SECTION 37

POST-RECLAMATION VEGETATION

TABLE OF CONTENTS

SECTION	SECTION TITLE	PAGE NUMBER
37	POST-RECLAMATION VEGETATION	37-1
37.1	Revegetation Plan	37-1
37.1.1	Schedule	37-1
37.1.2	Seedbed Preparation	37-1
37.1.3	Seed Mixture	37-2
37.1.4	Revegetation Seeding and Planting	37-4
37.1.5	Revegetation Mulching Techniques	37-5
37.1.6	Revegetation Irrigation	37-6
37.1.6.1	Irrigation Timing and Scheduling	37-6
37.1.7	Pest and Disease Control	37-7
37.1.7.1	Noxious Weed Control Plan	37-7
37.1.8	Measures to Determine the Success of Revegetation	37-8
37.1.8.1	Determination of Revegetation Success on Reclaimed Ash Disposal Areas	37-12

SECTION 37

POST-RECLAMATION VEGETATION

LIST OF TABLES

TABLE NUMBER	TABLE TITLE
37-1	Original Navajo Mine Reclamation Seed Mixture Applied 1975 to 1999
37-2	Cool Season Reclamation Seed Mixture
37-3	Warm Season Reclamation Seed Mixture
37-4	High Shrub Reclamation Seed Mixture
37-5	Overall Species Composition
37-6	Range Site Community Identification

SECTION 37

POST-RECLAMATION VEGETATION

LIST OF FIGURES

FIGURE NUMBER	FIGURE TITLE
37-1	Revegetation Schedule by Year and Pit

SECTION 37

POST-RECLAMATION VEGETATION

LIST OF EXHIBITS

EXHIBIT NUMBER	EXHIBIT TITLE
37-1	Navajo Mine Reference Area

SECTION 37

POST-RECLAMATION VEGETATION

LIST OF APPENDICES

APPENDIX NUMBER	APPENDIX TITLE
37.A	BHP Navajo Coal Company Noxious Weed Management Plan

SECTION 37

POST-RECLAMATION VEGETATION

LIST OF REVISIONS DURING PERMIT TERM

REV. NUMBER	REVISION DESCRIPTION	DATE APPROVED

37 POST-RECLAMATION VEGETATION

37.1 **Revegetation Plan**

The post-mining revegetation plan has been designed to establish a diverse, stable and self-sustaining vegetation that will satisfy the following criteria:

1. Adequate cover capable of stabilizing the soil surface from erosion,
2. Adequate forage to sustain the post-mining land uses (i.e. livestock grazing and wildlife habitat), and
3. Suitable species composition for enhancement of wildlife forage and cover.

No topdressing or revegetation of coal spoil fire areas will be conducted. If a coal spoil fire should begin beneath a previously revegetated plot; it will be monitored until it extinguishes itself. The area will then be assessed and, if necessary, revegetated.

Revegetated areas are shown on Exhibits 25-2, 25-3, and 25-4.

37.1.1 Schedule

Revegetation is initiated on those areas that have been graded and topdressed (or graded if suitable overburden exists) during the first normal period for planting following the completion of grading and topdressing activities (Table 30-3). Revegetation activities run from March through October and include seedbed preparation, seeding, mulching, and irrigation.

Occasionally portions of a Block (total years topdressed area) may be topdressed before the end of a normal period for planting to achieve the block approach to reclamation. These blocks will not be completely topdressed until after the normal season of planting. These areas will be identified and communicated to OSM during the annual backfilling and grading schedule meeting at the 4th quarter of each year. Blocks where topdressing is started during the normal period for planting but is not complete until after the normal period for planting will be seeded during the next normal period for planting. These topdressed areas will be protected from wind and water erosion by contour disking and installing V-ditches around plot perimeters. Fences are erected as needed to protect all revegetated areas during the first season of irrigation to eliminate grazing and unauthorized activities. These fences are patrolled and maintained throughout the year.

37.1.2 Seedbed Preparation

An essential component of a successful revegetation program is a properly prepared seedbed. Topdressing that has been redistributed on regraded areas is mechanically prepared to achieve the following benefits:

1. Reduce soil compaction caused by heavy equipment used in regrading and redistribution of topdressing,
2. Provide a transition at the interface between the spoil material and the topdressing to enhance root penetration,

3. Promote water infiltration,
4. Help control wind and water erosion,
5. Provide a firm and smooth surface for proper seed placement, and
6. Improve seed to soil contact for early seed development.

During regrading activities, certain areas become heavily compacted. This generally occurs in areas where rock trucks and scrapers are utilized for regrading. Most frequently, the heaviest compaction occurs in areas of repeated traffic (roads). These heavily compacted areas are either ripped with a dozer, blade, or disk depending on the severity of compaction. Once the spoil materials are loosened, the area is smoothed by a blade for topdressing placement.

Once topdressing is placed, the area is again disked to alleviate compaction. The severity of the compaction, depth of topdressing, and the texture of the topdressing determines the type and number of seedbed operations utilized. For example, if a large 36-inch disc is required to break through deep, heavily compacted, and heavy-textured topdressing, it will generally leave deep furrows and large clods. If this occurs, a second disking is required utilizing a smaller disk and/or roller harrow to smooth and firm the surface of the topdressing/seedbed. Rough seedbed surfaces are less effective for seeding since seeders are designed to place different seeds at their optimum seeding depth in smooth, firm seedbeds.

Additional preparation practices include contour furrowing and contour ditching. See Section 41 – Probable Hydrologic Consequences for specifics on designs and reclamation areas. For either of these operations to work effectively, the furrows and ditches have to be exactly on the contour. With undulating micro-topographies and equipment limitations, this was operationally impossible, and water therefore collected in the low spots breaching the furrows and ditches. This breaching usually continues down the slope from one furrow/ditch to the next creating an uncontrollable eroding channel. This has become a continuous problem in all the existing reclaimed areas requiring repeated repair efforts with little long-term success.

37.1.3 Seed Mixture

Since 1975, the seed mix (species and amounts) has been the subject of extensive research. Generally, the number of species seeded has increased since the first seedings, while the seeding rates (pounds of pure live seed planted) have decreased. The seeding rate is the subject of continual investigation to determine its impact on revegetation success.

In November 1999, Navajo Mine altered seed mixtures due to modifications in the revegetation success standards. The original general seed mix was replaced with three specialized seed mixtures, which include 1) Cool Season Mix, 2) Warm Season Mix, and 3) Shrub Mix. A copy of the original seed mixture will remain in the permit (Table 37-1) for historical reference.

Each specialized seed mix will be applied to a specific reclaim area based on several factors including, soil temperature, planting season and topography. Reclaiming with specialized seed mixtures will increase species diversity over the entire mine and reduce the competition between species within a given mix. Each seed mixture is designed to emphasize the establishment of assorted species based on natural differences in germination requirements.

The original seed mix had a total of 17 different species. The new mixtures have a maximum of 14 different species per mix. Having fewer species within a single mix will reduce the between species competition. The three specialized seed mixtures have a combined total of 21 different species. Applying three specialized seed mixtures over the mine will reduce the amount of competition between species within a given seed mixture but at the same time will increase the total number of different species being seeded over the entire mine.

