2.0 - 3.0	7.2 - 10.8	C	G
3. Tall wheatgrass	Agropyron elongatum	1.0 - 2.0	1.8 - 3.6	C	G
4. Inland saltgrass*	Distichlis stricta	0.1 - 0.2	1.2 - 2.4	W	G
5. Basin wildrye	Elymus cinereus	1.0 - 2.0	3.0 - 6.0	C	G
6. Prostrate kochia*	Kochia prostrata	0.25 - 0.5	2.3 - 4.6	W	S
7. Fourwing saltbush	Atriplex canescens	3.0 - 5.0	3.6 - 6.0	W	S
8. Shadscale	Atriplex confertifolia	1.0 - 2.0	1.5 - 3.0	W	S
9. Alkali sacaton*	Sporobolus airoides	0.25 - 0.5	10.0 - 20.0	W	G
10. Small burnet	Sanquisorba minor	2.0 - 3.0	2.6 - 3.9	C	F
11. Greasewood	Sarcobatus vermicuulatus	0.25 - 1.0	1.2 - 4.8	W	S
	Total	12.85 - 22.2	39.5 - 72.8		

[1] Seasonality: C = cool season, W = warm season.

[2] Lifeform: G = grass, F = forb, S = shrub.

NOTE: Species identified with an asterisk will be broadcast seeded.

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climatic affects, and the timing of various reclamation activities. Figure 1, "Reclamation Sequencing and Revegetation Activities", shows the sequence of reclamation starting with backfilling and grading, the interrelationships between the activities, and the cause-and-effect relationships between activities. The latter may control the timing and the method of application for a reclamation practice implemented during these activities.

Backfilling and grading activities occur throughout the year, while soil replacement is carried out primarily from mid-March to November. Soil replacement activities outside of that period are carried out when favorable handling or weather conditions exist. Mechanical surface manipulations, including deep ripping and contour furrow disking are conducted following soil replacement. Suitable plant growth media replacement areas are normally deep ripped only. Terraces and locations of downdrains or other conveyances may be established either before or after the mechanical surface manipulations however, ripping and contour furrowing are not conducted on the terrace berms (see Chapter 26, Surface Stabilization Plan).

Mulching operations, either as an anchored hay or straw mulch, are conducted following seeding. Hay mulch blown on the surface and crimped following seeding is the primary mulching method. Straw mulch, blown and crimped, is a secondary mulching method used primarily for temporary disturbance and topsoil stockpile stabilization. Mulching is detailed below in "Mulching and Other Soil Stabilization Practices".

In order to maximize the successful germination and establishment of the species in the rangeland seed mix, seeding practices must be compatible with the species to be seeded, anticipated climatic conditions, and other reclamation practices. This will ensure that revegetated areas are diverse and capable of achieving the intended postmining land uses. The primary planting season is dictated by precipitation patterns and periods of optimal soil moisture and temperature, assuming that topsoiling and site preparation activities are completed. These relationships are illustrated in Figure 1. Average annual precipitation for the Black Mesa Complex is approximately 8 inches and is characterized by bimodal precipitation patterns with precipitation similar to the southwestern desert patterns. A slight increase in precipitation can be expected in the winter through March, while nearly half of the annual precipitation can be expected in the period of July, August, and September. Temperatures are influenced by the approximately 7000 foot elevation of Black

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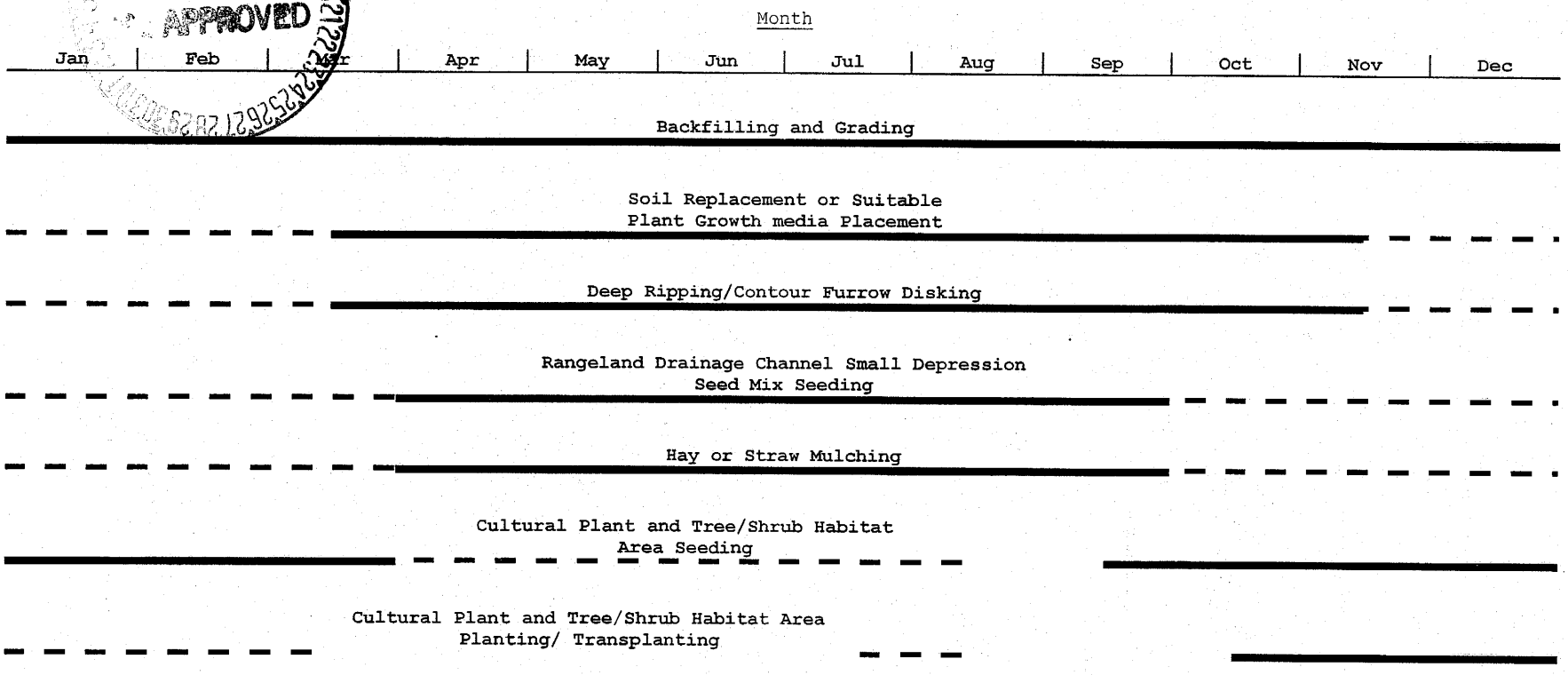
FIGURE 1

Reclamation Sequencing and Revegetation Activities



Notes:

Denotes period of maximum effort and optimum time frame for a treatment or practice.

Denotes periods outside of the optimum time frame where, under proper conditions, a treatment or practice may be used.

Downdrains and drainages are located during backfilling and grading, terraces are generally constructed after topsoil replacement (see Chapters 21 and 26).

Mesa with cold winters and mild summers that include upper daytime temperatures in the upper 80's to low 90's in July, August, and early September. The warm soil temperatures encourage better germination. Therefore the primary seeding season for permanent seed mixes is from April through September. The remainder of the year is considered the secondary season and seeding can be conducted when ground conditions are favorable.

Rangeland or Drainage Channel/Small Depression Seed Mix and cultural plant/habitat site seeding applications will be completed throughout the primary seeding season (April to September) as prepared seeding areas become available. As many acres as possible will be permanently seeded during this window however, logistics, the number of acres that need to be seeded, and operational considerations may require some seeding of these permanent seed mixes outside of the primary season.

If the permanent seed mixes are not seeded during the secondary seeding season, the soiled area will be ripped and/or disked on the contour and then permanently seeded and mulched during the next available primary seeding season. PWCC has found the resulting rough surface configuration to be highly effective for short-term stabilization.

Timing of seeding, aspect, slope, microsite conditions, soil characteristics, and climatic patterns dictate, to a great extent, the resulting stand composition. Late spring and summer seeding (primary season) enhances the establishment of the warm season and woody component of the seed mix when higher soil temperatures and moisture conditions (summer monsoon precipitation) favor their establishment. Fall, late winter, and early spring seeding (secondary season) favor the cool season component of the seed mix when lower soil temperatures and moisture conditions from frontal precipitation patterns and snowmelt are present. A residual seed bank of seeded species can remain in the seeded stand for some time allowing for continued germination and establishment. The resulting reclaimed tracts have good spatial variability in composition and seasonal variety, while providing excellent forage production, ground cover, and more diverse habitat.

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Seeding is accomplished using seed drills equipped with furrowing disks and multiple seed boxes, mechanical broadcast seeders, or hand seeding techniques. Current practice is to use a combination of drill and broadcast seeding as much as possible because of their versatility, proper seed metering, proper seeding depth for a variety of species, and ability to handle rough conditions. When logistics or site conditions prevent normal drill seeding

operations (e.g., small areas, areas with poor access, overly steep slopes, and rocky conditions), mechanical or hand broadcast seeding is employed. PWCC uses two types of drill seeders. A Truax seeder is used for the majority of seeding operations, while a heavy duty Rangeland drill is used for rough or rocky site conditions or interseeding.

The permanent seed mixes contain species with variable seed size, physical characteristics and planting depth requirements. Certain species are inherently difficult to seed because of seed morphology or high trash content associated with plant materials. To overcome these difficulties, the drill seeding equipment is equipped with multiple seed boxes to handle seed variability and differing seedbed ecology needs. The seed drop tubes can be manipulated to allow seed with shallow seeding depth requirements to be broadcast on the ground and lightly covered by drag chains, while seed requiring deeper coverage is dropped in the drill disk furrows and covered. Both the Truax and Laird rangeland drill seeders are similarly equipped and capable of seeding as described above.

The remaining reclamation practices including mulching and planting of cultural plants, shrubs and trees and associated wildlife habitat development and enhancement are discussed in detail in following sections of this chapter.

Mulching and Other Soil Stabilization Practices. Surface mulches are beneficial to vegetation establishment and provide surface soil stability by reducing wind and water erosion (Brammer, 1982; Plass, 1987; and Valentine, 1971). Mulching also enhances vegetation establishment by modifying seedbed microclimate characteristics, reducing loss of soil moisture and crusting, and increasing infiltration. The primary mulch used is native grass hay with grain straw used as a secondary mulching material and for temporary stabilization. The more specialized excelsior/straw type mattes or wattles and geotextile fabrics are used for rill and gully repair or localized site stabilization.

The Surface Stabilization Plan implemented during various phases of reclamation is presented in Chapter 26. Attachment B, "Terrace Spacing" to that chapter was developed as supporting documentation for the terracing program, a component of the overall surface stabilization plan. The Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978), updated in a USDA-ARS revised program titled Revised USLE (RUSLE) (Simanton, 1987), and further revised in 2003 (Toy and Foster, 2003) for reclamation operations was used to estimate soil loss when

terraces and BTCA practices, including contouring/surface roughness, mulching, and permanent vegetation were applied to reclaimed lands. The soil loss estimates derived from the RUSLE program runs support the effectiveness of the BTCA practices. The values for factor C (cover and management) used in the RUSLE program to determine newly reclaimed soil loss estimates were based on applied levels of native grass hay mulch. When these methods and expected levels of cover were evaluated using the C factor subroutine in the RUSLE program, the resultant low C factors were estimated to range from .050 to 0.55 for native grass hay mulching. These values, which reflect a high level of effectiveness, were determined through inputs that represent applied reclamation procedures and the resulting surface conditions specific to the Black Mesa complex.

PWCC will primarily stabilize all revegetated areas with anchored native grass hay and secondarily anchored straw mulch. Straw mulch will be used on all temporary revegetation and only on permanent revegetation when native grass hay is unavailable and a site needs immediate protection. Mulch, whether as native grass hay or annual grain straw, will be applied uniformly at an approximate rate of two tons/acre. All mulching materials will be clean and not contain noxious weeds. The mulch will be anchored by mechanical crimping. A tackifying agent would be an alternate anchoring method.

Areas that have been soiled outside of the primary seeding season and which will be permanently seeded during the next available primary seeding season will be ripped and disked on the contour as temporary stabilization without application of a mulch. The ripping and disking operations leave a very rough surface and contour disking features that further reduce wind erosion and runoff, trap snow, and increase infiltration. This fallow period allows the replaced soils to settle and develop a more firm and effective seedbed. Soil moisture is recharged in the profile as well. The effectiveness of PWCC's contouring/tillage practice is demonstrated by low P factor values in RUSLE evaluations presented in Attachment B to Chapter 26. These P factor values range from 0.36 to 0.39.

Soil replacement activities are maximized from mid-March to November (Figure 1). Soil replacement outside of that period occurs on an opportunistic basis dependent on soil conditions or adverse weather. Soil replaced from January to April and then again from

approximately October through December may be permanently seeded or the site will be contour ripped and disked to provide the necessary surface stabilization. Heavy rain or snowfall events are not common during the fall and winter months on Black Mesa and the surface roughness created by deep ripping and contour furrowing will provide interim stabilization. If conditions are suitable for seeding during the secondary season, the area will be seeded with the permanent seed mix and mulched. During the primary seeding period from April through September, native grass hay mulch will be applied on all soiled areas after seeding the permanent seed mixes.

Remedial stabilization, using hay or straw mulch, will be carried out on areas where the potential for soil loss, or otherwise unstable surface conditions may develop. In these situations, the permanent seed mix will be seeded, straw or hay will be blown on at an approximate rate of two tons/acre and anchored by crimping or through the use of a tackifying agent. Crimping or tackifying agents will be necessary in this situation since contour furrowing/disking operations had been carried out previously.

More intensive forms of surface stabilization including hydromulch, geotextile fabrics, organic fiber netting, plastic netting, wood chip, rock or stone mulches, and riprap may be used for stabilization. Many of these are discussed in Chapter 26, Surface Stabilization Plan.

Supplemental Revegetation Measures

Temporary Stabilization. Temporary and pond stabilization mixes are presented in Table 2. These mixes are to be used for topsoil stockpiles, road cut and fill sections, facilities areas, pond sites, or any other sites which may require a delay in final reclamation activities. The mixes include core species from the rangeland seed mix that have demonstrated quick establishment and effectiveness of vegetative cover under varying conditions.

The pond area stabilization mix includes a greater number of species to ensure effective vegetative cover and that can establish under varying moisture regimes. A more diverse mix

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TABLE 2. Seed Mixes for Temporary and Pond Area Stabilization

Temporary Stabilization Mix

Common Name	Scientific Name	Drilled Rate* PLS lbs/Ac	Drilled Rate* Seeds/ft²
Pubescent wheatgrass	Agropyron trichophorum	4.0	8.8
Thickspike wheatgrass	Agropyron dasystachyum	3.0	10.5
Russian wildrye	Elymus junceus	3.0	12.0
Yellow sweetclover	Melilotus officinalis	1.0	6.0
Total:		11.0	37.3

Pond Area Stabilization Mix

Common Name	Scientific Name	Drilled Rate* PLS lbs/Ac	Drilled Rate* Seeds/ft²
Pubescent wheatgrass	Agropyron trichophorum	2.0	4.4
Thickspike wheatgrass	Agropyron dasystachyum	2.0	7.0
Russian wildrye	Elymus junceus	2.0	8.0
Western wheatgrass	Agropyron smithii	3.0	7.5
Small burnet	Sanquisorba minor	3.0	3.9
Fourwing saltbush	Atriplex canescens	3.0	3.6
Blue flax	Linum lewisii	1.0	6.6
Basin wildrye	Elymus cinereus	1.0	3.8
Total		17.0	44.8

*Broadcast seeding rate is double the drilled rate.

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of perennial species is included in this mix in comparison to the temporary stabilization mix in the event that a pond may be retained as a permanent site.

Annual grain, including wheat or barley, may be seeded on topsoil stockpiles that are in place for less than a year. Annual grains will be applied at 40 to 60 pounds per acre for drill seeding and up to double this rate for broadcast seeding.

Rill and Gully Repair. A rill and gully repair seed mix is presented in Table 3. It may be used in all rill and gully repair areas in order to establish a quick and effective vegetative cover. The mix includes sodforming cool season grasses that have established quickly and performed well in reclaimed areas at Black Mesa. Fourwing saltbush and two forbs are included to further enhance ground cover and surface protection and provide diversity. This mix will be as effective as the rangeland seed mix in establishing effective ground cover, less costly, and will meet the postmine land use goals. This mix will be used only in rill and gully repair areas which have an areal extent of less than several acres. The rill and gully repair areas will be filled; scarified, ripped or disked; seeded and mulched, and then monitored.

