APPENDIX G
Revegetation Plan

This Page Intentionally Left Blank

1988 REVEGETATION PLAN FOR THE CHINA LAKE JOINT VENTURE GEOTHERMAL DEVELOPMENT

COSO KNOWN GEOTHERMAL RESOURCES AREA

prepared for McClenahan and Hopkins Associates
276 Purdue Avenue
Kensington, CA 94708

by

Barbara Malloch Leitner
5944 Taft Avenue
Oakland, CA 94618

June 28, 1988

TABLE OF CONTENTS

PREFACE

Several factors should be considered when planning revegetation at the Coso Known Geothermal Resource Area:

1. Growth of desert plants is slow even under the most favorable conditions, and revegetation will also be slow.

2. Weather is the single most influential factor, and its extreme variability confounds revegetation planning and brings mixed results.

3. Wind and dryness are the enemies of revegetation; both are present in quantity at Coso.

4. Artificially augmented plant growth brings on additional risk: watering and fertilization enhance leaf growth which can be suppported only by continued regular care for an indefinite period of time. Also, both watering and fertilization increase plant palatability to herbivores.

5. The remoteness of the Coso site makes intensive maintenance of a revegetation program difficult, although regular review of progress is required.

6. The continued presence of burros and cattle reduces the likelihood of success of a revegetation program.

These factors suggest that the most successful revegetation plan is one which relies primarily on natural processes and requires little intervention once site preparation is complete.

In order of priority, the two principal objectives of pre-abandonment revegetation at Coso are erosion control and the use of indigenous native plant species to help compensate for lost habitat for the threatened Mohave ground squirrel (*Spermophilus mohavensis*). These objectives can be accommodated concurrently, with the greater emphasis on erosion control in the initial stages.

The revegetation program outlined here calls for clearly-defined objectives, good site preparation, use of native seed, limited followup care and periodic monitoring.

INTRODUCTION

Geothermal development at the Coso Known Geothermal Resource Area (KGRA) by the China Lake Joint Venture (CLJV) involves the commitment of land for roads, pipelines, wellpads, power plants and transmission facilities. Most of the land is committed for the life of the project, but an estimated 5 percent consists of temporary use areas and cut and fill slopes. Treatment of these lands, present and future, is the subject of this plan. At this time, one power plant and 25 wellpads have been constructed; an additional power plant site and two wellpads are presently under construction; and two additional power plants and a number of wellpads are planned. This plan addresses the specific treatment of each existing facility, and sets forth procedures for in-progress and future work.

CLJV is presently operating under permit conditions requiring revegetation of unvegetated cut and fill slopes, stockpiling topsoil, use of indigenous plant species in revegetation, and whatever additional measures are required by the China Lake Naval Weapons Center (NWC) and Bureau of Land Management (BLM) to satisfactorily control erosion. In addition, the California Department of Fish and Game (CDFG) must approve of elements of the revegetation plan which affect wildlife habitat. This revegetation plan primarily addresses the use of plant material, and includes procedures for grading and maintenance of existing and future cut and fill slopes as these practices relate to revegetation.

Loss of wildlife habitat is the principal impact to biological resources from the Coso development, and of particular concern is the loss of habitat for the state-listed threatened Mohave ground squirrel (Spermophilus mohavensis). Information is presently being developed on the habitat requirements of this species as part of other mitigation measures on CLJV projects. The use of suitable plant materials in revegetation can help to compensate for, and in part replace, lost habitat for the Mohave ground squirrel.

Abandonment is not addresssed in this plan, since virtually no land is considered by CLJV to be abandoned at this time. The site-specific experience derived from revegetation efforts now will set the stage for effective revegetation when more extensive areas will be reclaimed upon abandonment.

OBJECTIVES

This plan is designed to meet two objectives: first and foremost, erosion control; second, the establishment of indigenous vegetation resembling that of the nearby landscape, with a priority on the use of plant materials having habitat value for the Mohave ground squirrel.

METHODS

Information on previous work on revegetation in the Mohave Desert was reviewed. Published material included reports prepared by the University of California Cooperative Extension, the U.S. Soil Conservation Service (SCS), and the California Department of Transportation, as well as proceedings from recent revegetation symposia. Knowledgeable individuals were also contacted by telephone to obtain additional information. Burgess L. (Bud) Kay, an authority on Mohave Desert revegetation, conducted a preliminary site visit in December, 1987. Drafts of this plan were reviewed by California Energy Company (Cal Energy, the operator for CLJV), NWC, BLM, and CDFG.