The three specialized seed mixtures have a total of ten grasses species, four forbs, and seven shrub species (21 total). There are also six additional species identified as substitutes, which may replace a given species as needed.

The following are general characteristic of each of the specialized seed mixtures.

Cool Season Mixture – This mixture has 14 species; 8 grasses, 3 forbs, and 3 shrub species (Table 37-2). Most species in this mix are characterized as "cool" season species and have best germination results in cooler temperatures. This mixture will mainly be applied when daytime soil temperatures are less than 60° Fahrenheit, in early spring or late fall.

Warm Season Mix – This mixture has 13 species; 5 grasses, 4 forbs, and 4 shrub species (Table 37-3). Most species in this mix are characterized as "warm" season species and have best germination results in warmer temperatures. This mixture will mainly be applied when daytime soil temperatures are greater than 60° Fahrenheit (late spring through summer).

Shrub Mix – This mixture has a total of 14 species; 5 grasses, 2 forbs and 7 shrub species (Table 37-4). The species seeding ratios are designed to enhance wildlife cover by establishing "shrub islands". This seed mix will be applied through out the seeding window to drainage's or small basins where water may accumulate. This mix will be applied conservatively to areas with desirable topography at the operator's discretion.

Changes in the overall species composition are provided in Table 37-5. These species are native to the San Juan Basin, which accounts for their ability to survive the soils and climatic conditions of the mine area. The herbaceous species provide nutritional qualities during the growing season, and the palatable shrubs such as four-wing saltbush,

shadscale, and winterfat provide good nutritional qualities throughout the year. Three non-palatable shrubs used in the seed mix, ephedra, greasewood, and rabbitbrush, provide cover for small mammals and passerine birds.

Navajo Mine will continue to investigate possible modifications to cultural practices (including irrigation practices) with the intent to enhance cover production and diversity of revegetation. When such trials involve altering the above seed mixture the regulatory authority will be consulted.

Subject to seed availability, the species listed in Table 37-2, Table 37-3, and Table 37-4 will be used at Navajo Mine. The quantities of pure live seed (PLS) used per acre and corresponding numbers of seeds per square foot will vary somewhat depending on seed availability, soil texture, topographic conditions and habitat features to be seeded. To ensure that good quality seed is used, state certified standards outlined under the Federal Seed Act will be followed.

Research on other species that are adapted to the mine area and are considered to be compatible with the postmine land use is continuing at the Navajo Mine. Should other species indicate suitability for revegetation and compatibility with the post-mining land use, they will be added to the seed mixture in quantities deemed appropriate. If an introduced species demonstrates adaptability and utility for reclamation use, approval of the regulatory authority will be obtained before the introduced species is included in the seed mix.

37.1.4 Revegetation Seeding and Planting

Following seedbed preparation, seeding is accomplished by either broadcasting or rangeland seed drilling. These seeding methods are designed to plant each species at their optimum depths. Optimum planting depths for each seeded species is reported in Table 37-2, Table 37-3, and Table 37-4. These depths have been determined using documentation prepared by the USDA-Soil Conservation Service, Plant Material Center and through field observation with site specific conditions at Navajo Mine.

Seeded species are separated into three groups to improve distribution and ensure that each species is being planted at its optimal depth. The three groups are as follows:

Broadcast Seed Group – These are small seeds which germinate best on the surface or less than ¼″ deep.

Fluffy Seed Group – These are seeds with hairy or bristly appendages on the seed coat. This group is contained in a separate seed box on the seed drill. This seed is drilled to depth of ¼″ - ½″.

Large Smooth Group – These are seed drilled between ½″ - 1″. This seed is also contained in its own seed box on the drill. The seed drill is equipped with depth bands to ensure proper seeding depth and packer wheels to ensure

better seed soil contact. When the topdressing is dry and powdery the area may pre-irrigated to improve the tilth of the soil.

Hand seeding will be used, occasionally, on areas where slopes are considered too steep for the safe operation of seed drilling equipment. Whenever possible, seeding is done along the contour of the land.

Seeds of shrubs will be hand broadcast around rock piles to promote the establishment of shrubs and to increase wildlife habitat diversity.

37.1.5 Revegetation Mulching Techniques

Navajo Mine utilizes mulch primarily as an erosion control tool during periods in which plants are established. Other advantages of mulch are as follows:

1. Slows evaporation at the surface of the soil,
2. Promotes better water infiltration,
3. Decreases surface wind velocity and soil crusting, and
4. Provides an organic base (carbon) for re-establishing a beneficial microbial population, and therefore promoting nutrient cycling.

The mulch used at Navajo Mine is primarily native grass which generally consists of:

1. Native bluestem (*Androgogon gerardi*),
2. Slender wheatgrass (*Agropyron trachycaulum*), and
3. Basin wildrye (*Elymus cinereus*).

The mulch is procured in large round bales that yield noncrushed stems and leaves for ease in application and for optimum tacking of the topdressing. A round bale Haybuster is used to apply 2.0 to 2.5 tons of mulch per acre. Once the mulch is applied, it is mechanically crimped into the soil. All crimping is done on the contour when practical.

In actual field operation, Navajo Mine's mulching and crimping program has proved to be far superior in controlling erosion than contour trenching and contour furrowing. A good quality mulch, crimped properly on the contour, will anchor topdressing far beyond plant establishment. Under an irrigation program, plant establishment is much faster than mulch decomposition. As discussed in this Section, contour ditching and contour furrowing have led to some very severe erosional problems which have required repeated repair efforts with little long-term success. For these reasons, Navajo Mine will utilize the prescribed mulching operation to limit contributions of sediment to stream flow outside the Permit Area.

37.1.6 Revegetation Irrigation

Early research at the mine showed that supplemental irrigation was required to produce uniform stands of vegetation in a reasonable period of time. Because large scale revegetation operations using irrigation had never been practiced in northwestern New Mexico when research at Navajo Mine began, there were many unanswered questions concerning application rates, scheduling, and the proper system for applications. Several research projects between 1972 and 1974 led to the basic procedures which were initiated in 1975.

From 1975 through 1978, an aluminum irrigation system was moved by hand across each revegetation site. Concurrent research led to the present procedure of irrigating through a solid-set system. This system allows for better timing and scheduling and has led to more efficient water use without adverse effect on seed germination and vegetation establishment. Research on methods for reducing water use has been, and will continue to be, an important aspect of the work at the Navajo Mine (Aldon, 1975). Water is a vital resource in the region and reducing its use, without effecting the quality of revegetation is one of the main goals of the Navajo Mine revegetation program.

37.1.6.1 Irrigation Timing and Scheduling

Irrigation is applied as needed from May to mid-October. The irrigation system utilizes various sizes of aluminum pipe to cover the reclaim plot.