Cultural Plant Establishment Methods and Materials

Introduction. Postmining land uses for reclaimed lands include livestock grazing, wildlife, and culturally important plants. Cultural plant use can have religious, medicinal, functional (e.g., utensils or building materials), or economic importance. The following plan has been developed to meet requests by the Navajo Nation and Hopi Tribe to return culturally important plants on reclaimed lands. The plan reflects a comprehensive and integrated approach and includes current best technology practices or development of new or improved technologies.

Potential Species. Table B-1 in Appendix B lists plant species considered for use in the cultural plant establishment program. The list was compiled from five primary references and information provided by traditional Navajo medicine men, herbalists, and residents living on Black Mesa. The Hopi Cultural Preservation Office also reviewed the list. The five references include Ethnobotany of the Navajo (Elmore, 1943), Ethnobotany of the Hopi (Whiting, 1939), Navajo Indian Medical Ethnobotany (Wyman and Harris, 1941), Nanise' - A Navajo Herbal (May[illegible] 1989), and Information on Plants Grown on Black Mesa

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TABLE 3. Rill and Gully Repair Mix

Common Name	Scientific Name	Drilled Rate* PLS lbs/Ac	Drilled Rate* Seeds/ft^2
Thickspike wheatgrass	Agropyron dasystachyum	4.0	14.0
Western wheatgrass	Agropyron smithii	4.0	10.0
Pubescent wheatgrass	Agropyron trichophorum	3.0	6.6
Fourwing saltbush	Atriplex canescens	4.0	4.8
Small burnet	Sanquisorba minor	3.0	3.9
Cicer milkvetch	Astragalus cicer	1.0	3.1
Total		19.0	42.4

*Broadcast seeding rate is double the drilled rate.

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(Navajo Health Authority, 1979). Contacts with medicine men, herbalists, and Black Mesa residents were made throughout 1995. A formal meeting was conducted in June 1995 to introduce the program to the local residents and gather more information on species for consideration or deletion from the list of potential species. Contacts regarding cultural plants continue and new species or information are added as necessary.

Table B-1 (Appendix B) includes over 120 potential species including at least 9 grasses, 76 forbs, 8 subshrubs, 20 shrubs, 5 trees, and 5 succulents. Efforts are concentrated on approximately 60 of the listed species that are more common in use, have broad application and meet a variety of land uses, or which were identified during interviews and site visits with residents, herbalists, and medicine men as particularly important. The list of species in use at any given time is dynamic, reflecting any additional species not currently listed or shifting priorities to other species on the list based on new information or feedback from contacts.

Plant Materials Sources. Plant materials include seed or nursery seedlings developed from Black Mesa site collections, regional native sources with similar habitat characteristics, or commercial sources. Pinyon pine, Utah juniper, and cliffrose are examples of species using Black Mesa site collected seed for nursery development. Penstemons, scarlet globemallow, and fourwing saltbush are examples of seed acquired from regional native sources; while blue grama and Indian ricegrass represent commercial native cultivar sources. Emphasis is on plant materials developed from Black Mesa site locations, thus using to advantage local genotypes that are site adapted and able to regenerate. Collections are taken from various stands to maintain genetic variation.

Plant Material Development. A number of the species have a low frequency of occurrence combined with poor or erratic seed production and little or no commercial availability. This has the potential to restrict the program because of limited availability of seed. To overcome these restrictions, additional collection sites have been or continue to be identified and information pertaining to seed collection methods, optimum collection periods, and appropriate seed cleaning and processing procedures have been developed. Sites previously planted with the site adapted germ plasm provide seed orchard opportunities and compliment native seed collections for seed increase of species that do not consistently produce the required quantity or quality of seed. Seed orchards can provide a more dependable source of viable seed where very large volumes of seed are not

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required. As a necessary component of the seed increase program, research is continuing on the more problematic species to determine plant growth, flowering, and fruiting requirements. This information will form the basis for development of appropriate seed increase technologies for a variety of species.

An intensive nursery program has been implemented to develop seedlings for out planting. Research has been conducted to determine germination treatments, propagation techniques, and nursery cultural practices for those species with little or no historical information. Varying cultural practices are used at the nursery to produce robust seedlings that have good root:shoot ratios, large stem calipers, and are sufficiently hardened-off to better adapt to field conditions. Seedlings remain in the nursery until adequately developed. Time in the nursery may be as long as one year for pinyon pine, dropping to as little as six months for some shrubs or forbs.

Development of specific nursery mycorrhizal inoculation methods have been implemented for all species. Restoration of critical plant-mycorrhizal symbiotic associations for southwestern native plant species is important for successful establishment, survival, and growth. Procedures include inoculation with commercial mycorrhizal strains or field collecting, isolating, and developing native mycorrhizal species and inoculating seedlings in the greenhouse. The intent is to establish effective mycorrhizal/plant associations before the seedlings leave the nursery. Greenhouse and nursery procedures are modified from standard procedures to insure higher rates of mycorrhizal infection on seedling roots. Successful development of these complex procedures enhances survival and growth of seedlings under field conditions.

Site Development. Regrading, topsoiling, seedbed, and planting site development procedures are discussed in Chapters 21, 22, and earlier in this chapter. Development of cultural plant sites follow procedures and methods for establishment of woodland and shrubland habitat sites. Direct haul and top-lift replacement of native soils, many classified as residual (e.g., scoria/red rock), are used to develop localized, select planting sites. Northerly facing, steep slopes (up to 3:1) will be the principal areas selected. The intent is to develop unique habitat or cultural plant sites that emphasize more mesic aspects and substrates with coarse textured or rocky soils similar to native sites that support pinyon-juniper and many cultural species. Spoil/soil suitability criteria in the cultural plant sites will be adjusted for several parameters from that

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presented in Chapter 22, Table 11. These adjusted parameters are presented below and better represent site conditions consistent with pinyon-juniper and cultural plant habitat.

pH (sat. paste)	unsuitable <4.5 or >8.8
EC (paste extract)	unsuitable >5 to 8 mmhos/cm

All other parameters in Table 11 (Chapter 22) remain unchanged.

These areas will pose no potential threat to successful establishment of vegetation since the sites are targeted for adapted plant species. Approximately five percent of the reclaimed lands reclaimed annually will include these types of sites. Potential areas of annual scoria placement will be discussed at the annual field meeting with OSMRE, the Navajo Nation and the Hopi tribe.

Seeding and Planting Methods. Cultural plants are established on all reclaimed areas using methods that result in extensive or localized establishment of cultural plant species through seeding, planting, and natural regeneration. The reclamation program emphasizes an ecological approach to reclamation that aids in restoring ecosystem function and conditions for successional development of reclaimed plant communities. This facilitates the reestablishment of culturally important plants in all reclaimed plant communities with varying composition and presence of these species.

Fertilizers are not applied on cultural planting sites. This is important for reducing annual weed competition, providing low fertility levels characteristic of native plant sites, and enhancing the reestablishment of mycorrhizal associations.

Tables 1 and A-1 (Appendix A) in this Chapter, detail the standard range mix and species that may be added or substituted. As applied, this mix normally contains about 25 species, with approximately 10 species identified as culturally important. The mix is seeded on the majority of permanently reclaimed areas and supports extensive establishment of cultural plants. Specific cultural plant sites are seeded with the core mix presented in Table 4 (see the Shrubland and Woodland Revegetation Section) which may included additional or substitute species from Table A-1 or Table B-1. Approximately 10 to 15 species, varying on availability or specific composition objectives for a site, are included in this cultural plant seed mix. Application of this seed mix is targeted towards localized cultural plant site development. Seeding methods follow the separate drill and broadcast application procedures outlined earlier in this chapter. Seeding is normally carried out at these sites during the summer or early fall.

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Nursery program seedlings will be planted in small, select sites either in combination with a cultural plant seed mix or alone. Planted densities will range from 1500 to 3000 seedlings per acre, comprised of varying combinations of woody species and forbs. Composition will vary depending on plant availability, individual site requirements, objectives, anticipated performance of planted species, or requests from local residents. Planting patterns will depend on the method of planting but a scattered, random distribution of seedlings will be encouraged. Planting will primarily be by hand as described later in this chapter. Planting period, handling, and protective measures are similar to that discussed in the following sections under Shrubland and Woodland Revegetation.

Additional Measures. Mulching of planted sites will only be done on topsoiled sites following seeding and before planting. Sites will be mulched with native grass hay. Topsoiled sites will be deep ripped and disked on the contour prior to mulching. Most of the cultural plant sites are developed from coarse textured or rocky materials and will not be mulched. Erosion will not be a problem on unmulched sites since the sites are small, the sites are ripped on the contour creating a high degree of surface roughness, and the planting sites often have numerous erosion resistant coarse fragments, rocks, or woody debris.

Monitoring and Evaluation. All cultural plant sites will be monitored on a continuing basis to evaluate the success of the seeding and planting programs. Monitoring will also track the development and successional change at the sites. Replanting or augmentation planting will be determined from the monitoring data and qualitative site evaluations. Any rework will be specific to each site. PWCC includes details of the annual planting program and any replanting/augmentation in annual reclamation reports submitted to OSMRE.

The cultural plant sites are enhancements in the overall reclaimed landscape and will be established in relatively small areas variously located in the reclaimed landscape. As such, they will be included in the overall sampling program and will fall under appropriate success criteria as presented later in this chapter.

Shrubland and Woodland Revegetation (Habitat Areas)

Introduction. The following describes methods and materials to establish shrubland and

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woodland areas within the reclaimed areas. Most, if not all of the woody plants in these areas will have cultural plant significance as well. The cultural plant establishment program discussed in the preceding section has similar components and procedures. As a consequence of these similarities, cultural plant establishment areas will also function as shrubland, woodland, and habitat sites.

Shrubland and woodland areas will be established as islands interspersed within reclaimed areas using select locations on predominantly north facing hillslopes or below ridgelines and along drainage bottoms. Non-vegetal components consisting of rock linear features, rock piles, and raptor perches may be associated with the shrubland, woodland, or cultural plant establishment areas. These sites will aid in restoring wildlife food and cover habitat, while providing increased edge in reclaimed landscapes complimented by high density shrub areas established through rangeland revegetation methods. These shrubland and woodland sites will be strategically located to provide the potential for developing thermal, escape, and travel corridor cover for wildlife; diversify habitat in the larger and more open rangeland areas; reestablish habitat for non-game fauna; and enhance the prey base. The sites will also provide a source of culturally significant plant materials, improve plant community and species diversity, and provide seed sources to aid in plant recruitment outside of the established sites. Woodland establishment sites and shrubland will be scattered in the reclaimed areas, and when combined with high density shrubland and the topographic relief characteristic of this landscape will establish thermal, travel, and hiding cover habitat features. Topographic diversity is a significant source for travel corridor potential. Drawing 85352 shows the current existing and proposed postmining contours and illustrates this travel corridor potential. Mapping of postmine revegetated areas considered for bond release will document the vegetal and nonvegetal features and their interrelationships. Annual reclamation and monitoring status reports also detail the ongoing establishment of shrubland, woodland, and cultural planting sites within the reclaimed areas. The shrubland, woodland, cultural species planting programs and the standard rangeland revegetation procedures creating high density shrubland will all serve to facilitate the establishment of wildlife habitat.

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<u>Site Preparation</u>. Site preparation methods detailed in the Rangeland Revegetation Methods and Materials section of this chapter and in Chapter 22 (Minesoil Reconstruction) apply to shrubland and woodland revegetation. These methods include contour deep ripping

and contour furrow disking. Residual soil materials (scoria/red rock) or supplemental surface plant growth media (see Chapter 22) will be the primary soils used for developing woodland areas (excluding live transplant sites), cultural planting sites, and some shrubland areas. These materials will be ripped on the contour for surface stabilization and to create microsites. Woody and cultural plant establishment are enhanced through the use of residual soils or similar plant growth media with high coarse fragment or rock content (Redente and Hargis, 1985; WRDC and Bunin, 1985; DePuit, 1984; and Amendola et al., 1984). Sites receiving residual soils or supplemental surface plant growth media will have lowered herbaceous vegetative cover to reduce competition for woody plant seedlings while mimicking site conditions that naturally support many native forbs and woody species. In addition, the salvage and direct reapplication of surface residual soils provides the potential for increasing the number of viable plant propagules and mycorrhizae from native woodland sites. Deep ripping thin topsoil to expose sub-surface rock and placing coarse residual soils on side slopes is beneficial to surface configuration and stabilization. Woody sites along drainage areas will be located on or immediately above the designed 100-year, 6-hour flood plain (main drainages), or the 10-year, 6-hour channel (smaller drainages). Slopes in these areas are slight. Tree, shrub, or a combination of these plantings in upland areas may be located on ridgelines and mid or lower slopes using mostly north facing aspects. These plantings will often be placed on more steeply sloping areas (exceed 10:1 in steepness). Use of residual soils (scoria/red rock)or supplemental surface plant growth media will be the primary material used in establishing these sites and will decrease any stability hazard. The scoria/red rock sites will total no more than five percent of annual reclaimed areas with a maximum size of five acres, with areas of one to three acres more common. Potential areas of annual scoria placement will be discussed at the annual field meeting with OSMRE, the Navajo Nation and the Hopi tribe.

Shrubland and woodland planting areas may be established during normal revegetation activities or separately. Strips or blocks of unseeded areas may be left in larger areas seeded with the rangeland mix to provide a zone for the exclusive planting of shrubland or woodland seed mixes, seedlings, or transplants. Larger woody planting areas may be established during topsoil or residual soil placement. These areas will receive a light seeding rate of low competition vegetation including bunch grasses, forbs, and shrubs to establish cover and diversity while maintaining a less competitive environment for woody species.

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Permanent impoundment sites with dependable water and sufficient wetted perimeter along shorelines will receive native cottonwood and willow plantings making them more attractive to a variety of wildlife and to aid in establishing riparian habitat. Plantings will be protected from browse and livestock damage by fencing with sheep tight wire at a sufficient height. If ponds are fenced to restrict livestock entry the top barb wire will be removed or replaced with smooth wire.

The following impoundments have potential for riparian plantings based on anticipated water levels and permanence, a reasonably established shallow depth to a wetted zone around the impoundment perimeter, and the ability to protect these plantings from livestock depredation during establishment. Included are the J19-RA and J19-RB internal impoundments and the TPF-E (or TPF-A), TPF-D, N12-C (or N12-C2), N10-A1 (or N10-A), N6-L, N11-A (or N11-A2), N11-G, J-7 Dam, N14-D, N14-F, N14-G, N14-H, J16-A, J16-L, J2-A, and J7-JR water control structures. Each impoundment will be evaluated to determine the development of a suitable planting zone based on the development of persistent water levels. Efforts to establish riparian type vegetation will not be restricted to the above impoundments. Small depressions or channel pools that show potential for willow or cottonwood plantings will also be considered. Some of the above impoundments are currently used as a source of water for dust suppression resulting in fluctuations in water levels during the year. Planting at these ponds may be delayed until dust suppression has stopped and water levels have stabilized.

In planting sites where excessive competing vegetation has become established, mechanical or chemical controls may be applied. Mechanical control by tillage of existing vegetation will be the primary method used prior to seeding or planting of the shrub/tree habitat area species. Mechanical tillage may be applied as a short-term fallow system to control weed growth and to store additional soil moisture prior to planting and seeding the sites. Erosion will be minimized by conducting all operations on the contour and retaining strips of vegetation around the tilled areas, and using soils with a high percentage of coarse fragments.

Preemergent herbicides or postemergent selective or non-selective herbicides may be applied separately or in combination with mechanical tillage for controlling excessive vegetation in habitat areas. Chemical or herbicidal control is an accepted, beneficial,

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and effective means of vegetation control (Plass and Powell, 1988). Properly applied, herbicidal control is an effective means of eliminating competing vegetation without disturbances associated with mechanical control. Soil moisture is retained because the soil is not tilled and a firm seedbed or planting area is also maintained. The potential for evapotranspiration losses are further reduced by elimination of live vegetation while remaining standing litter is preserved as mulch. Extending the length of control prior to planting can function as a fallow period with subsequent benefits to increased soil moisture. Target control areas are easily managed and follow-up control without additional surface disturbance can be realized by periodic reapplication of the proper herbicide(s).

Three categories of herbicidal application, postemergent non-selective, postemergent selective, and preemergent will be considered. Postemergent non-selective herbicides are used prior to planting for a complete vegetation control. It will be targeted towards undesirable herbaceous vegetation which has established competing cover. Selective postemergent herbicides when properly applied are not injurious to planted seedlings (Darbyshire, 1985 and Plass and Powell, 1988). Postemergent selective applications are for maintenance control during woody plant establishment while preemergent applications are used for maintenance control during woody plant establishment. Preemergent herbicides are applied as a preplant treatment, postplant treatment, or with foliage absorbed herbicides (Plass and Powell, 1988). These herbicides affect newly germinated seedlings and prohibit their establishment and can control invasion of grasses and forbs for some time, depending on application and environmental conditions. These herbicides are not persistent and are relatively short-lived. The preemergent herbicides can be applied or reapplied to areas of planted seedlings with minimal risk when proper procedures are followed. The herbicide category used will be dependent on desired goals or the existing field conditions at the planting sites.