DESCRIPTION OF THE REVEGETATION SITE

The CLJV geothermal development is located at 3000 to 4500 feet elevation in the Coso Range, China Lake Naval Weapons Center, Inyo County, California. Summers are hot and winters are cold. Freezing temperatures may be expected from at least November through March. Mean monthly temperatures range from about 40 degrees F (December) to about 85 degrees F (July-August). The area is subject to strong winds throughout the year.

Annual precipitation ranges from 3 to 6.5 inches (Environmental Monitoring and Services Center, 1980). Most precipitation falls in the winter. Occasional summer thundershowers take place in July and August; although sporadic, these storm events may have a significant influence on revegetation efforts. They provide important moisture during the critical summer months, but their intensity also presents potential for erosion caused by runoff.

Although the area has a complex geologic history, much of the present and proposed development is on recent volcanic formations. Slopes are gentle to rather steep (0 to 30 percent slopes in most developed areas). The soils are formed over welded tuff, or over sediments derived from tuff. Maynard Lake coarse sands predominate; coarse-textured sands are found on sideslopes and fine-textured material in alluvial basins. Coso-Rock Outcrop stony sandy loams are found on the higher slopes and upper basins (WESCO 1980).

The botanical features present include three natural communities: Mohave creosote bush scrub, Mohave mixed woody scrub; and desert saltbush scrub (Holland 1986). No rare and endangered plants are known to occur in the area presently being developed. The NWC resource staff have identified the Joshua tree (Yucca brevifolia) and the cottontop cactus (Echinocactus polycephalus) as plant species of special management concern within the KGRA. Transplanting of young, healthy Joshua trees within the subject operating area is recommended when practical to reduce project impacts (Leitner and Leitner 1987). This action appears as an approval condition attached to specific project permits, as appropriate. Salvage of the cottontop cactus may be carried out at the discretion of NWC.

THE REVEGETATION PROCESS

Certain aspects of the revegetation process are common to all sites:

1) A site evaluation is carried out to identify site condition and needs for revegetation and erosion control;

2) Revegetation procedures are developed, consisting of a site-by-site description of work needed;

3) In areas such as Coso where revegetation efforts are relatively new, testing of treatments helps to determine the most effective approach for the site conditions. Testing at this stage of the revegetation process is important for developing procedures that will be used more extensively during the abandonment phase.

4) Implementation is carried out by qualified contractors.

5) Monitoring is needed to assure that objectives have been met.

6) Review, evaluation and planning are carried out regularly to determine the effectiveness of various methods and to plan for future revegetation.

THE REVEGETATION PLAN

The revegetation plan presented here will proceed according to the steps outlined in the section above. What follows is a description of standard procedures. Some are common to all revegetation sites. Where a choice of treatment is available, the criteria for the selection of a treatment is given. Specific actions are outlined in Appendix I for each of 25 already-constructed wellpads; the Navy 1 power plant and fill disposal areas; and all future and under-construction wellpads. Appendix II presents a more detailed discussion of revegetation practices reviewed for their applicability at the Coso site.

1. Site Evaluation

A preliminary site evaluation was carried out in December, 1987 to assess revegetation needs and the feasibility of using various techniques. A preliminary plan was reviewed by Cal Energy, NWC, and BLM; this plan incorporates their comments.

Further evaluation will be carried out to develop a baseline on physical conditions at revegetation sites. Soils from representative sites will be collected and sent to SCS or a private laboratory for analysis of soil texture, water-holding capability, and available nitrogen, phosphorus, and potassium. These samples will be taken from wellpads 54-7, 72-18, 51-17, 64-18 (Navy 2 pad R), and BLM 1 Pad A to document typical conditions. Most pads are constructed on sites within the Maynard Lake soils mapping unit and are expected to be similar in their chemical and physical properties. More samples will be taken from additional sites if a wide variation in soil conditions is evident from this initial sampling. To assess potential low fertility soil conditions, soil samples will be taken from wellpads 75-7, 41-8, 73-19, 72-19 and 24-20. The angle and condition of each cut and fill slope will be documented and incorporated into a site-specific data base to be maintained on each revegetated site.