The irrigation schedule for the first growing season is divided into two parts: the germination cycle and support cycle. The goal of the germination cycle is to achieve field moisture capacity to over come seed inhibition and initiate germination. The germination cycle begins immediately after mulch application. Irrigation is applied for 5.0 hours at 55 PSI (within the lateral pipes) which is equivalent to 0.10 acre-feet or 1.15 inch application. This 5.0-hour application rate is repeated every fourth day for thirteen days, supplying a total germination application of 4.6 inches. Sprinkler head pressure is monitored using a pressure gauge with a Pitot tube attachment. This gradual application allows water to penetrate deep into the soil profile and slowly reach its field moisture holding capacity.

Following the thirteen day germination cycle the support cycle is initiated. The support cycle applies irrigation for 2.5 hours at 55 PSI, which is equivalent to 0.05 acre-feet or 0.57 inch application. This 2.5-hour application is repeated every eleven to thirteen days, depending on soil texture and environmental conditions. The support cycle continues through mid October. Soil moisture is retained longer during the cooler weather in September and October resulting in a reduced frequency of application. Soil moisture is continually monitored to determine the exact timing of irrigation. The occurrence of natural precipitation will decrease irrigation application accordingly.

Irrigation is discontinued by the third week in October as hard freezing frequently occurs. The irrigation pipe system is drained to avoid water freezing damage and left in place on the revegetated areas over the winter.

Reclaim plots may receive light irrigation during the second growing season. The goal of the second year irrigation is to continue promoting strong root development. The second year irrigation is generally a one time application scheduled in April or May. Irrigation is applied for 5.0 hours at 55 PSI, which is equivalent to a 1.15 inch application. During drought periods additional irrigation may be applied in June or July depending on environmental conditions such as temperature and total precipitation. During years of unusually high winter and/or spring precipitation, the second year irrigation is reduced or may be unnecessary. Reclaim plots are not irrigated during the third growing season.

37.1.7 Pest and Disease Control

Currently no pest or disease controls are implemented on revegetation plots at Navajo Mine. If such practices become necessary, the regulatory authority will be notified prior to implementation.

37.1.7.1 Noxious Weed Control Plan

Navajo Mine is committed to preventing the introduction and spread of noxious weeds. The introduction of noxious weeds is reduced by using reclamation seeds from licensed and reputable dealers. Emphasis is also placed on using grass-hay mulch from credible producers which is free of noxious weed seed. Farms which produce mulch for Navajo Mine are visited regularly by mine personnel to inspect field for noxious weeds.

All reclaim areas are monitored informally and formally on a regular basis. If noxious weeds are encounter during monitoring, proper action will be taken as outlined in the BIA's Navajo Area Noxious Weed Program. The BIA's weed list is not included in the permit as it is regularly updated. A copy of the current updated noxious weed list will be on file at Navajo Mine.

Navajo Mine will implement recommendations and procedures for managing noxious weeds, according to the BIA's Noxious Weed Management Program. The BIA has compiled a list of primary and secondary weed species of greatest concern in the local area. A rating is given to each species along with an emphasis for the level of management recommended for each rating. Species are rated as follows:

A- Potential invaders: These are noxious weeds as yet not found on the reservation, but the potential for invasion is imminent. Examples: leafy spurge and Dalmation toadflax. Emphasis will be placed on prevention, education, awareness, identification, and monitoring.

B- New invaders: New noxious weed known to have invaded isolated locales on the reservation. Example: diffuse knapweed, chickory, and spiny cocklebur. Emphasis is placed on immediate control, prevention of seed spread and eradication, education, awareness, identification, control and monitoring will be the priorities.

C- Established noxious weeds: These are weeds that are wide spread and well established on the reservation that rank high on the economic impact criteria but control effort is costly. Management is limited to awareness. Emphasis is placed on management, education, awareness, identification and monitoring

37.1.8 Measures to Determine the Success of Revegetation

The primary goal of revegetation success is to ensure that reclaimed areas are capable of supporting the post-mining land use of livestock grazing and wildlife habitat. Reestablishing all pre-mining plant communities after mining is not practical. Consequently, revegetation efforts were designed to establish plant communities capable of meeting the approved post-mining land requirements. The eight pre-mine plant communities and percentages of area they covered are presented in Table 37-6. A post-mining comparison to these communities will be used to demonstrate our revegetation success.

The range site reference areas to be used for determining revegetation success, for both cover and production, shall include only the alkali wash, arroyo shrub, and Alsan (i.e., the combined calcareous sands, sands, and saline sands) range sites. The cover and production revegetation standards shall be the equally weighted averages of the respective cover and production values for each of the range site reference areas.

These revegetation success criteria only apply to permanent program lands, and not to initial/interim and pre-law lands.

The program to determine revegetation success at Navajo Mine has the following goals:

- Identify native plant communities that represent the various pre-mine plant communities, then manage and use them as reference areas
- During the last two years of bond responsibility, sample both the reclaimed areas and the reference areas
- Compare the reclaimed areas to the reference areas to ensure they are equal to, or better than the reference areas
- Release the successfully reclaimed areas back to the Navajo Nation, so the land can be put back into productivity

Exhibit 37-1 identifies the reference areas in the Permit Area including approximate acreage. Reference Exhibit 15-1 for mine wide vegetation community delineation not shown on Exhibit 37-1.

The reference areas were primarily selected based on intact contiguous size, similarity in plant composition to pre-mine vegetation communities, likelihood of no future impact, and ability to control grazing similar to the reclaimed areas. Five of the pre-mine communities were selected with the three sandy communities (CASA, SA and SASA) combined into one community (ALSAN).

The Calcareous Sands, Saline Sands, and Sands range sites have been combined into a single range site, Alsan, for evaluation of revegetation success. This consolidation is based on the similarity of baseline soils and vegetation information. All three range sites are dominated by soil series that are classified as coarse or fine loamy, mixed, mesic, Typic Haplargids formed from either eolian or alluvial material. Common soil series include the Bacobi and Monierco, Blancot, Redlands variant, Shiprock, Mayqueen-Shiprock, and Razito. The plant communities are dominated by the perennial grasses *Sporobolus airoides* (Alkali sacaton), *Oryzopsis hymenoides* (Indian ricegrass) and *Hilaria jamesii* (Galleta) and perennial shrubs *Atriplex confertifolia* (Shadscale) and *Gutierrezia sarothae* (Broom snakeweed). Because of the limited differences between the soils and plant communities on these range sites consolidation of these communities is appropriate.

Baseline information contained in the PAP including geology, soils, slope, aspect, and vegetation demonstrate the reference areas are representative of the pre-mine areas. Soil type, precipitation, slope and elevation are predominant factors in the development of vegetation communities at Navajo Mine. With Navajo Mine covering a relatively small geographical area with little change in elevation or precipitation, the soils play a leading role in determining the different vegetation communities. The reference areas have the same soil mapping units as the disturbed areas did before mining; consequently, the vegetation communities are the same for both areas. The reference areas were part of the initial baseline soils and vegetation mapping and survey. More detailed information on geology can be found in Chapter 5, Permit NM-0003E and Chapter 11, Permit NM-0003C. More detailed information on soils can be found in Chapter 8, Permit NM-0003E and Chapter 18, Permit NM-0003C. More detailed information on vegetation can be found in Chapter 9, Permit NM-0003E and Chapter 16, Permit NM-0003C.