Prior to the use of any herbicide applications, current information will be obtained to determine which herbicide or group of herbicides will best suite a particular situation. The selected herbicide or herbicides will be registered and labeled for the intended application, with the specific application rates based on the Black Mesa climatic and site conditions, soils, type and amount of vegetation to be controlled, season of

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application, and length of control. The chemical label will be strictly adhered to for all applied chemicals and application will be under the supervision of a certified applicator. The use of herbicides will meet applicable regulations and requirements of the Navajo Nation Environmental Protection Agency (NNEPA).

Plant Materials. A number of shrub and tree species are proposed for use in establishing select shrubland and woodland sites on reclaimed lands. Some of the shrubs to be seeded and/or planted include: fourwing saltbush, shadscale, winterfat, antelope bitterbrush, cliffrose, apache plume, big sagebrush, rubber rabbitbrush, roundleaf buffaloberry, wolfberry, Mormon tea, willows, and yuccas. Additional shrub species may be found in Appendix B, Table B-1, List of Cultural Plant Species for Potential Use in Reclaimed Areas. All shrub species are native. Tree species include pinyon pine, Utah juniper, cottonwood, and Gambel oak. Pinyon pine, Utah juniper, Gambel oak, and most shrub species will be used on primarily upland sites and the cottonwood or willows will be used around pond sites, drainage areas, and in-channel pools with dependable moisture.

Native woody species and many forbs tend to be difficult to establish on soiled reclaimed sites and with standard rangeland seedings in arid and semiarid environments. These plants may require specific site or environmental conditions such as mycorrhizal associations to better ensure establishment and survival. Many species develop slowly and hence can be at a competitive disadvantage for moisture and nutrients when aggressive herbaceous vegetation is present during the seedling stage. This is a major factor affecting the success of woody plant establishment. Though many of the species are drought tolerant once established, they can be intolerant in the seedling stage. Establishment of an effective vegetative cover is required on reclaimed areas and is achieved mostly with herbaceous species. In woody planting areas, cultural practices, species selection, and planting techniques must be carefully considered to minimize herbaceous competition effects on survival and growth of the less competitive target species. An essential component is the use of residual soil materials or supplemental surface plant growth media that the target species are best adapted to. Applied cultural practices, use of proper substrates, appropriate seed mixes, planting combinations, and planting and seeding techniques help insure successful establishment. Annual woody and cultural plant establishment activities are presented in the Annual Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines.

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Table 4 represents a core seed mix for establishment of a seeded woody/herbaceous component for shrubland or woodland habitat areas. Additional species may be added or substituted in the mix from species listed in Appendix Tables A-1 or B-1 to enhance specific habitat characteristics and goals or prepare a mix better adapted to site conditions. The mix is designed to help maximize establishment of woody plants while providing an understory of forbs and grasses. The mix is balanced to favor the establishment of woody plants by reducing the relative composition of grasses and selecting native grasses and forbs that have rooting characteristics, moisture demands, and growth habits that make them more compatible with the native woody component.

Planted seedlings will be the primary method to establish concentrated shrubland and woodland habitat areas. The composition will be based on selections from woody species listed in Table 5 or in Table B-1. The areas planted with shrub or tree seedlings will be seeded with the core seed mix presented in Table 4.

Plant materials include seed or nursery seedlings developed from Black Mesa site collections, regional native sources with similar elevations and habitat characteristics, or adapted commercial sources. Pinyon pine, Utah juniper, and cliffrose are examples of Black Mesa site collected seed. Penstemon, scarlet globemallow, and fourwing saltbush are examples of regional native seed sources, while blue grama and Indian ricegrass represent commercial native cultivar sources. A number of species have low frequency of occurrence combined with poor or erratic seed production and little or no commercial availability. This may restrict or limit the use of certain species because of reduced seed availability or poor germination characteristics. Herbivory, drought, and spring frosts also have a major impact on seed availability on Black Mesa. Regional native collections or commercial sources for plant materials will be used when native local collection efforts are not successful.

An intensive nursery program has been implemented to develop seedlings for outplanting in reclaimed sites. Specific nursery cultural practices are used to produce robust seedlings for enhanced establishment and survival. Seedlings remain in the nursery until adequately developed. Time in the nursery may be as long as one year for pinyon pine, dropping to as little as six months for shrubs or forbs. Nursery seedlings receive

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TABLE 4. Shrubland, Woodland and Cultural Planting Site Core Seed Mix

Species	Scientific Name	Variety[1]	Rate[2]	Density[3]
1. Fourwing saltbush	Atriplex canescens	Native	1.0 - 2.0	1.3 - 2.6
2. Antelope bitterbrush	Purshia tridentata	Native	1.0 - 2.0	0.4 - 0.8
3. Bottlebrush squirreltail	Sitanion hystrix	Native	1.0 - 2.0	4.4 - 8.8
4. Needleandthreadgrass	Stipa comata	Native	1.0 - 2.0	1.6 - 3.2
5. Indian ricegrass	Oryzopsis hymenoides	Paloma	1.0 - 2.0	3.2 - 6.4
6. Galleta	Hilaria jamesii	Viva	1.0 - 2.0	3.9 - 7.8
7. Rocky Mountain beeplant	Cleome serrulata	Native	1.0 - 2.0	1.4 - 2.8
8. Scarlet bugler	Penstemon barbatus	Native	0.2 - 0.5	2.6 - 6.5
19. Annual sunflower	Helianthus annuus	Native	1.0 - 2.0	1.3 - 2.6
10. Cliffrose	Cowania mexicana	Native	1.0 - 2.0	1.5 - 3.0
Total			9.2 - 18.5	21.6 - 44.5

Appropriate alternates and additions may be selected from Table A-1 in Appendix A or Table B-1 in Appendix B.

[1] Adapted varieties will be given priority in plant materials acquisition. Common varieties indicate that no improved cultivars have been released - use adapted local and regional native genotypes.

[2] Rate = PLS lbs. of seed per acre.

[3] Density = Number of seeds per square foot at drilled rate.

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TABLE 5. Woody Plant Seedlings for Use in Shrubland and Woodland Habitat Sites and Cultural Planting Areas[1]

	Scientific Name	Common Name	Site[2]
Shrubs[3]	Artemisia frigida	Fringed sage	U,D
	Artemisia tridentata	Big sagebrush	U,D
	Chrysothamnus nauseosus	Rubber rabbitbrush	U,D
	Cowania mexicana	Cliffrose	U
	Ephedra viridis	Green Mormon tea	U
	Falugia paradoxa	Apache plume	U
	Lycium pallidum	Wolfberry	U
	Purshia tridentata	Antelope bitterbrush	U
	Rhus trilobata	Skunkbush sumac	U,D
	Shepherdia rotundifolia	Roundleaf buffaloberry	U
	Yucca sp.	Yucca	U
Trees	Juniperus monosperma	One-seed juniper	U
	Juniperus osteosperma	Utah juniper	U
	Pinus edulis	Pinyon pine	U
	Populus fremontii	Fremont cottonwood	D,P
	Quercus gambelii	Gambel oak	U
	Salix exigua	Coyote willow	D,P

[1] Additional species may be selected from Table B-1 in Appendix B.

[2] U = uplands, D = drainages, P = ponds or wet sites.

[3] Includes subshrubs

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appropriate mycorrhizal inoculation at the nursery and again at planting time to insure beneficial root infection. Containerized stock is the preferred source of materials, although bare rootstock, cuttings, or wildings may be used for dormant season plantings.

Seeding Methods and Rates. Seeding will be accomplished through drill seeding, broadcast seeding, or a combination of both. Drill seeding will be used on sites that do not have excessive coarse fragment or rock content. Species that require shallow seeding will be broadcast seeded. Very rough and rocky sites will be broadcast seeded. Seeding will be conducted primarily as summer monsoon and fall dormant applications. Fall dormant seeding will coincide with the primary planting period for seedlings in the fall. The secondary seeding season is in winter/early spring.

Table 4 lists the core seeding rate. The final seeding rate depends on substitutions or additions to the core mix. Final composition and seeding rates will vary based on goals, species availability, and anticipated seeding rates for included species. The summary of each year's seeding activities is presented in the Annual Reclamation Status and Monitoring Report for the Black Mesa and Kayenta Mines.

Planting Methods and Rates. Seedlings are planted in sites prepared with appropriate substrates. Aspects tend to be northerly, however east aspects or ridge tops may also be selected. The planting sites are concentrated in irregular clusters or groupings scattered in the reclamation with most sites in the one to three acre size. Some sites may be larger (up to five acres) based on site conditions or a specific goal. Seedlings are planted primarily by hand using dibbles, planting bars, or planting hoes. Hand planting allows for better microsite selection, provides a more random pattern of planting, and improves handling and placement of seedlings. The secondary method will be mechanical planting using a mechanical tree planter that has the capability to handle both bare root stock and containerized seedlings. This method is restricted to areas that are less rough and with low rock or coarse fragment content. Proper handling and planting procedures for seedlings include: 1) proper storage and handling of materials to avoid root desiccation; 2) proper planting depths; 3) firming the soil around roots and removal of air pockets; 4) proper positioning of the plants to minimize the potential for burial or root exposure; 5) avoidance of "J" rooting the plant materials; and 6) maximum use of available microsites.

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Protection from sun and drying winds are important factors governing the successful establishment of planted seedlings. Pinyon seedling survival is aided by nurse plants to ameliorate microclimatic stress (Drivas and Everett, 1987) or some artificial mechanism that produces the same result (personal communication, Rick Everett, USDA-USFS, Inter mountain Forest and Range Experiment Station, University of Nevada, Reno, January 21, 1988). Nursery seedling stock, even if properly hardened-off, are especially susceptible to desiccation. Measures to reduce these impacts include selection of more mesic, north-facing slopes, creation of planting areas with numerous microsites developed from woody debris and rocks, and providing a rough surface configuration from ripping. The hand planting of seedlings maximizes the use of these microsite features. When used, artificial shading will be restricted to shade cards or other similar structures. Sites mulched with native grass hay may also provide protection to the seedlings.

The planting period is primarily in the fall while soil temperatures are high enough to allow initial root development before low temperatures suspend it and precipitation is probable. This period will generally be October to early November. Summer plantings just prior to the monsoon period in mid-July will be considered as an optional planting period. Studies indicate that satisfactory establishment of containerized one-seed juniper seedlings can be obtained by planting in July which allows for adequate root development before soil temperatures are too low (Fisher et al., 1986; Fisher et al., 1987). Other species may also benefit from summer plantings provided adequate summer monsoon weather patterns are present (i.e., amount and distribution of precipitation).

Transplanting. Live pinyon pine and shrubs collected from native stands ahead of mining disturbance will be transplanted to select reclaimed sites. Utah juniper may also be selected though success has been poor with this species. A tree spade is used to collect and handle the salvaged plant materials. Tree size will be restricted to smaller trees pinyon trees less than five feet in height and juniper trees less than three feet in height. Ferguson and Frischknecht (1985) transplanted pinyon and juniper trees of varying height and found that the above-specified restrictions in height gave the best results. Restricting transplants to smaller trees will insure inclusion of the majority of the root ball, maintain a viable soil ecosystem with critical mycorrhizal and other soil plant associations, minimize planting shock, and facilitate proper handling. When transplanting, north facing canopy exposure of the tree will be marked and maintained at the new location. Transplanted materials are watered once at the time of

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transplant. Pinyon pine are commonly found growing within canopies of big sagebrush. This association will be maintained by selecting pinyon pine growing with sagebrush and other native plants. This will aid in improving reclaimed area diversity and reestablishing ecosystem function. Transplanting will be conducted in the late fall/winter when trees are dormant and soils are not frozen. Certain field conditions may restrict the number of trees transplanted annually. Dry, open winters result in very dry soils that do not allow root balls to be maintained. During very wet winters equipment can not effectively access the tree salvage sites. Both situations have limited transplanting in the past.

Shrubland and Woodland Planting Goals. In shrubland and woodland planting sites that include shrub seedlings, a minimum of three (3) shrub species will be planted. The stocking rate for shrubland sites will vary from 1000 to 1600 stems per acre. Sufficient shrub seedlings will be planted to achieve 800 established stems per acre. Seedlings will be distributed throughout the planting areas in patterns reflecting native sites. Spacing will be variable due to efforts to maximize microsite planting locations and mimic more natural patterns and distribution.

In woodland planting areas, approximately 300 tree seedlings per acre will be planted. Upland plantings will be of pinyon pine or juniper, or a mixed composition of pinyon pine, juniper, or Gambel oak. All upland woodland reclamation areas will include pinyon pine. Juniper and Gambel oak will be included as often as plant materials are available. Utah juniper has been difficult to grow in the nursery reducing availability. Acorn production for Gambel oak can be highly variable from year to year with none available in some years. PWCC's planting goal is to establish a minimum of 75 surviving trees per acre in woodland planting/transplanting sites. PWCC will plant sufficient numbers of trees on five percent of the reclaimed area each year to meet the 75 trees per acre goal, a reasonable target for survival and growth while ensuring an established understory. Densities above 160 trees per acre have been shown to eventually suppress understory shrubs (Frischknecht, 1975). Densities exceeding approximately 300 trees per acre create a closed canopy suppressing shrub and herbaceous vegetation and will accelerate additional pinyon and juniper seedling establishment (Severson 1986). In pinyon pine transplant sites, approximately 100 trees per acre will be planted. PWCC will work to transplant 200-400 pinyon pine per year, conditions permitting as described previously. Coyote willow, a regional native, will be used around select ponds or other wet areas targeted for enhancement. This species will be planted in bands along the shoreline (one plant/linear foot of shoreline). Coyote willow plant materials will be developed from cuttings from local sources or as nursery stock. Plantings will be made throughout the late fall, winter, and early spring. Native cottonwood plantings will be made around

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select ponds using seedlings or cuttings. Plantings will be made near shorelines where moisture conditions will favor establishment and growth. Approximately one tree will be planted for every 25 feet of pond shoreline.

Monitoring and Evaluation. All planting sites will be monitored on a continuing basis to evaluate success of the seeding and planting programs and track the development and successional change at the sites. Replanting or augmentation planting will be determined from the monitoring data and qualitative site evaluations. Any rework will be specific to each site. PWCC includes details of the annual planting program and any replanting or augmentation in the annual reclamation reports submitted to OSMRE.

These sites are enhancements in the overall reclaimed landscape and will be established in relatively small areas variously located in the reclaimed landscape. As such, they will be included in the overall sampling program and will fall under appropriate success criteria presented later in this chapter.

Selection and Justification of Species Used for Revegetation

Rangelands. Recommendations for species used in rangeland and drainage channel revegetation on Black Mesa have been received from several agencies including the Arizona Game and Fish Department, BIA (Lee, 1970 and Harter, 1979), OSMRE, and the Soil Conservation Service (currently Natural Resources Conservation Service) (Jordan, 1977). The species chosen are also those recommended in the literature for revegetation in the arid and semi-arid west (Plummer et al., 1964; Gould, 1973; McDougal, 1973; Humphrey, 1970; Thornburg, 1982; Wasser, 1982, USDA-SCS, 1987; Stubbendieck et al., 1982; Valentine, 1990; Valentine, 1971; USDA - Forest Service, 1937). Furthermore, the Rangeland and Drainage Channel Seed Mixes include many native species commonly found in the regional sagebrush and pinyon-juniper communities. A number of the species have demonstrated resilience and utility in the reclaimed areas over the last 20 years. These species provide high utility for livestock grazing during each season of the year and provide good utility for wildlife as forage, browse, mast, nesting, and escape cover (Table 6). The predominance of cool season grasses extends grazing significantly throughout the year. The species included in the seeding and planting lists in Tables 1 and 4 contain no poisonous or noxious species.