2. Revegetation Procedures

Short-term erosion control and long-term erosion control and revegetation needs must be addressed for all unvegetated sites. The present degree of erosion hazard and natural revegetation will dictate the emphasis placed on each. Slopes with little erosion hazard and some natural revegetation will require the least treatment; newly-graded slopes or existing slopes with rill and gully erosion, a history of frequent maintenance, or evidence of low-fertility soils will require the most intensive treatment.

The standard approach here to short-term erosion control is broadcasting barley seed. Barley is quick to form a dense, shallow root system to hold the soil, but is non-persisting in the desert and thus does not compete with native species after the first year. If a high erosion hazard exists, a dense seeding of barley is applied the first year. Long-term erosion control and revegetation is not attempted until slope stability is improved. On existing slopes not already treated for revegetation, barley will be applied in the fall (late October to early November) just before the onset of winter rains. Barley should be applied to newly completed slopes within 24 hours of final grading to allow loose soil to cover the seed. No watering is required.

Long-term erosion control and revegetation is approached through the use of indigenous plant materials. Seeding with perennial shrubs is the main element, although some native perennial grass seed will be included as well (see "Choice of plant materials" below). Sites with some natural revegetation and/or low erosion hazard will be spot seeded, a hand application measure described by Chan *et al.* (1977). In this treatment, a few seeds are placed into a hand-excavated shallow pit, and covered by a small amount of soil. Spot seeding can be done in any density specified; the recommended density here is on 6 foot centers. The procedure will be carried out in the fall, preferably late October. No additional watering is required. Fill slopes of future pads will receive an application of conserved surface soil; an application of 4 to 6 inches is recommended. The effectiveness of surface soil alone in encouraging growth of native shrubs will be compared with surface soil spreading plus broadcast seeding (see "Testing of Treatments", below).

Dust control is an ongoing air quality issue in the Coso area, and specific measures to control fugitive dust have been taken into account when planning revegetation work. Watering during grading is required for dust control; it helps the soil to form a crust. However, a heavy application of water may stimulate germination and cause subsequent seedling mortality. As a result, seeding should be timed to closely follow these dust control measures to achieve the benefit of some blown soil to cover seed, but avoid excessive moisture. Seeding is recommended within 24 hours following final grading.

A more detailed discussion of each type of revegetation site is presented below.

Existing cut slopes. Erosion hazard on cut slopes is generally not a problem, so use of broadcast seeded barley and native seed is not planned. Cut slopes will be spot seeded with a native shrub-grass mixture. The density of planting will depend on the degree of natural revegetation already in place.

Very little active maintenance is needed for most cut slopes. Natural seedfall from undisturbed slopes above is an excellent source of seed. Alluvium collecting on the wellpad from erosion of the cut slope will be allowed to assume its natural angle of repose and will not be graded off.

Existing fill slopes. Fill slopes are more susceptible to erosion than the more compacted cut slopes, and they lack a nearby source of native seed. Consequently, fill slopes require more attention than cut slopes. The following practices will be applied to fill slopes:

- Fill slopes with pronounced rill and gully erosion (shown as a plus (+) in the erosion column of the Appendix I tables) with a history of maintenance will be seeded in the fall. The recommended application rate for erosion control is 300 lbs/ac of barley. Spot seeding with a native seed mix will be done the following fall or when the slope shows signs of improved stability. Sites with minor rill and gully erosion will be discussed with Cal Energy maintenance to ascertain the anticipated maintenance schedule; these sites may be seeded with 300 lbs/ac barley in the fall (late October) or left until regrading, when they will be treated as for a newly-graded site.

- Fill slopes with low erosion hazard (shown as a minus (-) in Appendix I under "erosion") but having no natural revegetation (shown as a minus (-) in Appendix I under "natural revegetation") will be broadcast seeded in the fall (late October) with 100 lb/ac barley and spot seeded with a native seed mix.

- Slopes with low erosion and good natural revegetation (shown as a plus (+) in Appendix I under "Natural Revegetation") will receive no barley seeding but will be spot-seeded in late October with a native seed mix.

Standard procedures for newly graded sites. The principal short-term erosion control measure, as with older graded sites, is the use of direct-seeded barley. For long-term erosion control and revegetation, use of conserved surface soil is the most important element. Cut and fill slopes constructed in connection with wellpds, roads, power plant sites, or any other related facilities will be treated according to the following methods.