The reference areas will be fenced to exclude livestock from grazing. This will occur after obtaining all appropriate approvals. All reference areas will be fenced to exclude livestock grazing until the regulatory authority (RA) approves a grazing plan.

All areas will be posted as reference areas and managed similar to the reclaimed areas to which they will be compared. To similarly manage the reference areas, grazing plans for the reference area and reclaimed areas will be submitted to the RA for approval before grazing. Utilization studies will be conducted on both the reference areas and the reclaimed areas to determine actual utilization. Through this process, the reference areas will be grazed with similar intensity, livestock and duration as the reclaimed areas. Any reference area that needs additional rest before grazing will receive deferred grazing as approved in the grazing plan submitted to the RA.

In the event that future mining related activity impact the current reference areas, Navajo Mine has identified potential reference areas off lease/permit that could replace areas impacted or disturbed. If necessary, NTEC will commence discussions with appropriate permittee(s) and agencies about obtaining right of entry to those sites.

Before disturbing any reference area, NTEC will discuss the disturbance and replacement of reference areas with the RA.

Vegetation sampling for bond (responsibility) release will be conducted during the last two consecutive years of the bonding period. The earliest any bond release sampling will occur on permanent program lands will be nine years after the last augmented seeding, fertilizing or irrigation. This will allow the reclaimed area to be sampled in years nine and ten for subsequent release after year ten. Depending on location, and site conditions, reclaimed areas may not be sampled at the earliest opportunity.

Revegetation success criteria will include vegetation cover, productivity, shrub density, and species diversity. For final responsibility release, a reclaimed area (sampling unit) will meet each of the revegetation success criteria in at least two successive years. Reclaimed areas eligible for bond release sampling may be combined into a single sampling unit. Justification for combining reclaimed areas may include, but are not limited to:

- Adequate sampling area
- Seed mix used
- Proximity to one another
- Availability of water in a proposed release area
- Logical grazing blocks
- Similar appearance

Before conducting any bond release sampling, the areas to be combined for sampling will be discussed with the RA. The same sampling procedures will be used on reference and reclaimed areas. Sample locations in each area will be selected using randomly generated grid coordinates overlain on a map, computer generated point locations, or some other appropriate randomization method. Sampling will be conducted according to the following criteria:

- The following three pre-mine reference area range sites will be sampled for cover data: Alkali Wash, Arroyo Shrub and Alsan (combination of Calcareous Sands, Sands and Saline Sands). This data will be compared to the data from the reclaimed plot. These range sites were chosen for comparative purposes due to their similarity to the type of communities being reclaimed.
- Randomly located 50 meter cover transects will be used. At each half meter along the 50 meter transect, a laser pointer mounted on a tripod will be used to intersect the transect line. The first item the laser hits will be recorded (i.e., annual plant, perennial plant litter, rock, bare ground). Each 50 meter transect is considered to be one sample point. Data will be reported by species in absolute and relative percent vegetation cover.
- Production of herbaceous and shrub species will be clipped from a ten centimeter wide by ten meter long plot which is adjacent to each transect line. Each clipped plot will start at the zero meter mark and run ten meters

down the 50-meter transect line. The dominant species in each community will be clipped and bagged separately.

- Based on the 1985 baseline cover data the dominant species for each reference area range site follow:

  - Alkali Wash: Sporobolus airoides, Hilaria jamesii, Atriplex corrugata, and Atriplex obovata.
  - Arroyo Shrub: Oryzopsis hymenoides, Chrysothamnus nauseosus, and Sarcobatus vermiculatus.
  - Alsan: (combination of Calcareous Sands, Sands and Saline Sands) *Oryzopsis hymenoides, Sporobolus airoides, and Hilaria jamesii.*

The dominant species in the reclaimed areas will be the three perennial species with the highest percent cover as identified from previous sampling of the reclaimed areas. Before sampling for final bond release NTEC will present applicable data and seek the RA's approval of the dominant species on reclaimed land. The remaining perennial species in the reference area and the reclaimed areas will be harvested by life form. The life forms that will be clipped and included in the production calculations along with the dominant species are perennial grasses, perennial forbs and shrubs. All herbaceous biomass will be oven dried to a constant weight and recorded to the nearest 0.1 gram. Data will be reported in grams per square meter. Shrub production will be clipped and weighed, or a verifiable model that estimates shrub production based on measurable characteristics of the shrubs will be developed. Broom snakeweed (*Gutierrezia sarothrae*) and Salt Cedar (*Tamaix ramosissima*) production will not be included in the determination of revegetation production success.

Shrub density will be measured in a belt transect one meter wide along the entire length of the 50 meter cover transect. Shrub density will be reported in number of shrubs per acre by species.

Vegetative cover and production will be considered successful when the total vegetative cover (i.e., percent cover of live plants plus litter) and total vegetative production (annual and perennial) of the reclaimed areas are not less than 90 percent of the total vegetative cover and total vegetative production of reference areas.

Revegetation success data will first be evaluated to determine if they are distributed normally. If the data approximate a normal distribution, the sample adequacy formula, $n_{min}=t^2s^2/(dx)^2$, will be used to determine if an adequate number of samples have been collected. When sampling is adequate and the data approximates a normal distribution; a one-sided, two-sample, t-test (alpha=0.1) will be used to determine if cover and production on the reclaimed lands are greater than or equal to 90% cover and production on the reference area. The two-sample t-test will use the following null and alternative hypothesis:

H_O: $\mu_{reclaimed} \geq 0.90\ \mu_{reference}$

H_A: $\mu_{reclaimed} < 0.90\ \mu_{reference}$

For shrub density, a one-sided, one-sample, t-test (alpha=0.1) will be used. If the data does not approximate the normal distribution, the RA will be consulted to identify appropriate statistical techniques to be used to evaluate the data and determine revegetation success.

Shrub density will be considered successful if the number of shrubs is greater than or equal to 190 shrubs per acre on 80% of the area and greater than or equal to 500 shrubs per acre on 20% of the area in shrub islands and corridors.

Species diversity will be determined as follows:

- At least one perennial grass species will have a relative perennial herbaceous cover value equal to or greater than five percent. A second perennial grass species will have a relative perennial herbaceous cover value equal to or greater than three percent. No one species shall account for more than 85 percent relative herbaceous cover.
- Cumulative perennial forbs on the reclaimed areas will be greater than or equal to 0.5 percent relative perennial herbaceous cover. This forb standard will be adjusted in drought years. In years when cumulative total precipitation for January through April at Navajo Mine (average of MET I and II stations) is less than or equal to 0.85 inches, the forb component will be successful if a single forb is encountered on the shrub density belts.
- In addition to the dominant shrub species there will be a minimum of 20 shrubs per acre of additional combined species.

37.1.8.1 Determination of Revegetation Success on Reclaimed Ash Disposal Areas

Revegetation success on ash disposal areas will be measured in the same manner used to determine success on other reclaimed areas based on their land status.