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A mixture of native and introduced species is utilized in rangeland revegetation. Several introduced species are included for the following reasons:

1. The introduced species utilized:
   - A. Are palatable to livestock, provide good forage during most of the year, and improve the utility of the reclaimed area.
   - B. Are tolerant of grazing pressure and are compatible with grazing systems.
   - C. Provide rapid and permanent erosion protection.
   - D. Are readily established and sustainable.
   - E. Are tolerant of alkaline and saline soils.
   - F. Add organics and nutrients to the spoil material.
   - F. Aid in reducing annual weed infestations.
   - G. Add to overall diversity and seasonal variety.
2. Seeding of introduced species in conjunction with native species provides a broader time base for maximum forage production and quality because:
   - A. Introduced (cool season) species develop and produce abundant biomass early in the growing season with significant regrowth in the fall and can continue to produce biomass in drought conditions.
   - B. The palatability and productivity of the introduced cool season species begins to decline, as that of the native cool and warm season species begins to increase (Stoddart and Smith, 1955).
   - C. The introduced cool season species have the ability to produce regrowth in the summer, fall, and winter thereby extending grazing periods.
   - D. The introduced species have equal or superior utility for the postmining land uses of livestock grazing and wildlife.

Five of the 20 core species in the Rangeland Seed Mix and three of the 10 core species in the Drainage Channel/Small Depression Mix are introduced species. Introduced species included in this mix are listed below with associated justification.

<u>Pubescent Wheatgrass</u> - <u>Agropyron</u> <u>trichophorum</u>

1. Sod-former, easily established, good growth rate.
2. Drought tolerant.
3. Tolerant to lower soil fertility levels.
4. Moderate to high palatability, nutritious early spring and fall.

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TABLE 6. Grazing and Wildlife Utility for Select Species Commonly Included In the Rangeland, Shrubland, and Woodland Revegetation Lists[1]

Species	Native or Introduced	Season of Growth	Forage Usability[2,3,5,9] Early Spring	Late Spring	Summer	Fall	Winter	Wildlife Value[3,4,5-9] Cover	Food
Blue Grama	N	W	2	1	1	1	1	3	3
Sideoats Grama	N	W	2	2	1	1	2	2	2
Galleta	N	W	2	2	1	2	2	-	-
Little Bluestem	N	W	2	3	1	1	2	2	2
Sand Dropseed	N	W	3	2	2	2	3	2	2
Alkali Sacaton	N	W	3	1	1	2	2	2	2
Tall Wheatgrass	I	C	3	1	1-2	2	2	2	2
Bluebunch Wheatgrass	N	C	1-2	1-2	2	3	3	2-3	2
Palmer Penstemon	N	C	2	1	1	-	1	3	1
Gooseberry Globemallow	N	C	2	2	2	3	1	3	2
Desert Globemallow	N	W	2	1	1	2	2	3	2
Scarlet Globemallow	N	C	2	2	2	2	2	3	2
Small Burnet	I	C	1	1	2	3	3	3	1
Western Wheatgrass	N	C	1-2	1	2	2	2	1	2
Slender Wheatgrass	N	C	2	1	1	2	3	-	-
Thickspike Wheatgrass	N	C	2	2	1	1	2	2	2
Pubescent Wheatgrass	I	C	2	1	1	1	2	1	2
Russian Wildrye	I	C	1	1	2	1	2	1	3
Buffalograss	N	W	2	2	1	1	2	2-3	1
Bottlebrush Squirreltail	N	C	1	1-2	3	3	2	2-3	2-3
Indian Ricegrass	N	C	1	1	2	2	1	2	1
Inland Saltgrass	N	W	3	2	2	3	3	3	3
Arizona Fescue	N	C	2	2	2	2	3	3	1

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TABLE 6 (Cont.). Grazing and Wildlife Utility for Select Species Commonly Included In the Rangeland, Shrubland, and Woodland Revegetation Lists[1]

			Forage Usability[2,3,5,9]					Wildlife Value[3,4,5-9]	
Species	Native or Introduced	Season of Growth	Early Spring	Late Spring	Summer	Fall	Winter	Cover	Food
Blue Flax	N	C	2	2	3	3	3	-	1
Sainfoin	I	W	2	1	1	2	2	2	2
Prairie coneflower	N	W	2-3	2-3	3	3	3	2-3	2-3
Prostrate kochia	I	C-W	1	1	1	2	3	2	2
Fourwing Saltbush	N	W	2	2	1	1	1	2	1
Winterfat	N	C	2	1	1	1	1	1	1-2
Shadscale	N	W	2	2	2	2	2	2	2
Apache Plume	N	S	2	3	3	2	3	2	2
Cliffrose	N	D	2	2	3	3	2	1	1
Skunkbush Sumac	N	D	2	3	3	3	2	1	2
Big Sagebrush	N	C-E	3	3	3	3	2	2	1
Streambank Wheatgrass	N	C	2	1	1	2	2	2	2
Rubber Rabbitbrush	N	E	3	3	3	2	2	3	2
Basin wildrye	N	C	1-2	2	2	3	2-3	1-2	2
Fringed sagebrush	N	W	1-2	2	2	2	2	2	1-2
Needleandthreadgrass	N	C	1	1-2	3	3	2	2-3	2-3
Scarlet bugler penstemon	N	C	2	2	3	3	3	2-3	2-3
Antelope bitterbrush	N	E	1	1	2	2	1	1-2	1-2

[1]SYMBOLS: I = Introduced; N = Native; C = Cool; W = Warm; E = Evergreen; D = Deciduous; S = Semievergreen; 1 = Good, 2 = Fair, 3 = Poor

[2]SOURCE : Valentine, 1971.

[3]SOURCE : Wasser, 1982.

[4]SOURCE : Vories and Sims, 1977.

[5]SOURCE : Stevens and Monsen; In Hall, 1985.

[6]SOURCE : Tiedeman et al., 1983a.

[7]SOURCE : Tiedeman et al., 1983b

[8]SOURCE : McCarthur and Welch, 1986.

[9]SOURCE : USDA-SCS, 1987.

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5. Tolerant to moderate sodium levels.
6. Recommended for soil stabilization and erosion control.
7. Provides cover for birds and forage for big game.

Sources: Long, 1978.

Sainfoin - Onobrychis viciaefolia

1. Good germination, easily established, good growth rate, strong and deep tap root.
2. Nitrogen fixer, moderately long lived.
3. Highly palatable, non-bloat legume adapted to dry rangeland seeding situations.
4. Good tolerance to drought and higher pH soil conditions, grows well in soils with low phosphorus levels
5. Recommended for soil improvement, pasture, conservation, and wildlife plantings.
6. Performs well in arid southwestern reclamation sites above 6500 feet.

Sources: Heath et. al. (1985).

V. Pfannenstiel (personal observations at P. & M. mine, 1997)

Tall Wheatgrass - Agropyron elongatum

1. Easily established, good germination and rate of growth.
2. Very tall and coarse bunchgrass; late maturing cool season grass.
3. Large biomass producer, moderately palatable to elk and fair to livestock.
4. Resistant to heavy grazing, heat, drought, and periodic flooding.
5. Excellent salt and good alkaline condition tolerance.
6. The large upright plants provide excellent wildlife cover and food.
7. Provides excellent erosion protection.

Sources: Wasser, 1982.

Russian Wildrye - Elymus junceus

1. Good germination, good rate of spread.
2. Tolerant to close grazing.
3. Highly palatable, high in protein (for grasses), excellent standing hay.
4. Good salt and drought tolerance.
5. Recommended for erosion control.

Source: Long, 1978.

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Small Burnet - Sanquisorba minor

1. Easily established, drought tolerant, adapted to a variety of sites.
2. Palatable to livestock and a variety of wildlife, moderate tolerance to grazing.
3. Evergreen succulent forb desirable for diverse mixtures.
4. Early spring growth.

   Source: Wasser, 1982.

Prostrate (Forage) kochia - Kochia prostrata

1. Good establishment, good rate of spread and stand maintenance. Compatible with other perennial species.
2. Drought tolerant shrub to half-shrub, semi-evergreen.
3. Highly palatable to livestock, especially sheep and goats. Palatable to a variety of wildlife species.
4. Low oxalate levels. Good nutrient qualities, particularly protein.
5. Aids in soil stabilization.

   Source: Wasser (1982), Stevens and VanEpps (1983).

Woodland, Shrubland, and Cultural Plant Areas. Tables 4 and 5 list forb, shrub, and tree species that will be utilized in shrubland and woodland wildlife habitat and cultural plant sites. Table 7 lists the wildlife utility of shrub and tree species used to establish shrubland and woodland habitat in reclaimed areas. These species, representing eleven families, are mostly native to Black Mesa and have the highest potential for successful establishment on reclaimed areas. Of the 19 species listed, five of the species (Atriplex canescens, Atriplex confertifolia, Ceratoides lanata, Purshia tridentata, and Kochia prostrata) have been routinely included in the Rangeland Seed Mix. The remaining 14 species are natives, have been successfully seeded or planted at the Black Mesa Complex, and have good forage and/or cover attributes for wildlife. Additionally, these species have been identified as culturally important as described previously in the cultural plant establishment discussion. Appendix B lists additional native culturally important species that may be included in seeding and planting efforts.

The shrubs from the family Chenopodiaceae, particularly fourwing saltbush, have high forage quality for deer and good qualities for other wildlife. They have varying growth forms and provide cover and food for deer as well as habitat for songbirds and small mammals. The Chenopods as a family cover a greater expanse of arid ranges than any other

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TABLE 7. Wildlife Utility of Shrub and Tree Species Used to Establish Shrubland and Woodland Habitat in Reclaimed Areas

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Family	Species	Common Name	Max Ht (ft)	Forage Value*				Cover Value*			
				Deer	Game Birds	Song Birds	Small Mammals	Deer	Game Birds	Song Birds	Small Mammals
Chenopodiaceae	Atriplex canescens	Fourwing saltbush	8.2	2	1	1	1	1	-	-	1
	Atriplex confertifolia	Shadscale	3.3	1	2	2	1	3	-	1	1
	Ceratoides lanata	Winterfat	2.6	1	2	2	1	3	-	-	-
	Kochia prostrata	Prostrate kochia	3.3	1-2	1	-	-	3	1	-	-
Rosaceae	Cowania mexicana	Cliffrose	6.5+	1-2	-	-	-	1	-	-	-
	Fallugia paradoxa	Apache plume	6.0	2	2	2	2	3	2	2	2
	Purshia tridentata	Antelope bitterbrush	6.5+	1	1	1	1	2	-	1	1
Salicaceae	Salix exigua	Coyote willow	15.0	1	-	-	-	-	2	1	-
	Populus fremontii	Fremont cottonwood	100.0	-	-	-	-	-	1	1	-
Compositae	Artemisia tridentata	Big sagebrush	1.5	1	1	2	1	3	1	-	1
	Chrysothamnus nauseosus	Rubber rabbitbrush	15.0	1-2	-	-	-	3	-	-	-
Solanaceae	Lycium pallidum	Wolfberry	5.0	3	2	2	2	3	2	2	2
Elaeagnaceae	Shepherdia rotundifolia	Roundleaf buffaloberry	6.0	3	1	1	1	2	2	1	2
Ephedraceae	Ephedra viridis	Green Mormon tea	4.0	3	3	3	3	3	2	2	2
Fagaceae	Quercus gambelii	Gambel oak	50.0	2	1	1	1	1	1	1	2
Anacardiaceae	Rhus trilobata	Skunkbush sumac	8.2	2	-	1	1	1-2	-	-	-
Pinaceae	Pinus edulis	Colorado pinyon	35.0	2	-	1	1	1	2	1	1
Cupressaceae	Juniperus osteosperma	Utah juniper	40.0	2	-	1	1	1	2	1	1
	Juniperus monosperma	One-seed juniper	25.0	2	-	1	1	1	2	1	1

*References:

- Martin, et al., 1951
- Dennis and Antonio, 1980
- USFWS, 1978

Wasser, 1982
USDA-SCS, 1987
Thornburg, 1982

Stubbendieck, et al. 1982
Little, Jr., 1968
Vines, 1976

Everett, 1987

Footnotes:

1 = Good
2 = Fair
3 = Poor

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group of plants and are extremely valuable in revegetating arid lands with erratic and sparse rainfall and alkaline or saline soil conditions (Plummer, 1977). The chenopods used in the revegetation program are well adapted, prominently represented in reclaimed areas, a valuable component of the revegetated landscape, and important for wildlife habitat. Fourwing saltbush is a dominant component of high density shrubland areas (> 800 stems/acre) in the reclaimed areas.

Integrated Reclamation to Establish Wildlife Habitat

Fish and wildlife resource information has been collected by PWCC in various portions of the leasehold and adjacent areas since 1979. This information has been collected as baseline studies or as monitoring activities that are performed annually. The information obtained from these studies is used by PWCC to identify potential impacts, develop procedures for minimizing or preventing the impacts, and develop measures for enhancing wildlife habitat in the postmining landscape. Wildlife resource information is presented in Chapter 10. Impact analysis and wildlife resource protection are discussed in the last two sections of that chapter. As discussed below a combination of reclamation components, non-vegetal enhancements, and development of potential water sources and associated vegetation combine to achieve wildlife habitat in postmining landscapes.

Reclamation Components. The reclamation program described in this plan and implemented routinely to establish wildlife habitat is comprehensive and integrates regrading and use of various soiling materials and suitable plant growth substrates (red rock/scoria) to aid in establishing diverse vegetation and increased woody species, and Regrading develops a reclaimed topography that provides travel corridors, cover habitat, and increased opportunities for achieving plant and community diversity essential for habitat development. Soiling procedures and use of plant growth media (red rock) similar to substrates associated with native pinyon-juniper communities aid in establishing site areas with diverse shrub and tree habitat established under the shrubland and woodland habitat planting program. Revegetation methods effectively employ complex seed mixes and the planting of seedlings. Rangeland revegetation establishes high density shrubland throughout the reclaimed landscape. Cultural planting sites function both as cultural plant sites and provide habitat while providing a good source of native adapted plant

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propagules for migration into adjacent reclaimed areas. Planting of cottonwood and willows around select ponds on and adjacent to reclaimed areas further augment wildlife habitat and utility.

An effective revegetation program minimizes both short and long term impacts to wildlife. It may appear that emphasis has been placed on optimizing livestock grazing over protecting wildlife and mitigating habitat disturbances or loss. However, successful accomplishment of objectives related to the grazing postmining land use serves to reduce short and long-term impacts to wildlife. In the short-term, cover and forage are made available to species capable of utilizing reclaimed grassland and woody habitat. In the long-term, permanent vegetation provides stabilization of soils, continued community development through successional processes, and other benefits that either directly or indirectly benefits wildlife.

The habitat potential provided by the revegetation plan described earlier in this chapter is supported by extensive monitoring data collected in reclaimed permanent program areas. In spring 2003 and during the height of a drought period, 34 permanent and random transects representing a large geographic area of reclamation were sampled for various vegetation parameters including woody density. The average woody density was over 4800 stems per acre of subshrubs, shrubs, and trees. Shrubs dominated with 3889 stems per acre. Woody density ranged from 203 to over 16,148 stems per acre with only 2 out of 34 plots with less than the high density shrubland target of 800 stems per acre. Established cultural plant sites, which also serve as wildlife habitat, averaged 2738 woody stems per acre with 203 of those represented by trees. Twenty-two different subshrubs, shrubs, and trees are represented in all permanent program reclaimed areas. The variable overall woody density with interspersion of planted and transplanted sites provides increased edge and improves and diversifies habitat. The majority of these species have been established in reclaimed areas and provide forage and browse in both quality and quantity. Long term monitoring also shows that forage production, all of which is useable by wildlife, is significantly greater in reclaimed areas when compared to native sagebrush shrubland or pinyon-juniper communities. The result is a maximization of the interspersion of a variety of habitat requirements (forage, protective cover, and thermal cover) relative to the animal's mobility (Proctor, et al., 1982). The revegetation plan has and will continue to achieve desirable wildlife habitat features. It is not static and will continue to improve through development and

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application of improving BTCA practices, both internally and through technology transfer.

Annual monitoring of revegetation activities and reclaimed area results provide the basis for demonstrating establishment of wildlife habitat. Bond release evaluation, in addition to normal vegetation sampling results, will include detailed analysis of postmine topography, mapping of high density shrub areas, and identification of the interspersed woody habitat areas established through shrubland, woodland, cultural plant, and pinyon transplant revegetation efforts.

Non-vegetal Enhancement. Rock features will be incorporated as appropriate into the habitat areas and general reclaimed landscape. The benefits of constructed rock features for wildlife have been documented (Stoecker, et al., 1985; Giles, 1971; Tessman, 1982) and include big game escape and thermal cover, enhanced shrub establishment sites, small mammal denning, and raptor perch and foraging areas. However, residents of Black Mesa have voiced concerns about these features and have requested that their use be limited due to concerns of disease associated with increases in small mammal populations.

Rock features will be constructed in suitable locations at an average rate of 1 per 100 acres of reclaimed land. These primarily linear rock features may be located along ridge tops, or as small outcrop features on slopes. These linear features will be a minimum of 100 feet long, 10 feet wide, and 5 feet high if on a ridge or flat area, or from the outside edge down to the ground level (face) if on a slope. Rocks piled up to 8 feet in height, irregular in configuration, and approximately .01 acres in extent may be included as rock features for areas constructed prior to 2001 and occasionally in newer areas. For purposes of durability, the structures will be constructed entirely of rock. Rock downdrains, spillways, and drainages will often be included as rock features since they typically provide area wide habitat, structural diversity, and landscape stability.