References

Aldon, E. F. 1975. Reclamation of Coal-Mined Land in the Southwest. Journal of Soil and Water Conservation, Volume 33, No. 2. [Permit NM-0003C, Chapter 26, page 26-16]

Table 37-1 - Original Navajo Mine Reclamation Seed Mixture Applied 1975 – 1999

Species common name	Species scientific name	Seeding method/ seed group	Seeding depth	Ave. # of seeds/lb	Seeding rate ave. PLS lb/ac	PLS/sq. ft
Alkali Sacaton	Sporobolus airoides	B/B	<1/4″	1,758,000	0.04	1.61
Blue Grama	Bouteloua gracilis	D/F	¼″-1/2″	825,000	0.25	4.73
Galleta	Hilaria jamesii[1]	D/LS	1/2″- 1″	470,000	0.25	2.70
Giant Dropseed	Sporobolus giganteus	B/B	<1/4″	1,723,000	0.10	3.96
Indian Ricegrass	Oryzopsis hymenoides [2]	D/LS	3″- 6″	141,000	1.00	3.24
Needle and Thread	Stipa comatai[3]	D/F	¼″-1/2″	115,000	0.50	1.32
Sand Dropseed	Sporobolus cryptandrus	B/B	<1/4″	5,298,000	0.10	12.16
Western Wheatgrass	Agropyron smithii	D/LS	1/2″- 1″	110,000	0.80	2.02
Fourwing Saltbush	Atriplex canescens	D/LS	1/2″- 1″	52,000	1.20	1.43
Mormon Tea	Ephedra viridis.	D/LS	1/2″- 1″	19,000	0.08	0.03
Rubber Rabbitbrush	Chrysothamnus nauseosus	D/F	¼″-1/2″	400,000	0.25	2.30
Shadscale	Atriplex confertfolia	D/LS	1/2″- 1″	64,900	1.00	1.49
Winterfat	Ceratoides lanata (Eurotia)	B/B	<1/4″	56,700	0.75	0.98
Prairie Aster	Aster tanacetifolius.	B/B	<1/4″	500,000	0.02	0.23
Blue Flax	Linum lewisii	B/B	<1/4″	293,000	0.03	0.20
Globemallow	Sphaeralcea grossulariaefolia.	D/F	¼″-1/2″	500,000	0.03	0.34
Rocky Mtn. Penstemon	Penstemon strictus	B/B	<1/4″	592,000	0.02	0.27
Total:					6.42	39.02

[1] Caryopsis will be used when available.

[2] Oryzopsis hymenoides is seed separately in sandy topdressing.

[3] Stipa neomexicana may be substituted when available.

Seeding method: B = Broadcast, D = Drilled.;

Table 37-1 (Continued)

Seed Group: Seeds are separated into groups; B = Broadcast group, F = Fluffy seed, LS = Large smooth seed.

Table 37-2 Cool Season Reclamation Seed Mixture[3]

Species common name	Species scientific name	Seeding method/seed group	Seeding depth	Ave. # of seeds/lb	Seeding rate ave. PLS lb/ac	PLS/sq. ft
Thickspike Wheatgrass	Agropyron dasystachyum	D/LS	1/2″- 1″	154,000	0.75	2.65
Blue Grama	Bouteloua gracilis	D/F	¼″-1/2″	825,000	0.15	2.84
Galleta	Hilaria jamesii[1]	D/LS	1/2″- 1″	470,000	0.15	1.62
Prairie Junegrass	Koeleria cristata	B/B	<1/4″	2,315,400	0.05	2.66
Indian Ricegrass	Oryzopsis hymenoides [2]	D/LS	3″- 6″	141,000	1.50	4.86
Bottlebrush Squirreltail	Sitanion hystrix	D/LS	1/2″- 1″	192,000	0.50	2.20
Alkali Sacaton	Sporobolus airoides	B/B	<1/4″	1,758,000	0.04	1.61
Needle and Thread	Stipa comata	D/F	¼″-1/2″	115,000	0.20	0.53
Fourwing Saltbush	Atriplex canescens	D/LS	1/2″- 1″	52,000	1.20	1.43
Shadscale	Atriplex confertfolia	D/LS	1/2″- 1″	64,900	1.00	1.49
Winterfat	Ceratoides lanata	B/B	<1/4″	56,700	1.30	1.69
Evening Primrose	Oenothera pallida	D/LS	1/2″- 1″	512,000	0.30	3.53
Palmer Penstemon	Penstemon palmeri	B/B	<1/4″	210,000	0.40	1.93
Globemallow	Sphaeralcea grossulariaefolia.	D/F	¼″-1/2″	500,000	0.30	3.44
				TOTAL:	7.84	32.48

[1] Caryopsis will be used when available.

[2] Oryzopsis hymenoides is seed separately in sandy topdressing.

[3] Seed mixture established November 1999.

Seeding method: B = Broadcast, D = Drilled; Seed Group: Seeds are separated into groups; B = Broadcast group, F = Fluffy seed, LS = Large smooth seed

Table 37-3 Warm Season Reclamation Seed Mixture[2]

Species common name	Species scientific name	Seeding method/ seed group	Seeding depth	Ave. # of seeds/lb	Seeding rate ave. PLS lb/ac	PLS/sq. ft
Blue Grama	Bouteloua gracilis	D/F	¼″-1/2″	825,000	0.30	5.68
Galleta	Hilaria jamesii[1]	D/LS	1/2″- 1″	470,000	0.30	3.24
Alkali Sacaton	Sporobolus airoides	B/B	<1/4″	1,758,000	0.04	1.61
Sand Dropseed	Sporobolus cryptandrus	B/B	<1/4″	5,298,000	0.05	6.08
Giant Dropseed	Sporobolus giganteus	B/B	<1/4″	1,723,000	0.10	3.96
Fourwing Saltbush	Atriplex canescens	D/LS	1/2″- 1″	52,000	0.75	0.90
Winterfat	Ceratoides lanata	B/B	<1/4″	56,700	1.50	1.95
Douglas Rabbitbrush	Chrsothamous vicidiflorus	D/F	¼″-1/2″	782,000	0.30	5.39
Greasewood	Sarcobatus vermiculatus	D/LS	1/2″- 1″	210,000	0.40	1.93
Prairie Sage	Artemisia ludoviciana	B/B	<1/4″	4,500,000	0.05	5.17
Evening Primrose	Oenothera pallida	D/LS	1/2″- 1″	512,000	0.45	5.29
Palmer Penstemon	Penstemon palmeri	B/B	<1/4″	210,000	0.40	1.93
Globemallow	Sphaeralcea grossulariaefolia.	D/F	¼″-1/2″	500,000	0.30	3.44
				TOTAL:	4.94	46.57

[1]Caryopsis will be used when available.

[2]Seed mixture established November 1999.

Seeding method: B = Broadcast, D = Drilled.

Seed Group: Seeds are separated into groups; B = Broadcast group, F = Fluffy seed, LS = Large smooth seed.