A selection of shrubs and trees listed in Tables 4 or 5 may be seeded or planted in conjunction with the rock feature, with north and east facing aspects preferred. Rock features will not be established in areas where residents have requested that they not be used. The final number of rock features will be strongly controlled by the availability of suitable rock. Durable rock of sufficient size is limited on the leasehold. Furthermore, there is a great demand for this large durable rock for armoring drainage channels to reduce or eliminate channel erosion. The regulatory authority has emphasized

mitigation of channel erosion and this has required most of the durable rock to be used there leaving considerably less for construction of rock features. Rock armored downdrains, spillways, and drainages, including those where inlet terraces have been removed, will often be kept as permanent rock features thereby offering wildlife habitat, landscape stability, and providing structural diversity.

Mitigation plans for potential impacts to raptors on the leasehold are described in detail in Chapter 10 and include annual ahead-of-mining monitoring for active raptor nests and appropriate monitoring studies to assess populations of and potential impacts to the Mexican spotted owl, red-tail hawks, and other raptors.

Raptor hunting and resting perches, constructed of steel pipe, wooden posts, or a combination of both with cross-bars or small platforms will be placed on reclaimed lands. The final design will be based on current BTCA designs developed for raptor perches. Additionally, some power line transmission poles crossing the reclamation will be retained to serve the same function. The perches will be installed at a minimum density of one per 400 acres. The perches will be approximately 10 feet in height but may be taller. Perches will be established in areas not visible from a permanent road.

Annual monitoring studies are conducted in established, active prairie dog colonies to assess the potential occurrence of black-footed ferrets (when prairie dog surveys suggest the need). See Chapter 10, Wildlife Resources for detail. Wildlife monitoring is conducted in reclaimed areas on an ongoing basis to document use of these areas by wildlife and identify any need for more intensive studies such as reestablishment of prairie dog colonies in reclamation or observation of Mexican vole activity. The unique aspects of Mexican vole populations within the leasehold are discussed in Chapter 10. Baseline studies and ongoing monitoring have revealed that substantial populations of this species occur in certain reclaimed areas and as a preferred habitat.

Livestock and Wildlife Watering Facilities. Water resources are a critical habitat factor for wildlife and a necessary nutritional requirement for livestock. On Black Mesa premining water resources have been limited, compounded further by an arid and highly variable climate. Premining water resources within and adjacent to the Black Mesa leasehold consisted of wells, water impoundment structures, springs, and intermittent reaches of ephemeral channels. Chapter 17, Protection of the Hydrologic Balance describes premine water resources and these are shown on Drawing 85322. For the most

part, these water resources were not reliable, poorly constructed or maintained, and widely distributed. The arid and highly variable climate causes groundwater fluctuations and can make intermittent reaches of ephemeral channels and springs unreliable or insufficient sources of water. The few premine structures on the leasehold were small, breached, or filled with sediment. Wells and windmills provided a more dependable source of water but maintenance issues and distance from where the water resource was needed compromised their effectiveness and made logistics difficult.

Achievement of the postmine land uses of livestock grazing and wildlife habitat on reclaimed lands is facilitated by the availability of water resources. PWCC will provide new water resources and mitigate the loss of certain existing or premine water resources affected by mining. These water resources will benefit not only reclaimed lands but also native undisturbed areas adjacent to reclaimed lands resulting in regional benefits.

PWCC will mitigate the loss of seven pre-existing or current water resources that may be impacted by mining including springs, wells, and surface water structures. They include Wells 4T-403 and 4T-404; Benally Spring (NSPG147) and Spring Site No. 97 (northwest corner of the N14 mining area); and surface water structures DM-1, DM-7, and DM-9. Interim and permanent alternative or replacement provisions for these water sources are discussed in Chapters 6, 17, and 18 and include permanent impoundment's, replacement wells, and the public watering standpipes that are tied into the N-aquifer potable water distribution system (Drawing 85324). There are no projected direct effects for intermittent reaches of the major ephemeral channels by mining activities (see Chapter 18, Probable Hydrologic Consequences). However, any potential impacts would be mitigated by the replacement features described above and in the following discussion. Mining and reclamation activities will provide a number of opportunities for permanent water source availability on the leasehold for both livestock and wildlife. These water sources are a significant improvement over premining wells, springs, and intermittent reaches in ephemeral channels that have provided a potential water resource in the past. Four types of permanent water sources have or will be developed on the PWCC leasehold as a result of mining and reclamation activities (see Drawing 85324). They include pre-law and approved or proposed postlaw internal impoundments, water control structures (ponds), public water standpipes connected to the N-aquifer potable water distribution system, and intermittent reaches of ephemeral channels.

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Nineteen permanent internal impoundments currently exist or will be available for livestock and/or wildlife use as a part of the postmining landscape (Drawing 85324). Three are located in the N-2 coal resource area: N2-RA (wildlife habitat only), N2-RB, and N2-RC. The remaining 16 are pre-law and post-law internal impoundments located in the J-3 coal resource area (J3-G and five other unnamed impoundments), J-1 coal resource area (J1-RA and J1-RB), N-8 coal resource area (N8-RA), the N-1 coal resource area (N1-RA and six unnamed impoundments). One additional proposed permanent internal impoundment has been constructed in the J19 coal resource area (J19-RB). Additional existing pre-law depressions that periodically hold water are also available but are not considered permanent water sources due primarily to restricted watersheds and climatic variation.

PWCC will also retain 31 existing and future sediment control structures (permanent impoundments) providing additional surface water bodies for livestock and wildlife to those above. The impoundments include nine existing MSHA structures: J-7 Dam, J-7-JR, J2-A, J16-L, J16-A, N-14H, N14-G, N14-F, and N14-D. Twenty existing sediment control structures are also included. They include J3-D, J3-E, N5-A, N6-L, N11-G, J7-R, TPF-D, J27-RA, J27-RB, J27-RC, TPF-E, N7-D, J16-G, J21-A1, J21-C, N7-E, N10-A1, N10-D, N11-A, and N12-C. Two sediment ponds scheduled for construction during the remaining life-of-mining activities are also proposed and include N10-G and J21-I. These existing and proposed ponds all meet or will be upgraded to meet the permanent pond design criteria. Their size, configuration, and upstream watersheds indicate persistent water retention (see the discussion of Permanent Impoundments, Chapter 6). Monitoring of water quality will provide sufficient information to demonstrate the suitability of these sources to support the intended postmining land uses.

Two public water standpipes have been constructed by PWCC on the leasehold, one west of the N14 coal resource area and one west of the J1 coal resource area. These sites, located on Drawing 85324, are connected to the N-aquifer potable water distribution system and provide excellent water in terms of quality and quantity. These sources of water are available for further development as livestock and wildlife watering areas, should the Tribes desire their retention in the postmining land use plans.

Maintenance and Management

PWCC’s maintenance and management program for revegetated areas includes, but may not be limited to: monitoring; interseeding, reseeding and augment planting; weed control;

control; fencing and fence maintenance; erosion monitoring; rill and gully repair and drainage maintenance; mowing; or grazing.

Maintenance and management activities related to interseeding, reseeding, augment planting, and weed control are based upon the performance of revegetated stands as determined by quantitative annual vegetation monitoring and ongoing qualitative field inspection activities. When quantitative measurements indicate that a revegetated area is not making reasonable progress towards establishment of a diverse, effective and permanent vegetation cover, the site may be interseeded, augment planted, or tilled and reseeded as necessary. The activity or activities will be directed towards the specific problem or problems identified by the evaluations.

Historical vegetation monitoring and sampling for termination of jurisdiction (TOJ) or bond release have shown that few areas require reseeding and most established stands are capable of meeting success standards. To insure seeding success on permanently reclaimed lands, stands are included in ongoing qualitative and quantitative evaluations. All seeded stands are evaluated following germination and establishment and continue to be monitored on a periodic basis. Stands with poor germination tend to be evident after the first full growing season, while stands with poor establishment may not be apparent until after the third growing season. At times adequate stand establishment does not occur until after the third growing season. Experience has shown that qualitative field evaluations of seeded stands has provided the best measure of when reseeding should be conducted. Generally, revegetated areas will be reseeded if it appears that the stand will not adequately develop. These stands may be interseeded or completely reseeded during the next primary seeding season.

Seeded or planted stands of shrublands, woodland, or cultural plant sites are evaluated yearly. As in seeded stands, qualitative observations have provided a good measure for deciding the need for remedial work. Rework in these areas is based on field evaluation of grass, forb, shrub, and tree establishment. Replanting or augment planting of forbs, shrubs, and trees is conducted during the fall planting season. Interseeding of herbaceous species may be done if that component has not adequately established.

Vegetation monitoring and field observations of reclaimed areas since 1981 indicate weed infestations are generally not a problem. A steady increase in the contribution of

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perennial species to total vegetation cover reduces weedy forb cover over time as a function of successional processes. The amount of cover contributed by weedy forbs is very sensitive to precipitation input and timing and season of seeding. It can display a marked degree of variation as it declines. This in turn, influences the variability in total cover for the first several years following seeding. After about five years, weedy species mostly become a minor component of the stand. These observations are supported in annual vegetation monitoring reports submitted to OSMRE since 1981.

The weedy species are comprised of annual or biennial vegetation, serve as early successional components in the developing plant community, and only are considered weedy if they persist beyond several years as a dominant component. Proper timing of tillage during seedbed preparation, maximizing seeding during the primary season, and use of native grass hay for mulch have significantly reduced the establishment of weedy species. Still, annual weeds may gain a strong presence in a seeded stand. If sampling or observation indicates that weeds comprise more than 40 percent of the total vegetation cover in a rangeland reclamation unit for two consecutive years by the end of the fourth growing season, weed control measures will be implemented.

Rodent control measures will be implemented to protect shrub and tree plantings if monitoring indicates such measures are necessary. Rodent activity in rangeland seeded areas is a normal function in this type of ecosystem and generally not a problem. Rodent control may consist of measures that include application of rodenticides or polypropylene netting and meshed tubes around seedlings. The most appropriate BTCA practices for the particular situation will be used. If pesticides are chosen as a control measure, appropriate permits and controls required by Tribal or federal authorities will be obtained and followed. Certified applicators will be used when necessary. Raptor perches may be established in reclaimed areas with problematic rodent populations.

As previously stated, livestock grazing is a primary land use on Black Mesa. Free roaming cattle, sheep, goats, and horses are common and at times problematic. This situation requires that all newly revegetated areas and many of the facilities be fenced. Newly revegetated areas are fenced with a forty-eight inch high woven wire fence topped by one strand of barbed wire. Posts are mixed wooden and steel. An alternative fence consists of four strand barbed wire with mixed wood and steel posts. Facility fencing

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would include the same specifications. Sediment or other mine related ponds will have only the dam structure fenced unless complete exclusion of livestock is required. Trespass livestock are removed as necessary from areas not authorized for grazing.

PWCC has implemented a reclaimed area livestock grazing and management program with residents on or adjacent to the Black Mesa Complex. For areas reclaimed under the Initial Program regulations this includes areas approved as ready for grazing by the regulatory authority. For Permanent Program lands, reclaimed areas with established vegetation may be included in the grazing program without regulatory approval. The reclaimed land grazing goals include preventing excessive wolf plant development; stimulating vegetative growth, productivity, and nutrient cycling; encouraging plant regeneration through seed dispersal and seedling establishment; demonstrating successful postmine land use achievement, and providing a grazing resource to residents during the liability period. Proper grazing under a managed program benefits the reclaimed rangeland plant communities while providing residents with education opportunities in grazing management principles and sustainability of the resource. PWCC develops a grazing plan and agreement for areas included in the managed grazing program. The documents describing the plan and maps showing locations are maintained at PWCC administrative offices with copies provided to the residents.

Revegetation Success Standards

Background. PWCC uses a combination reference area comparison and technical standard approach for judging revegetation success on Permanent Program reclaimed lands at the Black Mesa Complex. The application of this approach has evolved as a result of ongoing negotiations with regulatory authorities and operating experience.

In the original 1981-1985 Mining and Reclamation Plan (Permit AZ-0001), PWCC proposed using large unfenced pinyon-juniper woodland and sagebrush shrubland reference areas. The areas were several hundred acres in size and each contained a tenth-acre exclosure to account for livestock grazing effects. In response to Stipulation No. 26 attached to Permit AZ-0001, PWCC expanded the original exclosures in the large reference areas such that each exclosure exceeded two acres in size. The large unfenced areas were dropped, and the enlarged exclosures of 2 acres or more were adopted as the reference areas.

Application of the reference areas on AZ-0001 jurisdictional lands (Initial or Interim Program) is described in the Permit Application Package for Permit AZ-0001 (Volume 1, Chapter 3, page 29, and Volume 6, Appendix 16) and in the Vegetation and Wildlife Resources 1981 Report (Appendix B, Page 26).

An additional issue raised by regulatory authorities during the review of the 1981-1985 Mining and Reclamation Plan concerned the use of pinyon-juniper reference areas for judging the success of grassland dominated reclaimed areas. Although the pinyon-juniper reference areas accurately represent approximately 65 percent of the premining vegetation on lands disturbed by mining, OSMRE technical staff expressed concern that comparison of pinyon-juniper reference areas with reclaimed grasslands was invalid. The concern was based on the naturally sparse shrub and herbaceous understory characteristic of this community. It was suggested that reference areas in the sagebrush shrubland provided a more realistic standard for success because of assumed greater herbaceous cover and production associated with the sagebrush community.

In the Mining and Reclamation Plan for the J-21 mining area (Permit AZ-0002A), the N-14 sagebrush shrubland reference area was proposed for use in determining revegetation success. This approach was applicable to lands disturbed during the period from the date of permit issuance (December 28, 1984) to the date Permit AZ-0001C was issued (July 6, 1990). The Jurisdictional Permit Map (Drawing 85360) shows the J-21 mining areas where Permit AZ-0002A revegetation success standards were applicable.

Revegetation success for J21 lands included under Permit AZ-0002A will be evaluated using standards and methods applicable under Permits AZ-0001D and AZ-0001E. A complete description of the previous revegetation success standards for Permit AZ-0002A jurisdictional areas is contained in the AZ-0001 permit at Volume 39, Chapter 3, Page 22; Volume 44, Appendix I, Page 105; and Volume 53, Tab 14, Section 3. The inclusion of AZ-0002A permit areas with the AZ-0001D and AZ-0001E permit areas for revegetation success evaluations makes the process more efficient and simpler to administer with no less stringent requirements. The J21 AZ-0002A lands were reclaimed with methods similar to those used on AZ-0001D and AZ-0001E lands and are for all practical purposes indistinguishable.

Condition No. 3 attached to Permit AZ-0002A required PWCC to present an evaluation of techniques for determining revegetation success to OSMRE. The OSMRE was apparently still

uncomfortable with the reference area approach as it was being applied on the Black Mesa leasehold. PWCC submitted the response on June 11, 1985. The evaluation, and subsequent discussions with OSMRE personnel, indicated that although valid with regard to SMCRA and subsequent regulations, the reference area approach may not be the most appropriate method for setting all revegetation success standards at the Black Mesa and Kayenta Mines. The primary problem appears to be comparisons of different plant communities (i.e., herbaceous dominated reclaimed versus woody dominated native vegetation) to determine revegetation success. This fundamental problem exists throughout the western U.S. where surface mining is regulated under SMCRA.

OSMRE transmitted the results of the first midterm permit review (MPR) of Federal Permit AZ-0001C on February 16, 1993. Deficiencies in the AZ-0001C PAP were identified in the MPR, prompting OSMRE to order several revisions to the permit document. Revision Order No. 5 included nine required modifications to address concerns about vegetation measurement techniques and success standards. PWCC took issue with some of the modifications required in Revision Order No. 5. After a series of discussions, these issues were resolved (OSMRE correspondence dated October 7, 1993) and proposed revisions were incorporated in the PAP on November 8, 1993.

Land use is the prime consideration in reclamation planning and implementation at the Black Mesa Complex. Therefore, land use should serve as the framework around which reclamation success is determined. The postmining land uses of livestock grazing, wildlife habitat and cultural plant use are similar to premining uses on the leasehold. The land capability for grazing and certain kinds of wildlife habitat on the leasehold are vastly improved in the postmining landscape as a result of established reclaimed plant communities. The revegetation plan establishes reclaimed lands with much greater utility for the grazing land use without diminishing the ability to provide wildlife habitat and populations of culturally significant plants. The premining vegetation resources (Chapter 9), although compatible with the existing land uses, cannot serve them adequately in many cases because of historically overstocked and overgrazed range.

The response to Condition No. 3 (Permit AZ-0002A) stated PWCC's intention to develop revegetation success standards based upon a combination of technical guidance documents and pre-existing vegetation attributes. In response to Permit AZ-0001C Midterm Review Revision Order No. 5, PWCC was required to conduct additional monitoring to develop a

historical record of ground cover utilizing new sampling methods. Since the fall of 1991, PWCC has annually monitored the native reference areas for ground cover using point intercept methods. PWCC has observed variation in seasonal cover for the sagebrush reference areas based on seasonal climatic variation. While not as widely fluctuating as the herbaceous dominated reclaimed areas, it is felt that using seasonal comparisons to the sagebrush reference areas is an appropriate method for evaluating cover success. The proposed standards for the rangeland and key habitat areas are presented in the following sections. These tables are included with the respective rangeland and habitat area sections of this chapter. The derivation of each is discussed below. The standards will be used to measure revegetation success on lands reclaimed under the jurisdiction of Permits AZ-0001C, AZ-0001D, AZ-0001E, and AZ-0002A.

Rangeland Success Standards. The Permanent Program Performance Standards indicate that the key intent of the cover success criterion is effectiveness for stabilizing the soil surface from accelerated erosion. Vegetation cover alone, while providing an important means to document species composition, does not provide a complete indication of the potential for preventing soil loss. In this context, ground cover as defined in 30 CFR 701.5 appropriately satisfies the intent of the regulations.

PWCC will use ground cover as the standard for the revegetation success cover criteria. Ground cover is defined as the portion of total ground surface area that would be hidden by the combined cover of live vegetation, standing dead plant material, and litter when viewed in a vertical projection downward. Litter is defined as dead plant material that has detached and fallen to the ground. Standing dead material is still attached to the plant and may include grass culms, leaves, or woody material. This measurement subtracted from 100 percent would equal the portion of bare, exposed soil, and thereby quantify the effectiveness of the cover for reducing and resisting soil erosion. Rock, while effective as hydrologic cover is not included in determining the cover standard.

PWCC will derive the ground cover standard for rangelands (Table 8) from vegetation data collected from the three sagebrush shrubland reference areas on the Black Mesa leasehold (reference area comparison approach). These reference areas are J7 sagebrush, N7/8 sagebrush, and N14 sagebrush. A technical standard for cover was not developed because: (1) the Natural Resources Conservation Service (NRCS) Form-5 soil series interpretation records do not specify expected ground or vegetation cover values; (2) limited range site

Table 8. Revegetation Success Standards for Permanent Program Regulatory Lands at the Black Mesa Complex

Reclaimed Community or Habitat Type	Parameter	Standard
Rangeland	Ground Cover[1,2]	Reference area comparison
	Production[3]	545 pounds per acre (air dry)
	Shrub Density	400 woody stems per acre
	Diversity[3,4]	3 grasses, 3 forbs, and 2 shrubs/halfshrubs
Shrubland (upland or drainage locations and can include red rock sites)	Ground Cover[1,2]	Reference area comparison
	Production[3]	545 pounds per acre (air dry)
	Shrub Density	800 woody stems per acre
	Diversity[3,5]	3 grasses, 3 forbs, and 2 shrubs/halfshrubs
Woodland (red rock sites with seedlings)	Ground Cover[1,2]	Reference area comparison
	Production	No production standard [30 CFR 816.116(b)(3)]
	Shrub Density	800 woody stems per acre
	Tree Density	75 trees per acre
	Diversity[3,6]	2 grasses, 4 forbs, 4 shrubs/halfshrubs, and 2 trees
Woodland (pinyon transplant sites)	Ground Cover[1,2]	Reference area comparison
	Production	No production standard [30 CFR 816.116(b)(3)]
	Shrub Density	800 woody stems per acre
	Tree Density	75 trees per acre
	Diversity[3,7]	2 grasses, 2 forbs, 2 shrubs/halfshrubs, and 1 tree

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[1] Ground cover as defined in 30 CFR 701.5 and described in this section. Ground cover is comprised of living plant cover (adjusted for annuals if necessary), standing dead, and litter (adjusted if necessary), but excluding rock.

Table 8. (continued),

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[2] The allowable contribution of annual vegetation to the revegetated area cover value used for evaluating success can be no greater than 10 percent of the measured total live plant cover and the allowable contribution of litter to the ground cover value cannot exceed the combined measured live plant cover and standing dead cover (adjusted for annual vegetation if necessary).

[3] Production, expressed as pounds per acre (air dry), will be based on perennial species and up to 10 percent annuals. Diversity will be comprised of perennial plant species only.

[4] **Rangeland Diversity:** Three grass species with relative cover values equal to or greater than 5 percent each, no single grass species greater than 65 percent relative cover, and the combined perennial grass relative cover not to exceed 80 percent. Three forbs present with one forb having 20 percent frequency of occurrence (frequency) and two forbs each having 10 percent frequency. Three woody plant species consisting of at least one shrub and one subshrub with no single species comprising more than 80 percent of the density.

[5] **Shrubland Diversity:** Two grasses with relative cover of 5 percent or greater each, no single species with greater than 65 percent relative cover, and the combined perennial grass relative cover not exceeding 80 percent. Two forbs present, both with 10 percent frequency. Two shrubs or one shrub and one halfshrub with no single species comprising more than 90 percent of the density.

[6] **Woodland Diversity** (red rock sites): Two grasses with relative cover equal to or greater than 5 percent each, no single species with greater than 65 percent relative cover and combined grass cover not to exceed 80 percent. Four forbs present with two forbs having 50 percent frequency and two forbs having 25 percent frequency. Four shrubs or halfshrubs (half shrubs contributing no more than two species) with one species with relative density of at least 25 percent and one species with relative density of at least 10 percent. Two tree species present.

[7] **Woodland Diversity (pinyon transplant sites):** Two grasses with relative cover of 5 percent or greater each, no single species with greater than 65 percent relative cover and combined perennial grass relative cover not to exceed 80 percent. Two forbs present both with 10 percent frequency. Two shrubs or one shrub and one halfshrub present with no single species comprising more than 90 percent of the density. One tree species present.

Note: Reference area annual cover contribution will be adjusted similarly to reclaimed areas

description information is available for the region which includes the Black Mesa leasehold; (3) the range site descriptions generated from the Soil and Range Inventory of the 1882 Executive Order Area do not include cover estimates except pinyon-juniper canopy density classes on woodland site; and (4) historical cover data collected in the sagebrush shrubland reference areas was collected using a modified Daubenmire sampling method. PWCC is using the point intercept cover method at this time. OSMRE determined previously collected Daubenmire data was not comparable to cover data collected in the reclaimed areas using the point intercept method. However, as of this time PWCC has fifteen years of point intercept cover data available.

Vegetation sampling is conducted at the peak of the spring growing season and again at the peak of regrowth in the fall at permanent transects and select reclaimed units. Reference areas are sampled in spring, fall, or both seasons as required, but in some years may not be sampled. Point intercept cover sampling includes measurement of total nonoverlapping ground cover, total vegetation cover by species, standing dead plant material, lichen and moss cover, litter cover, and rock cover. The point intercept method is discussed in Chapter 9, Attachment 2. Livestock have been excluded from all reference areas since 1982.

The cover success standard is based on mean annual spring or fall cover values from the three sagebrush shrubland reference areas. Cover values for reclaimed areas are compared to the mean reference area values from the same season. Cover sampling is conducted using the point intercept method, with an adequate number of samples collected each season based on the revised equation in Chapter 9, Attachment 2. Seasonal comparisons of reclaimed areas to reference areas can account somewhat for climatic variation when evaluating revegetation success, however this remains a dominant woody (reference area) to dominant herbaceous (reclaimed area) comparison.

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During the sampling period, PWCC may investigate other appropriate technical approaches to derive a cover success standard that may more accurately reflect herbaceous dominated revegetation communities. Should a more appropriate technical standard be developed, PWCC will submit an application to revise the applicable portions of the permit document.

PWCC uses a technical standard approach to derive the vegetation production success standard. Production is defined as the aboveground vegetation yield produced by a unit area for a unit of time. Annual production of shrubs, half-shrubs, grasses, and forbs are

used. Yield is expressed in terms of weight per unit area. The technical documents used as the basis are the Form-5 soil series interpretation records developed from the Order 1 and 2 soil surveys conducted in the life-of-mine coal resource areas. The soil series interpretation records are maintained on file by PWCC.

The production standard of 545 lb/acre (air dry wt.) was derived by calculating the weighted potential mean annual production for the soils to be disturbed. The data and calculations used to derive the standard are presented in Table 9. The areal extent of each soil series to be disturbed by mining was determined from the soil series maps (Drawing 85305A, Sheets 1 through 15). The percent of total acreage of each soil within the disturbance areas were multiplied by the corresponding Form-5 potential production estimates (including both moist and dry phases). The products were then summed to obtain the weighted mean production figure. The 545 lb/acre production standard is applicable to all permanent program rangeland and shrubland reclaimed areas.

PWCC will establish shrubs throughout the rangeland and shrubland reclaimed areas equal to the applicable density standards. The increased longevity, tolerance to herbage removal, and greater rooting depths that are characteristic of the shrubs used to establish rangeland and shrubland reclaimed lands will improve the long term utility and sustainability of reclaimed areas. Long term reclaimed area monitoring records show that woody density is highly variable on reclaimed lands with consequent benefits to habitat edge and community diversity.

Various wildlife agencies were contacted to obtain recommendations for desirable shrub densities. These agencies included the Arizona Game and Fish Department, the USDI Fish and Wildlife Service's Ecological Services branch in Phoenix, Arizona, the Navajo Nation Forestry Department and the Navajo Nation Department of Fish Wildlife. In addition to the agencies listed above, the Bureau of Indian Affairs, Branch of Land Operations, and the Albuquerque, New Mexico Field Supervisor for Ecological Services, USFWS (Mr. Joe Medlin), were contacted. The Wildlife Management Techniques Manual (Page 338), discusses shrub and forb densities. One shrub per 9.3 square meters (435 shrubs/acre) and one herb per 0.93 square meters are suggested as an approximate minimum. The original reference for these figures is Plummer et al., 1964.

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TABLE 9. Summary of Data Used to Calculate the Production (Weighted Mean) Success Standard[1]

Soil Series	Moist Phase				Dry Phase			
	Acres[2]	Percent[3]	Production[4] (lbs./ac.)	Wt. Avg. (Production lbs./ac.)	Acres[2]	Percent[3]	Production[4] (lbs./ac.)	Wt. Avg. Production (lbs./ac.)
Begay	78.7	0.7	1000	7.0	173.2	1.5	650	10.0
Bond	22.7	0.2	500	1.0	79.7	0.7	500	3.5
Cahona	570.0	5.1	1000	50.6	1088.9	9.7	750	72.5
Chilton	0.0	0.0	750	0.0	0.0	0.0	750	0.0
Dulce	954.6	8.5	600	50.8	1780.7	15.8	600	94.8
Las Lucas	380.2	3.4	675	22.8	479.7	4.3	675	28.7
Oelop	0.0	0.0	750	0.0	68.2	0.6	750	4.5
Pulpit	295.2	2.6	800	21.0	148.7	1.3	600	7.9
San Mateo	37.3	0.3	750	2.5	145.1	1.3	750	9.7
Sharps	57.3	0.5	1200	6.1	399.5	3.5	600	21.3
Travessilla	0.0	0.0	225	0.0	67.6	0.6	225	1.3
Zyme	1134.2	10.1	400	40.2	2348.4	20.8	300	62.5
Soils A	56.9	0.5	500	2.5	268.1	2.4	450	10.7
Soils B	43.9	0.4	500	1.9	171.5	1.5	450	6.8
Other Soils	33.3	0.3	500	1.5	54.2	0.5	450	2.2
Ustic Torriorthents	0.0	0.0	350	0.0	18.8	0.2	350	0.6

TABLE 9 (Cont.)

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Soil Series	Moist Phase Acres[2]	Moist Phase Percent[3]	Moist Phase Production[4] (lbs./ac.)	Moist Phase Wt. Avg. (Production lbs./ac.)	Dry Phase Acres[2]	Dry Phase Percent[3]	Dry Phase Production[4] (lbs./ac.)	Dry Phase Wt. Avg. Production (lbs./ac.)
Rock Outcrop	82.8	0.7	0	0.0	232.6	2.1	0	0.0
Disturbed Land	312.7	-	-	-	1011.1	-	-	-
Riverwash	0.0	-	-	-	1.6	-	-	-
Reclaimed Land	0.0	-	-	-	0.0	-	-	-
Topsoil Stockpile	0.0	-	-	-	34.5	-	-	-
Total	4059.8	33.2		207.9	8572.1	66.8		337.0
						Air-Dry Production		544.9

[1]Computational Formula:

$$P_w = \sum_{i=1}^{21} (AM_i)(PM_i) + (AD_i)(PD_i)$$

where, P_w = Weighted Average Production (lbs/ac)

AM_i = Percentage of area disturbed for the moist phase of a soil $series_i$

AD_i = Percentage of area disturbed for the dry phase of a soil $series_i$

PM_i = Soil $series_i$ potential productivity (lbs/ac by moist phase)

PD_i = Soil $series_i$ potential productivity (lbs/ac by dry phase)

[2]Acres of each moist or dry phase for soil series affected by mining disturbance

[3]Percentage of total soil series disturbance for each soil series by moist or dry phase

[4]Potential production for soil series by moist or dry phase

Because of the varied habitat preferences of wildlife, a logical goal is to provide for the needs of a variety of species within the constraints of environmental conditions controlling plant adaptability and the critical need to improve wildlife forage habitat in a native environment severely depleted by livestock overgrazing. The utility of reclaimed lands for wildlife has been previously described. Furthermore, livestock grazing has been requested as a postmine land use emphasis. Thus, varying densities and areas of lower shrub density can benefit both livestock and wildlife land uses.

An approximate level of 400 shrubs per acre in a beneficial herbaceous forage matrix is a desirable shrub density for meeting wildlife habitat values on reclaimed rangeland areas. The success standard for shrub density on reclaimed rangelands is 400 stems per acre consisting of two or more woody species. High density or other identified shrublands will have a success standard of 800 stems per acre consisting of two or more woody species. Shrublands will be identified and mapped within the overall reclaimed areas (excepting woodland areas as described below) as high density shrub stands (> 800 stems per acre). Permanent transect and random monitoring data indicates many of these high density shrublands will exceed the 800 stems per acre. This results in considerable heterogeneity in overall woody density, improved community diversity, and increased establishment of edge habitat.

The diversity standards presented in Table 8 are based upon species composition and woody density. Additional considerations include the nutritional needs of livestock and habitat values for wildlife; avoiding establishment of monocultures; and providing sufficient diversity of life forms to insure vegetation stability, sustain plant community development and diversity. The standards are based on vegetation baseline data and, indirectly, Form-5 soil series interpretation records. Additionally, annual monitoring reports for reclaimed areas submitted to OSMRE since 1990 and discussions with OSMRE contributed to development of the diversity standards. Diversity standards also reflect the various applied BTCA practices, including revegetation seed mixes and planting lists, varying environmental conditions, and successional timeframes. These considerations are necessary for realistic expectations of success.

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Shrubland and Woodland Areas. All reclaimed areas whether rangeland, shrubland, or woodland provide wildlife habitat in varying degrees or function while providing grazing and foraging areas for livestock. A third use, cultural plants, is provided for in the

cultural plant reclamation sites that also serve as woodland establishment areas where red rock substrates are used. Woodland areas will be established in scattered locations on permanent program reclaimed lands as both sites established on red rock substrates or as pinyon pine transplant areas. Because of the various BTCA inputs required to establish these woodland sites and maximize future habitat benefits, success standards are somewhat different from those presented under rangeland and shrubland reclaimed plant communities.

Revegetation success for cover on lands reclaimed as woodland will be evaluated by their inclusion in the overall sampling area of a bond release unit. Cover is evaluated using the reference area comparison approach and random sampling techniques. Therefore the interspersed woodland areas will have as equal a chance of a sample being taken there as the rest of the sampling unit. The revegetation program for woodland areas includes herbaceous species to aid in stabilizing the soil surface from accelerated erosion reflecting the intent of the cover standard.

A production standard is not included in revegetation success evaluations for the woodland areas. There is no requirement in the Permanent Program Rules for a production standard for lands developed as woodland or wildlife habitat [30 CFR 816.116(b)(3)].

The shrub density standard for shrubland and woodland areas is 800 stems per acre (Table 8). This reflects BTCA inputs, Black Mesa environmental conditions, successional time frames, and establishment of wildlife habitat as discussed previously under shrublands.