Table 37-4 High Shrub Reclamation Seed Mixture[2]

Species common name	Species scientific name	Seeding method/ seed group	Seeding depth	Ave. # of seeds/lb	Seeding rate ave. PLS lb/ac	PLS/sq. ft
Thickspike Wheatgrass	Agropyron dasystachyum	D/LS	1/2″- 1″	154,000	0.20	0.71
Blue Grama	Bouteloua gracilis	D/F	¼″-1/2″	825,000	0.08	1.52
Galleta	Hilaria jamesii[1]	D/LS	1/2″- 1″	470,000	0.15	1.62
Bottlebrush Squirreltail	Sitanion hystrix	D/LS	1/2″- 1″	192,000	0.20	0.88
Alkali Sacaton	Sporobolus airoides	B/B	<1/4″	1,758,000	0.02	0.81
Fourwing Saltbush	Atriplex canescens	D/LS	1/2″- 1″	52,000	1.00	1.19
Shadscale	Atriplex confertfolia	D/LS	1/2″- 1″	64,900	1.50	2.23
Mat Saltbush	Atriplex corrugata	D/LS	1/2″- 1″	60,000	0.75	1.03
Winterfat	Ceratoides lanata	B/B	<1/4″	56,700	1.70	2.21
Douglas Rabbitbrush	Chrysothamous vicidiflorus	D/F	¼″-1/2″	782,000	0.30	5.39
Mormon Tea	Ephedra viridis.	D/LS	1/2″- 1″	19,000	0.10	0.04
Greasewood	Sarcobatus vermiculatus	D/LS	1/2″- 1″	210,000	0.50	2.41
Evening Primrose	Oenothera pallida	D/LS	1/2″- 1″	512,000	0.25	2.94
Globemallow	Sphaeralcea grossulariaefolia.	D/F	¼″-1/2″	500,000	0.20	2.30
TOTAL:					6.95	25.28

[1] Caryopsis will be used when available.

[2] Seed mixture established November 1999.

Seeding method: B = Broadcast, D = Drilled.

Seed Group: Seeds are separated into groups; B = Broadcast group, F = Fluffy seed, LS = Large smooth seed.

Table 37-5 Overall Species Composition

Common Name	Scientific Name	Form	Comments
Prairie Aster	Aster tanacetifolius	Forb	Removed from Mix 11/1999
Blue Flax	Linum lewisii	Forb	Removed from Mix 11/1999
Rocky Mtn. Penstemon	Penstemon strictus	Frob	Removed from Mix 11/1999
Thickspike Wheatgrass	Agropyron dasystachyum	Grass	Added to Mix 11/1999
Prairie Junegrass	Koeleria cristata	Grass	Added to Mix 11/1999
Bottlebrush Squirreltail	Sitanion Hystrix	Grass	Added to Mix 11/1999
Mat Saltbush	Atriplex Corrugata	Shrub	Added to Mix 11/1999
Douglas Rabbitbrush	Chrsothamous vicidiflorus	Shrub	Added to Mix 11/1999
Greasewood	Sarcobatus vermiculatus	Shrub	Added to Mix 11/1999
Prairie Sage	Artemisia Ludoviciana	Forb	Added to Mix 11/1999
Evening primrose	Oenothera pallida	Forb	Added to Mix 11/1999
Palmer Penstemon	Penstemon palmeri	Forb	Added to Mix 11/1999D
Castle Valley Clover	Atriplex Cuneata	Shrub	Added as substitute species 11/1999
Sulfur Flower	Eriogonum Umbellatum	Forb	Added as substitute species 11/1999
Nelson Globemallow	Spharealcea parvifolia	Forb	Added as substitute species 11/1999
Munro Globemallow	Spharealcea munroana	Forb	Added as substitute species 11/1999
New Mexico Needle grass	Stipa neomexicana	Shrub	Changed to a substitute species
Rubber Rabbitbrush	Chrysothamnus nauseosus	Shrub	Changed to a substitute species

Table 37-6 Range Site-Community Identification

Navajo Mine	Bureau of Indian Affairs (BIA)	Soil Conservation Service (SCS)	Percent of Area 1
Alkali Wash	Badlands	Sodic Slopes, Loamy	31.2 %
Arroyo Shrub	Saline Lowlands	Loamy	01.7 %
Badlands	Shaley Saline, Badlands	Sodic Slopes	27.7 %
Calcareous Sands 2	Calcareous	Sandy, Limy	02.7 %
Dunes	Choppy Sands	Deep Sands	05.5 %
Sands 2	Sandy, Sands	Limy	10.7 %
Saline Sands 2	Sandy Saline	Limy, Sandy	10.1 %
Thinbreaks	Thinbreaks	Shallow	10.4 %

[1]Percent of Native communities obtained from Section 2, Tables 2-1 and 2-2..

[2]For 1996 and future comparison, the three sandy communities were combined into one sand community (ALSAN).

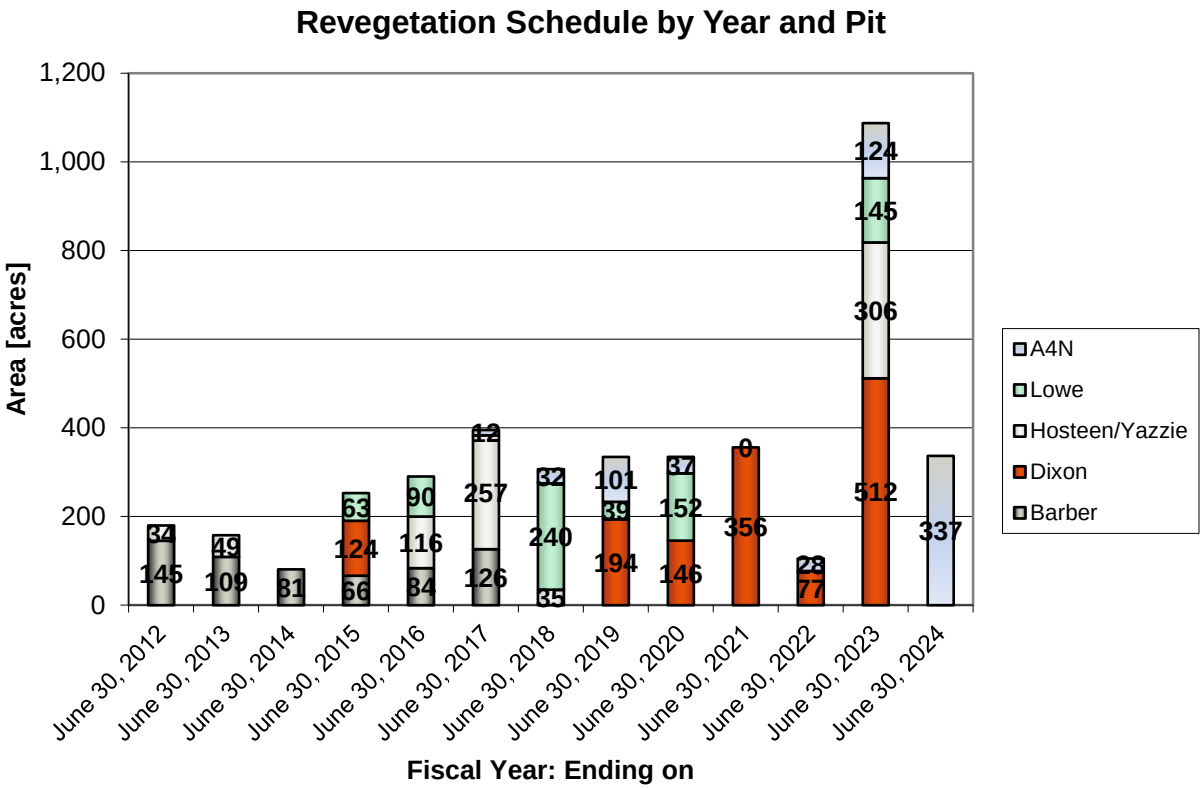
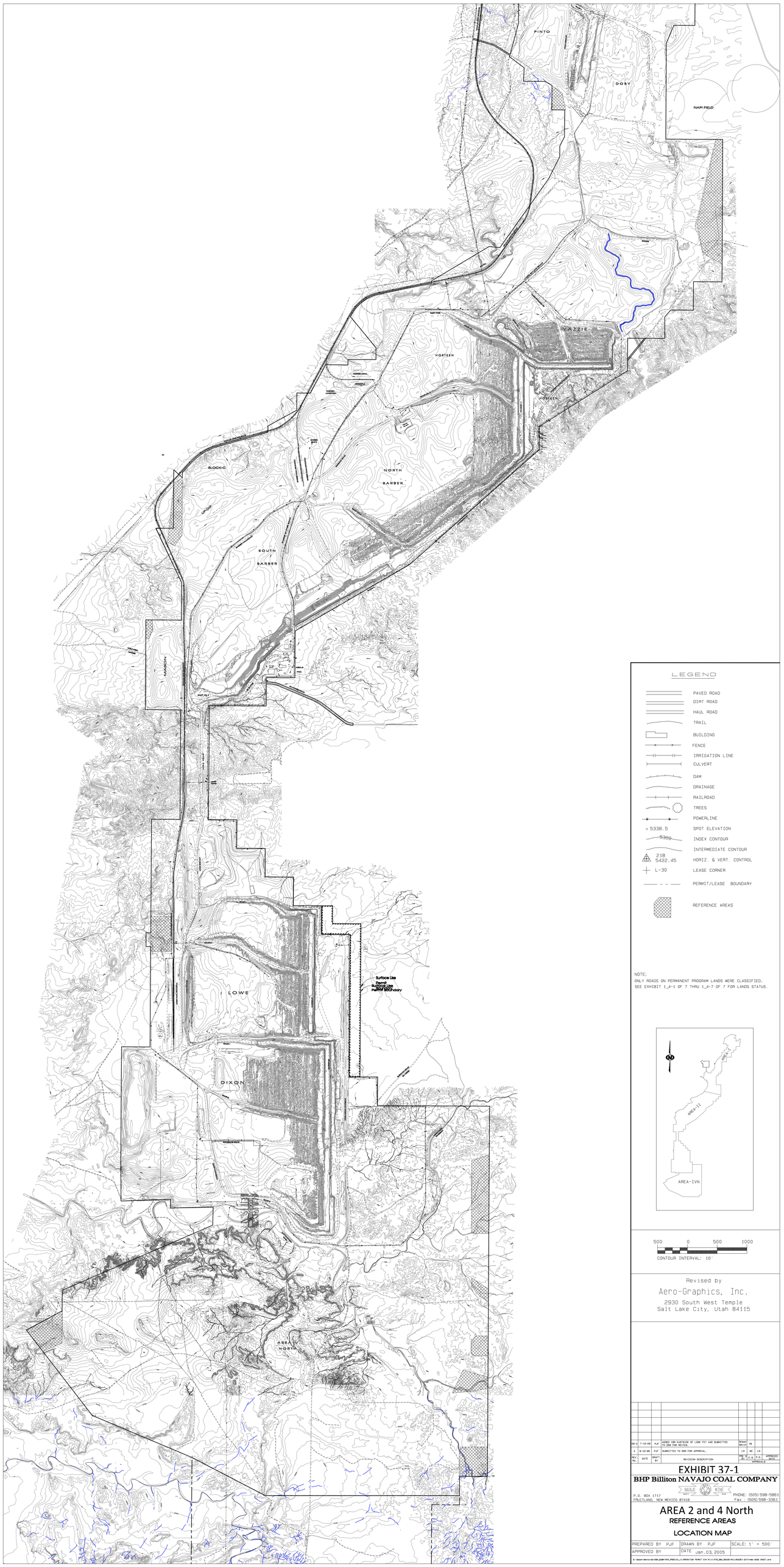

Revegetation Schedule by Year and Pit
Area [acres]
1,200
1,000
800
600
400
200
0
34
145
49
109
31
63
124
66
90
116
84
12
257
126
32
240
35
101
39
194
37
152
146
0
356
28
77
124
145
306
512
337
June 30, 2012
June 30, 2013
June 30, 2014
June 30, 2015
June 30, 2016
June 30, 2017
June 30, 2018
June 30, 2019
June 30, 2020
June 30, 2021
June 30, 2022
June 30, 2023
June 30, 2024
Fiscal Year: Ending on
A4N
Lowe
Hosteen/Yazzie
Dixon
Barber

Figure 37-1


PINTO
DOBY
NAP FIELD
NAZZIE
HORTEEN
BLOCK-C
NORTH
BARBER
SOUTH
BARBER
MASON
LOWE
DIXON
AREA-I NORTH
Surface Use
Permit
Surface Use
Permit Boundary
LEGEND
PAVED ROAD
DIRT ROAD
HAUL ROAD
TRAIL
BUILDING
FENCE
IRRIGATION LINE
CULVERT
DAM
DRAINAGE
RAILROAD
TREES
POWERLINE
5338.5
SPOT ELEVATION
5300
INDEX CONTOUR
INTERMEDIATE CONTOUR
218
5422.45
HORIZ. & VERT. CONTROL
L-30
LEASE CORNER
PERMIT/LEASE BOUNDARY
REFERENCE AREAS
NOTE;
ONLY ROADS ON PERMANENT PROGRAM LANDS WERE CLASSIFIED.
SEE EXHIBIT 1_4-1 OF 7 THRU 1_4-7 OF 7 FOR LANDS STATUS.
AREA-I
AREA-II
AREA-IVN
500 0 500 1000
CONTOUR INTERVAL: 10'
Revised by
Aero-Graphics, Inc.
2930 South West Temple
Salt Lake City, Utah 84115
DR-A 7-12-05 PJF ADDED IBM EASTSIDE OF LOWE PIT AND SUBMITTED TO OSM FOR REVIEW.
A 9-12-05 PJF SUBMITTED TO OSM FOR APPROVAL.
REV. NO. DATE DRAFT BY REVISION DESCRIPTION
DRAWN BY LR TB
LR MC LR
DR. R.G.S. P.F.S. APPROVED
DATE
EXHIBIT 37-1
BHP Billiton NAVAJO COAL COMPANY
MAKE WORK MINE FUN
P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416
PHONE: (505) 598-5861
Fax : (505) 598-3361
AREA 2 and 4 North
REFERENCE AREAS
LOCATION MAP
PREPARED BY PJF
DRAWN BY PJF
SCALE: 1" = 500'
APPROVED BY
DATE Jan.03, 2005

Appendix 37.A

BHP Navajo Coal Company Noxious Weed Management Plan

BHP Navajo Coal Company Noxious Weed Management Plan

I. INTRODUCTION

Invasive weeds pose a serious threat to many native plants in New Mexico. They specialize in colonizing highly disturbed ground. They are able to establish quickly and grow faster on disturbed areas than other plants.