The woodland tree density standard is 75 trees per acre for areas identified as woodland. Areas specified as shrubland do not have a tree density standard. This standard was apparently agreed upon in meetings between the Navajo Nation, Bureau of Indian Affairs, and [illegible] This density standard was conveyed to PWCC via a meeting (held in Flagstaff, Arizona on December 10, 1987 by OSMRE technical staff) and letter correspondence (dated December [illegible], 1987 and January 21, 1988 from Mr. Peter Rutledge, Chief, Federal Programs Division, OSMRE to Mr. Gary Melvin, Senior Manager, Environmental Affairs, Peabody Coal Company). The standard addresses wildlife utility and potential emigration of trees by improving the number and proximity of seed dispersal sources. It reflects a stand density that provides for desirable community development and diversity while allowing for good levels of understory vegetation.

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Diversity - All Reclaimed Lands. The diversity standards (Table 8) are based on BTCA reclamation inputs, ecological considerations, and successional time frames during the reclamation liability period. They reflect varied nutritional and cover requirements or other habitat needs of wildlife and that the established vegetation has a reasonable level of species richness and evenness for communities in earlier phases of succession. It further reflects the potential for accelerated emigration of varying plant species and growth forms by improving the number, variety, and proximity of seed dispersal sources. Development of the standards was aided by an intensive review of the baseline vegetation data (Chapter 9), the Form-5 soil interpretation records in Appendix A of the Mine Plan (potential native plant community descriptions), annual monitoring of pinyon-juniper and sagebrush reference areas, and review of nearly 20 years of reclaimed area monitoring data. These empirically derived data indicate that only a few species dominate the shrublands, woodlands, or shrubland understory of woodlands. Other species are represented as a sub-dominant expression, or are uncommonly represented. The diversity standards reflect this kind of vegetative expression and the anticipated level of succession for communities eligible for revegetation success evaluations. The developed diversity standards also reflect the widely varying environmental conditions common on Black Mesa necessary for consideration of realistic expectations of success.

Determination of Revegetation Success

This section describes the program PWCC uses to evaluate and demonstrate the success of revegetation on permanent regulatory program lands on the Black Mesa leasehold. The program involves collection of statistically valid vegetation samples, evaluation of the equality of the vegetation sample means and other sample results with respective success standards, necessary statistical analysis, and application for performance bond releases.

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The success standards for ground cover, production, shrub density, and diversity (species composition) presented in the previous section (Table 8) apply to revegetation success evaluations. Vegetation sampling detailed in Attachment 2 of Chapter 9 describes the methods used to collect the quantitative vegetation data necessary to determine revegetation success. Random sample transect location insures that unbiased estimates of sample means and variances are made for valid statistical comparisons of sample data and the success standards. The collection of samples that are representative of population mean values within reasonable statistical confidence intervals supports the validity of

sample means used for comparisons.

Revegetation success standards must be applied in accordance with the approved postmining land uses. The postmining land uses on the Black Mesa leasehold are livestock grazing, wildlife habitat, and cultural plant use. Therefore, the ground cover, production, and shrub or tree density must be at least "equal" to the respective success standards listed in Table 8. These parameters are considered equal to the standards when they are not less than 90 percent of the standards with 90 percent statistical confidence. In addition, the vegetation must be sufficiently diverse to meet the prescribed diversity standard.

Ground cover comparisons between the mean of the reclaimed area data set and the mean value for the sagebrush reference areas are made using a two sample t-test. Means will only be tested if the revegetated area values are less than the sagebrush reference area cover values (standard). When a statistical comparison is required it is at a 90 percent confidence interval for a one tailed test with n-1 degrees of freedom. The hypothesis to be tested is H_o: the reclaimed area ground cover is greater than or equal to the reference area ground cover and H_A: the reclaimed area ground cover is less than the reference area ground cover. By convention, the null hypothesis is accepted when the calculated t-value is less than or equal to the tabled value.

Production and woody plant density comparisons between the reclaimed area and the success standards are made using a one sample t-test of sample means and the respective success technical standards. Means will be tested only if they are less than the minimum values prescribed in the success standards. The 90 percent confidence interval is used for all production comparisons when one is required such that the tabled t-value is $t_{0.10(1),\ N-1}$. The 90 percent confidence interval ($t_{0.10(1),\ N-1}$) is used for shrub or tree density comparisons. The one-tailed hypothesis that will be tested is H_O: the population mean (represented by the sample mean) is greater than or equal to the success standard and H_A: the population mean is less than the success standard. Acceptance of the null hypothesis indicates successful revegetation with regard to the comparison parameter. By convention, the null hypothesis is accepted when the calculated t-value is less than or equal to the tabled value. The nature of the statistical test requires that mean comparisons must be made separately for each year.

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PWCC samples vegetation at or near the peak of the spring growing season and again at the

peak of the later fall season growth or regrowth. Sampling is scheduled in this manner to quantify dynamics of the vegetation resulting from the bimodal precipitation patterns. Cool and warm season perennial species and seasonal annuals differ in times of peak development. Sampling twice annually better describes the variable vegetation response in terms of this seasonality.

The Black Mesa leasehold receives an average annual rainfall that is well under 26 inches and must meet the 10 year liability requirements of the regulations. The following paragraph describes the manner in which vegetation sampling results are used in revegetation success evaluations. Sampling and demonstration of revegetation success will be within the time frames of the responsibility period as specified in 30 CFR 816.116.

Reclaimed area ground cover data from either the spring or fall sampling periods, but collected in two distinct years, and no sooner than year nine of the liability period, is used resulting in two sample means which quantify the annual ground cover needed for comparative purposes. The reclaimed area cover data is compared to the mean sagebrush reference area data collected during the same season and year. Vegetation cover data will not be pooled or combined from two seasonal samples. The shrub or tree density data, collected once each year (spring or fall), provides two sample means for comparison. The greatest seasonal reclaimed area production data for the spring or fall sample periods in each of the two required years of sampling is used for the production parameter. This spring or fall "peak of green", is compared to the production success standard. The lesser seasonal production will also be reported to better describe the off-season production, but will not be used in success determinations.

Sampling results are presented in much the same manner as they have been presented in annual vegetation resources reports submitted to regulatory authorities. All data necessary to support the comparisons will be included.

Revegetation Plan Summary

The Revegetation Plan, in association with Chapter 22 (Minesoil Reconstruction) provides the basis for development and establishment of stable and productive plant communities that have a high level of utility and can meet the intended land use goals of livestock grazing,

wildlife habitat, and cultural plant use as well as any secondary land use goals outlined in Chapter 14 (Land Use).

Diverse seed and planting mixes, the various shrubland, woodland, and cultural site planting scenarios, and the varying topographic and edaphic characteristics provided by the reclaimed landscape, will aid in the development of heterogeneous plant communities that are themselves diverse and have a high level of utility. These methods reflect the best available technology currently available, and barring force majeure, provide the greatest opportunity for the overall success of reclamation. The methods and technology detailed in the overall reclamation plan are designed to restore basic ecosystem function and advance successional processes, thus providing a high degree of assurance that reclaimability and sustainability of affected lands can be met. Changes or improvements in the best available technology currently available, based either on outside research or findings from PWCC's test plots and operational experience, are incorporated as needed to insure that successful reclamation is met and the postmining land use goals are achieved.

Four Federal permits and reclamation plans are enforced at the J-21 mining area (Permit Nos. AZ-0002A, AZ-0001C, AZ-0001D, and AZ-0001E and their related renewal permits). Permit AZ-0002A is enforced on lands disturbed during the period from the date of issuance (December 28, 1984) to the date Permit AZ-0001C was issued (July 6, 1990). Permits AZ-0001C, AZ-0001D, AZ-0001E, and their related renewal permits are enforced on lands disturbed after July 6, 1990. The Jurisdictional Permit Map (Drawing No. 85360) shows the relationship of these permit areas at the J-21 mining area.

The seed mix and planting dates used on Permit AZ-0002A reclaimed lands may be found in the permit application package at Volume 53, Tab 14 (Sections 1 and 2). That seeding plan is similar to the plan presented herein for Permits AZ-0001C, AZ-0001D, AZ-0001E, and their related renewal permit jurisdictional lands.

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APPENDIX A

Supplemental Plant Materials List
for Revegetation Practices at the
Black Mesa and Kayenta Mines

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TABLE A-1

Supplemental Plant Materials list for Revegetation Practices at the Black Mesa and Kayenta Mines

Common Name	Scientific Name	Drilled Rate PLS Lbs/Acre	PLS Seeds per Ft^2
Switchgrass	Panicum virgatum	0.5 - 1.0	4.5 - 8.9
Spike muhly*	Muhlenbergia wrightii	0.1 - 0.3	3.8 - 11.0
Little bluestem	Schizachyrium scoparium	0.5 - 1.0	3.0 - 5.9
Spike dropseed*	Sporobolus contractus	0.1 - 0.2	6.4 - 12.8
Giant dropseed*	Sporobolus giganteus	0.2 - 0.4	6.4 - 12.8
Basin wildrye	Elymus cinereus	1.0 - 2.0	3.8 - 7.6
Mammoth wildrye	Elymus giganteus	1.0 - 3.0	1.3 - 3.9
Buffalograss	Buchloe dactyloides	1.0 - 3.0	1.2 - 3.6
Yellow bluestem	Bothriochloa ischaemum	0.1 - 0.2	3.2 - 6.4
Arizona fescue	Festuca arizonica	0.25 - 0.75	2.6 - 7.8
Canby bluegrass*	Poa canbyi	0.25 - 0.50	4.2 - 8.4
Plains bristlegrass	Setaria macrostachya	0.50 - 1.0	3.5 - 7.0
Intermediate wheatgrass	Agropyron intermedium	1.0 - 2.0	2.0 - 4.0
Streambank wheatgrass	Agropyron riparium	1.0 - 2.0	3.6 - 7.2
Tall wheatgrass	Agropyron elongatum	1.0 - 2.0	1.8 - 3.6
Beardless bluebunch wheatgrass	Agropyron inerme	1.0 - 2.0	3.4 - 6.8
Bluebunch wheatgrass	Agropyron spicatum	1.0 - 2.0	3.2 - 6.4
Slender wheatgrass	Agropyron trachycaulum	0.5 - 1.0	1.8 - 3.6
Sandberg bluegrass*	Poa sandbergii	0.2 - 0.4	4.2 - 8.4
Bottlebrush squirreltail	Sitanion hystrix	0.5 - 1.0	2.2 - 4.4
Big Bluegrass	Poa ampla	0.2 - 0.4	4.0 - 8.0

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TABLE A-1 (Continued)

Common Name	Scientific Name	Drilled Rate PLS Lbs/Acre	PLS Seeds per Ft^2
Needleandthreadgrass	Stipa comata	1.0 - 2.0	1.6 - 3.2
New Mexico feathergrass	Stipa neomexicana	1.0 - 2.0	1.6 - 3.2
Prairie coneflower*	Ratibida columnaris	0.1 - 0.3	2.1 - 6.2
Rocky Mountain Beeplant*	Cleome serrulata	0.25 - 1.0	0.4 - 1.4
Annual sunflower	Helianthus annuus	1.0 - 2.0	1.3 - 2.6
Purple prairie clover	Petalostemon purpureum	0.25 - 0.5	1.5 - 3.0
White prairie clover*	Petalostemum candidum	0.1 - 0.2	0.8 - 1.6
Scarlet bugler*	Penstemon barbatus	0.1 - 0.3	1.3 - 3.8
Firecracker penstemon*	Penstemon eatonii	0.1 - 0.25	1.4 - 3.4
Cicer milkvetch	Astragalus cicer	0.5 - 1.0	1.5 - 3.1
Parry penstemon*	Penstemon parryi	0.25 - 0.50	1.6 - 3.2
Rocky Mountain penstemon*	Penstemon strictus	0.1 - 0.2	1.4 - 2.8
Tufted evening primrose*	Oenothera caespitosa	0.1 - 0.2	2.1 - 4.2
Pale evening primrose*	Oenothera pallida	0.2 - 0.4	2.3 - 4.6
Showy evening primrose*	Oenothera speciosa	0.05 - 0.1	2.9 - 5.8
Common gaillardia (blanket flower)	Gaillardia aristata	0.5 - 1.0	1.5 - 3.0
Sulfur wildbuckwheat	Eriogonum umbellatum	0.25 - 0.5	1.2 - 2.4
Plains aster*	Aster bigelovii	0.1 - 0.2	3.6 - 7.2
Tansyleaf aster*	Aster tanacetifolius	0.2 - 0.4	2.3 - 4.6
Scarlet globemallow*	Sphaeralcea coccinea	0.1 - 0.2	1.2 - 2.4
Littleleaf globemallow*	Sphaeralcea parvifolia	0.1 - 0.5	1.2 - 5.8

TABLE A-1 (Continued)

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Common Name	Scientific Name	Drilled Rate PLS Lbs/Acre	PLS Seeds per Ft^2
Desert globemallow*	Sphaeralcea ambigua	0.1 - 0.25	1.2 - 3.0
Western Yarrow	Achillea millefolium v.occidentallis	0.1 - 0.2	6.4 - 12.8
Early Indian paintbrush*	Castilleja chromosa	0.1 - 0.2	5.6 - 11.2
Narrowleaf Indian paintbrush*	Castilleja linariaefolia	0.05 - 0.1	5.6 - 11.2
Gooseberry globemallow*	Sphaeralcea grossulariaefolia	0.1 - 0.3	1.2 - 3.5
Munro globemallow*	Sphaeralcea munroana	0.1 - 0.2	1.2 - 2.4
Apache plume*	Fallugia paradoxa	0.2 - 0.4	1.8 - 3.6
Green Mormontea	Ephedra viridis	0.25 - 2.0	0.2 - 1.2
Cliffrose	Cowania mexicana	1.0 - 2.0	1.5 - 3.0
Mountain mahogany	Cercocarpus montanus	0.5 - 2.0	0.7 - 2.8
Skunkbush sumac	Rhus trilobata	1.0 - 2.0	0.5 - 1.0
Wolfberry	Lycium pallidum	1.0 - 2.0	0.7 - 1.4
Antelope bitterbrush	Purshia tridentata	1.0 - 2.0	0.4 - 0.8
Big sagebrush*	Artemisia tridentata	0.1 - 0.2	5.7 - 11.4
Sand sagebrush*	Artemisia filifolia	0.1 - 0.2	5.0 - 10.0
Fringed sagebrush*	Artemisia frigida	0.1 - 0.2	10.3 - 20.6
Black sagebrush*	Artemisia nova	0.1 - 0.2	2.1 - 4.8
Rubber rabbitbrush*	Chrysothamnus nauseosus	0.1 - 0.2	1.6 - 3.2
Small soapweed	Yucca glauca	1.0 - 2.0	0.5 - 1.0
Greasewood*	Sarcobatus vermiculatus	0.25 - 0.50	1.2 - 2.4
Alfalfa (falcata - type)	Medicago falcata	0.25 - 0.50	1.3 - 2.5

TABLE A-1 (Continued)

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Common Name	Scientific Name	Drilled Rate PLS Lbs/Acre	PLS Seeds per Ft^2
Sainfoin	Onobrychis viciaefolia	1.0 - 3.0	0.7 - 2.1
Yellow Sweetclover*	Melilotus officinalis	0.25 - 0.5	1.5 - 3.0
American vetch	Vicia americana	0.5 - 2.0	0.4 - 1.5
Prairie sage*	Artemisia ludoviciana	0.1 - 0.25	10.0 - 25.0
Purple verbena*	Verbena stricta	0.1 - 0.2	1.0 - 2.0
Wild lupine	Lupinus perennis	1.0 - 2.0	0.4 - 0.8
Silverleaf lupine	Lupinus argenteus	1.0 - 2.0	0.5 - 1.0
Northern sweetvetch	Hedysarum boreale	0.5 - 1.0	0.4 - 0.8

NOTE: Species identified with an asterisk will be broadcast seeded

See Appendix B, Table B-1 for list of additional species which may be added to the rangeland mix or as components of cultural plant site mixes.