As a surface coal mining operation, BHP Navajo Coal Company (BNCC) has numerous acres of disturbed land. Land disturbances associated with mining provide a habitat conducive to invasion and spread of noxious weeds. A weed management plan is needed to assist with BNCC's revegetation plan to establish diverse, stable and self-sustaining vegetation that will satisfy the following criteria:

1. Adequate cover capable of stabilizing the soil surface from erosion,
2. Adequate forage to sustain the post-mining land uses (i.e. livestock grazing and wildlife habitat), and
3. Suitable species composition for enhancement of wildlife forage and cover.

The Navajo Nation is in the process of developing a Noxious Weed Management Plan. Their plan will supersede this plan when it is completed and accepted.

II. INVENTORY OF NOXIOUS WEED SPECIES

The main areas of concern for noxious weeds at Navajo Mine are on the older reclaimed plots and along waterways. The new reclaimed plots undergoing irrigation will be watched for noxious weeds but will not be addressed unless the weeds consistently persist after irrigation has ceased. These irrigated plots commonly have a high initial density of noxious weeds (which are in the form of annuals). However, the amount is often reduced when the area is no longer irrigated.

There are 5 weed species that are known to be present on the mine site (Table 1). Only 3 of the weeds listed are considered Noxious Weeds.

Table 1. Weed species found at Navajo Mine.

Scientific Name	Common Name	New Mexico Class	Comments
Cenchus longispinus	Sandbur	Not designated	Not noxious
Elaeagnus angustifolia	Russion Olive	C	Noxious
Halogeton glomeratus	Halogeton	B	Noxious
Salsola iberica	Russian Thistle	Not designated	Not noxious
Tamarix ramosissima	Saltcedar	C	Noxious
Kochia scoparia	Kochia	Not designated	Not noxious

III. OBJECTIVES

One of the reclamation objectives stated in the permit is to "Establish on all affected areas a diverse, effective, and long-lasting vegetative cover of the same seasonal variety as the native vegetation" (Chapter 12.1). In addition, BNCC's Health, Safety, Environmental, and Community (HSEC) policy strives for zero harm and long-lasting benefits to the local environment from mining operations. Noxious weeds must be addressed to adhere to this policy.

The objectives of BNCC's weed management plan are prevention, early detection and control of noxious weeds to assist in achieving successful reclamation.

1. Prevention

The best weed management action is to prevent noxious weeds from becoming established in the first place. Preventing weeds from invading a site is the most effective and least costly method for controlling weeds.

Reclamation activities provide a venue for the introduction of noxious weeds. The introduction of noxious weeds can be reduced by purchasing seeds and mulch from licensed and reputable dealers. Routine inspections and familiarization with these dealers will be conducted to ensure no new weed seeds or vegetative parts enter the site through a contaminated seed source in seed mix, straw, and mulch.

Areas will be seeded using native species or carefully chosen non-invasive introduced species as soon as possible after mining has ceased. Quickly establishing a good stand of desirable vegetation will minimize the timeframe for noxious weed establishment by increasing the competition.

2. Early Detection

Early detection of new noxious weeds on the mine site is paramount for controlling noxious weeds. Isolated infestations are high in priority to monitor and control if needed. The BNCC environmental department will remain up to date on the noxious weeds present on the mine site and those that have the potential to invade the mine site from surrounding areas.

3. Control

Control of noxious weeds at BNCC primarily consists of informally monitoring the disturbed/reclaimed areas. These areas are informally inventoried throughout the year via regulatory inspections, irrigation pipeline checks, and general field inspections by BNCC environmental specialists. Infestations of noxious weeds will be addressed according to suitable control measures for each individual species.

3.A. Russian Olive

Russian Olive was introduced from Europe. It is usually found on wet, saline affected sites as well as riparian corridors. They have deep taporoots and a well developed lateral root system. Their fruits are eaten by birds that disseminate it to other areas. At 3 years of age, the trees begin to flower and fruit. Yellow flowers appear in June and July and are later replaced by clusters of fruits. The seeds remain viable for up to 3 years. Control is most effective when the tree is young.

Russian Olive is typically found around ponds and riparian. Russian Olive is well established around Morgan Lake on the northern portion of the mine, outside the mine lease boundary. It is also found in some areas intermixed with saltcedar on the mine site. Russian Olive plants will be both mechanically and chemically treated at the same time and in the same manner as saltcedar.

3.B. Halogeton

Halogeton is an annual forb introduced from Russia. It is toxic to grazing animals, especially sheep. It is adapted to alkaline soils and semiarid enviroments. When an infestation occurs, it makes the area less favorable for revegetation with other species. The abundance of halogeton is dependent upon year to year precipitation. Halogeton produces two types of seeds, a brown and a black. The brown seeds are controlled by long photoperiods, have no dormancy, and are viable for one year. The black seeds are produced during short photoperiods, have dormancy and can survive buried up to 10 years. It is not extremely competitive with other plants because it does not grow a large root system early in the growing season.

The main concern for halogeton at BNCC is on older reclaimed plots where it continues to persist. The control plan for halogeton is to mechanically treat an infested area. Infestations will be determined by density which will be calculated by randomly placing ten 1 m^2 frames (if size allows) in areas where halogeton is present. If the density averages 12 individual halogeton plants or more, the area will be deemed infested. These areas will be treated by hand pulling and hoeing halogeton early in the season before seeds are mature.

3.C. Saltcedar

Saltcedar was introduced from Europe and Asia. It is commonly found where water is present such as irrigation canals, springs, seeps, lakes, playas, arroyos, and dirt stock tanks.

Saltcedar's root system is dominated by a root crown that extends about 12-18 inches below the soil surface. Saltcedar has a high evapotranspiration rate. Its consumption of water can dry out springs, drain pools, and even dry up perennial streams.

Saltcedar is well established along the existing Chinde waterway at Navajo Mine. Methods that target and destroy the root crown are the only techniques that truly provide plant control. Mechanical treatments will be applied to young plants for saltcedar control along the planned permanent Chinde waterway. The mechanical method will consist of hand pulling, hoeing, or digging. This method is effective provided the root crown and associated layered roots have entirely been removed from the soil.

Where saltcedar is well established on the current Chinde waterway, chemical treatment will be applied and followed up by the same mechanical treatment mentioned earlier. The herbicide control will be contracted out. Saltcedar control will occur after nesting and fledging time periods have passed, minimizing the impacts to bird species. Native willows or other suitable riparian species will be planted to replace saltcedar to maintain wildlife habitat.