APPENDIX B

Cultural Plant Species for
Potential Use in Reclaimed Areas
at the Black Mesa and Kayenta Mines

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TABLE B-1

List of Cultural Plant Species for Potential Use in Reclaimed Areas

Scientific Name	Common Name	English Translated Navajo Name
GRASSES		
Agropyron smithii	Western wheatgrass	Brittle Grass
Bouteloua gracilis	Blue Grama	Bent Grass
Hilaria jamesii	Galleta	Red Grass
Muhlenbergia wrightii	Spike Muhly	Sand Broom
Munroa squarrosa	False Buffalograss	Pulverized Frost Grass
Oryzopsis hymenoides	Indian Ricegrass	Toasted or Scorched Seed
Sporobolus airoides	Alkali sacaton	Awl Grass
Sporobolus cryptandrus	Sand Dropseed	Slender Grass
Schizachyrium scoparium	Little Bluestem	Red Grass
FORBS		
Achillea millefolium	Yarrow	Chipmunk-like Tail
Allium spp.	Wild Onion	Onion
Amaranthus graecizans	Prostrate Pigweed	Spread Out
Asclepias subverticillata	Whorled Milkweed	Slender Milky Plant
Astragalus calycosus var. scapiosus	Torrey Milkvetch	Resembling Beans
Astragalus lentiginosus	Blue Loco	Resembling Beans
Astragalus wingatanus	Fort Wingate Milkvetch	Resembling Beans
Calochortus aureus	Golden Sego Lily	Children's Food
Calochortus nuttallii	Sego Lily	Children's Food
Campanula parryi	Parry Bellflower	Small Blue-flowered Plant Used for Pollen
Castilleja chromosa	Desert Indian Paintbrush	Humming Bird's Food
Castilleja linariaefolia	Wyoming Paintbrush	Humming Birds's Food
Chenopodium spp.	Goosefoot	Grass White
Cirsium spp.	Thistle	Rounded Medicine
Cleome serrulata	Rocky Mountain Beeplant	The Beeweed
Convolvulis arvensis	Field Morning Glory	Plant Twining
Corydalis aurea	Scrambled Eggs	Little Turkey-like Odor
Croton texensis	Texas Doveweed	Spider Food
Cryptantha bakeri	Baker Cryptantha	Grey Plant with Sticky Seeds
Cryptantha flavoculata	Roughened Cryptantha	Grey Plant with Sticky Seeds
Cymopterus spp.	Spring Parsley	Big Wild Celery
Delphinium scaposum	Barestem Larkspur	Blue Pollen
Dimorphocarpa wislizenii	Common Spectaclepod	Grey Kangaroo Rat Food
Eriogonum alatum	Winged Wildbuckwheat	Earth Medicine
Eriogonum racemosum	Redroot Wildbuckwheat	Big on Top of Ground
Eriogonum umbellatum	Sulfur Wildbuckwheat	Adobe Standing Red
Erodium cicutarium	Filaree	Bee Food
Euphorbia fendleri	Fendler spurge	Little Milkweed

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TABLE B-1

(Continued)

Scientific Name	Common Name	English Translated Navajo Name
FORBS (Con't)		
Gaillardia pinnatifida	Blanketflower	Wasp Food
Gaura coccinea	Scarlet Gaura	Medicine Plant which Keeps One Cool
Gilia aggregata	Skyrocket Gilia	Humming Bird's Food
Gilia subnuda	Few-leaved Gilia	Red Leaf Blessing Way Tobacco
Grindelia aphanactis	Rayless Gumweed	Red Ant Killer
Happlopappus amerioides	Thrifty Goldenweed	Goldenweed
Happlopappus nuttallii	Nuttal Goldenweed	Goldenweed
Happlopappus spinulosus	Ironplant Goldenweed	Goldenweed
Helianthus annuus	Annual Sunflower	Sunflower
Hymenoxys acaulis	Stemless Bitterweed	Owl-like Food
Hymenoxys richardsonii	Colorado Rubberweed	Owl-like Food
Lappula redowski	Bluebur Stickseed	Plant Whose Seeds are Sticky
Leuceline ericoides	White Aster	Slender Snuff
Lesquerella intermedia	Bladderpod	Water Sprinkler's Eye Wash
Linum lewisii	Blue Flax	Slender Navajo Plant
Lithospermum incisum	Narrowleaf Gromwell	Red Root Medicine
Lithospermum multiflorum	Manyflower Gromwell	Black Root Medicine
Lupinus argenteus	Silvery Lupine	Wondering About Medicine
Malva neglecta	Roundleaf Mallow	White-flowered Medicine
Marrubiam vulgare	Common Horehound	Gray Knotted Medicine
Medicago sativa/falcata	Alfalfa	Horse Hay Like Beeplant
Mentzelia pumila	Stickleaf Mentzelia	Plant with Tenacious Slender Leaves
Mirabilis multiflora	Colorado Four O'Clock	Falling-on-Rock
Nicotiana attenuata	Wild Tobacco	Wild Tobacco
Oenothera albicaulis	White Evening Primrose	White at Night
Oenothera caespitosa	Tufted Evening Primrose	Grey Night-blooming Plant
Oenothera pallida	Pale Evening Primrose	White at Night
Oxytropis lambertii	Lambert Loco	Sheep Tobacco
Penstemon barbatus	Scarlet Bugler	Humming Bird's Food
Penstemon eatonii	Firecracker Penstemon	Humming Bird's Food
Penstemon linarioides	Mat Penstemon	Many Root
Petalostemon spp.	Prairie Clover	Looks Like a Man's Hair Braid
Petradoria pumila	Rock Goldenrod	Yellow Plant
Plantago purshii	Wooly Plantain	Medicine
Portulaca oleracea	Purslane	Breeze Through Rock
Rudbeckia laciniata	Cutleaf Coneflower	Big-Arrow-Poison Antidote
Rumex crispus	Curly-leaf Dock	Plant with Yellow Root
Solanum elaeagnifolium	Silverleaf Nightshade	Yellow Eyes

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TABLE B-1

(Continued)

Scientific Name	Common Name	English Translated Navajo Name
FORBS (Con't)		
Sphaeralcea ambigua	Desert Globemallow	Big Gummy Medicine
Sphaeralcea coccinea	Scarlet Globemallow	Gummy Medicine
Sphaeralcea parvifolia	Littleleaf Globemallow	Big Gummy Medicine
Thelesperma subnudum	Navajotea Greenthread	Tea Plant
Townsendia exscapa	Stemless Townsendia	Unraveling Plant
Townsendia incana	Hoary Townsendia	Unraveling Plant
Tradescantia occidentalis	Prairie Spiderwort	Mariposa-like Leaf
Tripterocalyx carnea	Wooton Sandpuff	Smelly Onion
Verbena macdougalii	Spike Verbena	Large Blue Pollen
Verbesina encelioides	Golden Crownbeard	Gray Sunflower
SUBSHRUBS		
Artemisia frigida	Fringed Sage	Flexible Plant
Ceratoides lanata	Winterfat	Jack Rabbit Food
Chrysothamnus greenei	Greene Rabbitbrush	Medicine for Alien Diseases
Chrysothamnus viscidiflorus	Sticky-leaved Rabbitbrush	Yellow on Top
Ephedra torreyana	Torrey Mormon Tea	Gray Rubbing Grass
Ephedra viridis	Green Mormon Tea	Cough Medicine
Eriogonum rotundifolium	Wild Buckwheat	Red Ant Foot
Senecio douglasii var. longilobus	Threadleaf Groundsel	Rotten Medicine
SHRUBS		
Artemisia tridentata	Big Sagebrush	The Sagebrush
Atriplex canescens	Fourwing Saltbush	Gray Greasewood
Atriplex confertifolia	Shadscale	Sharp Saltbush
Cercocarpus montanus	Mountain Mahogany	Heavy as Stone
Chrysothamnus nauseosus	Rubber Rabbitbrush	Big Yellow on Top
Coleogyne ramosissima	Blackbrush	Black Plant
Cowania mexicana	Cliffrose	Baby Cradle
Fallugia paradoxa	Apache Plume	---
Fendlera rupicola	Cliff Fendlerbush	Hard Wood
Lycium pallidum	Wolfberry	God's Food
Purshia tridentata	Antelope Bitterbrush	The Antelope Brush
Foresteria neomexicana	New Mexico Privet	Black
Gutierrezia sarothrae	Broom Snakeweed	Big Dodge Weed
Quercus gambelii	Gambel Oak	Rock Plant
Rhus trilobata	Skunkbush Sumac	Sumac
Sarcobatus vermiculatus	Greasewood	Black Bushy Shrub
Shepherdia rotundifolia	Roundleaf Buffaloberry	Sheep's Food
Yucca angustissima	Spanish Bayonet	God's Yucca
Yucca baccata	Banana Yucca	Wide Yucca
Yucca glauca	Small Soapweed	Narrow Yucca

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TABLE B-1

(Continued)

Scientific Name	Common Name	English Translated Navajo Name
TREES		
Acer negundo	Boxelder	The Boxelder
Juniperus monosperma	One-seed Juniper	The Juniper
Juniperus osteosperma	Utah Juniper	Male Juniper
Pinus edulis	Pinyon Pine	Pinyon
Populus fremontii	Fremont Cottonwood	Broadleaf Cottonwood
SUCCULENTS		
Echinocereus spp.	Hedgehog Cactus	Heart Twisted
Mammillaria spp.	Pincushion Cactus	Cactus
Opuntia phaeacantha	Pricklypear	Broad Cactus
Opuntia polyacantha	Plains Pricklypear	Broad Cactus
Opuntia whipplei	Whipple Cholla	Big Needle Cactus

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APPENDIX D

IMPROVED PASTURE RECLAMATION PLAN
N14 COAL RESOURCE AREA

OCT 2000
APPROVED

Revised 09/11/00

Appendix D

Improved Pasture Reclamation Plan
N14 Coal Resource Area

Residents living in the vicinity of the N14 Coal Resource Area have requested that flatter areas within N14 undergoing reclamation in year 2000/2001 be reclaimed to a postmining land use of Improved Pasture. Based on meetings with the residents, two areas were identified as having potential for reclamation to this land use. The areas shown on Exhibit D-1 include approximately 61 acres in the old ramp 5 interior (Area 1) and 23 acres in the old ramp 7 interior (Area 2). These areas are nearly flat and have a potential for run-on from adjacent reclaimed lands. This, in combination with the flatter topography, will result in greater infiltration and improved soil moisture level potential. The postmining land use of livestock grazing will be benefited through potentially higher forage production and improved livestock performance. The species proposed for revegetation under this land use can withstand drought but can also respond to increased soil moisture conditions with increased forage production and quality.

The seed mix to be used in establishing the approximately 84 acres of improved pasture is presented in Table D-1. With the exception of thickspike wheatgrass, all species are introduced. Pubescent wheatgrass, Russian wildrye and thickspike wheatgrass have historically performed well in reclaimed areas at the Black Mesa Complex. Cicer milkvetch has been observed as a volunteer in certain reclaimed areas at the Black Mesa Complex and has been able to survive and sustain productivity. This non-bloat legume can provide a good source of protein that is a limiting nutrient on regional rangelands.

Improved pasture is compatible with the regional land use of livestock grazing. The area of improved pasture proposed is small relative to the larger reclaimed areas and adjacent native range. The species will provide erosional stability similar to reclaimed lands currently established at the Black Mesa Complex.

Revegetation success standards for improved pasture will follow the discussion for Rangeland revegetation success as presented in Chapter 23, Revegetation Plan. Revegetation success for improved pasture will be judged on cover and production. Ground cover will be used as the standard for cover success criteria and will be derived from data collected in the three sagebrush shrubland reference areas. The success standard for production will use a technical standard approach that has been established at 545 lb./acre. Shrubs are not a component of the vegetation establishing improved pasture and thus there is no standard proposed. All species proposed in the seed mix have been observed in established reclamation at the Black Mesa Complex and therefore will establish and be present in the improved pasture reclaimed areas. All maintenance and management procedures follow those presented in Chapter 23, Revegetation Plan.

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Table D-1
Improved Pasture Seed Mix - Resource Area

SPECIES

Scientific Name[1]	Common Name	Variety[2]	Rate[3]	Density[4]
Astragalus cicer	Cicer milkvetch	Lutana	2	6.6
Agropyron dasystachyum	Thickspike wheatgrass	Critana	4	14.0
Agropyron trichophorum	Pubescent wheatgrass	Manoka	4	9.2
Elymus junceus	Russian wildrye	Bozoisky	3	12.0
Total			13	41.8

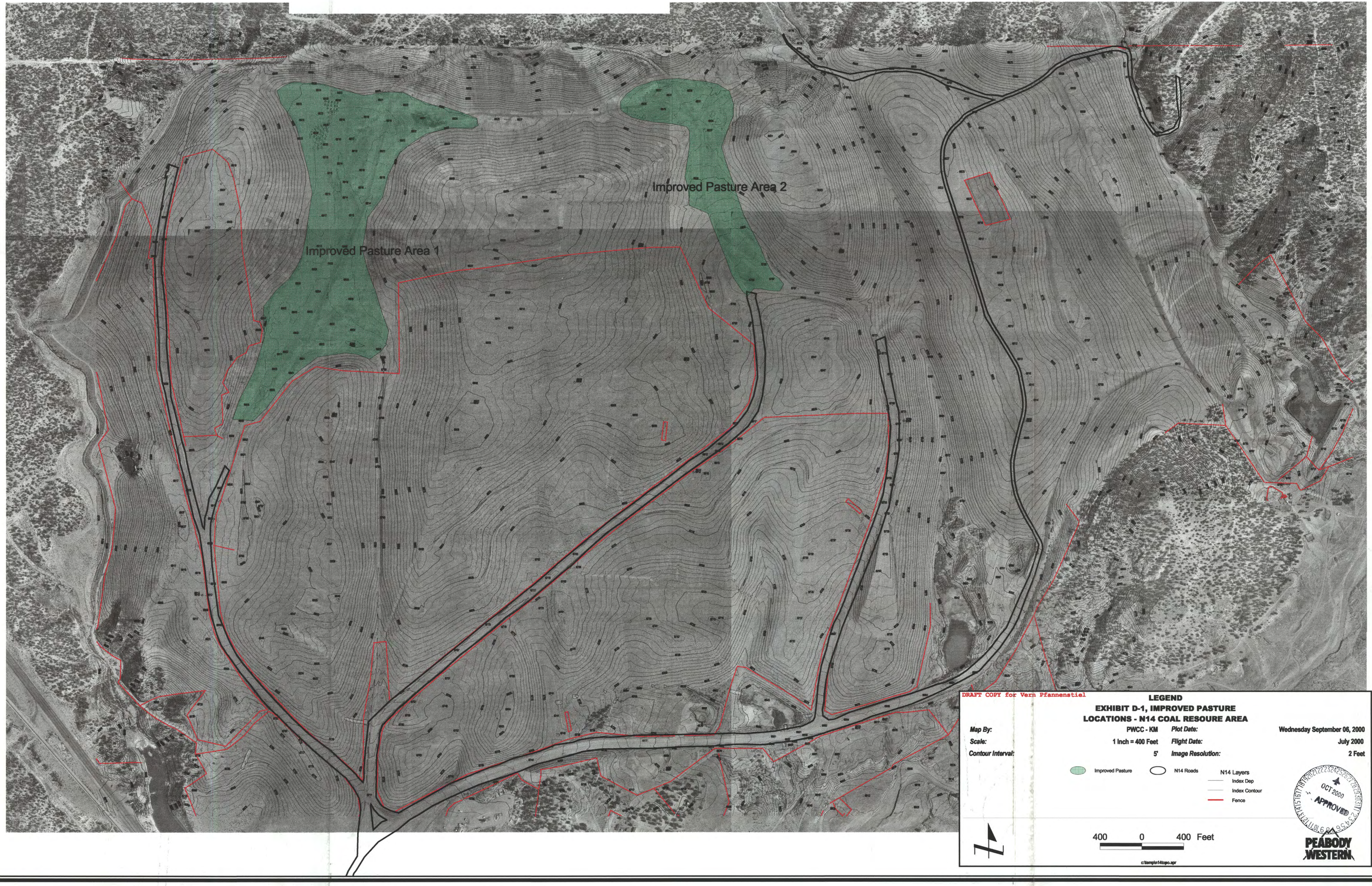
[1] Cross reference - new scientific nomenclature

Pubescent wheatgrass	Elytrigia intermedia ssp. trichophorum
Thickspike wheatgrass	Elymus lanceolatus ssp. lanceolatus
Russian wildrye	Psathyrostachys juncea

[2] Variety. The variety specified for thickspike wheatgrass may also include Bannock or Schwendimar. The variety for pubescent wheatgrass may include Luna.

[3] Rate = PLS lbs/acre (PLS - pure live seeds)

[4] Density = seeds/ft^2


Improved Pasture Area 2
Improved Pasture Area 1
DRAFT COPY for Vern Pfannenstiel
LEGEND
EXHIBIT D-1, IMPROVED PASTURE
LOCATIONS - N14 COAL RESOURE AREA
Map By: PWCC - KM
Plot Date: Wednesday September 06, 2000
Scale: 1 Inch = 400 Feet
Flight Date: July 2000
Contour Interval: 5'
Image Resolution: 2 Feet
Improved Pasture
N14 Roads
N14 Layers
Index Dep
Index Contour
Fence
400 0 400 Feet
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PEABODY WESTERN