Before grading begins on a new site, the application site for conserved surface soil will be identified and a plan developed for its use. Newly graded sites will have the surface soil (no less than 2 inches and no more than 4 inches) collected for application on final-graded fill slopes. For a standard size 6 acre wellpad (including cut and fill slopes), conserved soil removed to the minimum depth of 2 inches will amount to 1,613 cubic yards of volume. If an average depth of 3 inches is taken, about 2,400 cubic yards will result.

Conserved surface soil quickly deteriorates when stockpiled, and the benefit to revegetation likewise diminishes. Collecting and applying conserved surface soil in the same operation is the least expensive method, since the soil must be loaded and unloaded only once. To assure viability of surface soil organisms, application to a completed fill slope must take place within 24 hours of initial grading during the season (November-April and within one week of any summer precipitation exceeding 0.25 inches). When soils are dry, they must be applied within 5 days of collection.

Conserved surface soil will be applied to newly completed fill slopes to a depth of 4 to 6 inches, and smoothed and compacted according to existing requirements for engineering and dust control. Maximum surface roughness will be sustained.

Standard mitigation measures for the preservation of Joshua trees will also be observed, including avoiding surface disturbance within 50 ft of a Joshua tree whenever possible, and transplanting Joshua trees when necessary to avoid their loss.

New cut slopes will be treated as follows:

1) Where the maximum cut is 20 ft or less of depth, the angle of cut will be 2:1. Where the maximum cut exceeds 20 ft due to sloping terrain, the angle of cut will range between 2:1 and 1:1 as needed.
2) For each 10 ft of depth, a contour trench at least 6 inches in width will be constructed in the cut slope.
3) Maintain maximum surface roughness during final grading.

New fill slopes will be treated as follows:

1) Slopes will be graded as close to a 3:1 slope as possible.
2) During final grading, conserved surface soil will be applied to the slope. The recommended rate is 4 to 6 inches.
3) Maintain maximum surface roughness with tractor cleats.
4) Apply broadcast-seeded barley at 100 lb/acre as soon as possible, preferably within 24 hours of final grading and watering, and allow soil to cover.
5) If surface soil is not available, broadcast seed at 20 lb/ac with native seed mix immediately following grading or in late October.

Laydown areas. Laydown areas are considered to be areas of disturbance and must be permitted by the same procedure as wellpads. It should be noted that no laydown areas presently exist, since wellpads have been used for this purpose. Laydown areas are areas bladed to remove vegetation but the surface topography has not been altered. They generally have been compacted from the action of heavy equipment, and this compaction must be relieved to achieve good revegetation. Seeding with barley is not expected to be required, since laydown areas are generally level and do not present an erosion hazard. Treatment of laydown areas which are not expected to be re-used is as follows:

1) If creosote bush was present, harrow lightly to relieve compaction without damage to root crowns.
2) If no creosote bush, rip to a depth of 18 inches.
3) Spread surface soil to a depth of 4 to 6 inches, if available.
4) If surface soil is not available for application, broadcast seed a native seed mix at 20 lb/ac in late October.

Transmission lines. CLJV constructed the 28.5 mile 115 k/v Devil's Kitchen-Inyokern transmission line in the summer of 1986. Site inspections of the construction area in 1987 and 1988 show that natural revegetation has occurred at a fast enough rate to stabilize soils and prevent erosion; no further actions are proposed. New transmission lines, including the 220 kV line and taps from power plants to the line, will be treated as follows:

1) Vegetation will be crushed instead of bladed at the structure sites and along spur access roads whenever topography allows. Crushing instead of blading preserves soils and seed sources on-site.
2) In areas of greater topographic relief where cut and fill slopes are required, such slopes will be treated as described above, under "Standard procedures for newly graded sites; cut and fill slopes".

Choice of plant materials. Desert saltbush (*Atriplex polycarpa*), fourwing saltbush (*A. canescens*), and buckwheat (*Eriogonum fasciculatum*) have produced good results in seeding trials carried out by the California Department of Transportation near the Coso area (Clary and Slayback 1984). Limited to poor success was obtained from cheesebush (*Hymenoclea salsola*), Mormon-tea (*Ephedra nevadensis*), creosote bush (*Larrea tridentata*), and Indian ricegrass (*Oryzopsis hymenoides*). No information on seeding trials using spiny hopsage (*Grayia spinosa*) was available, although it is a significant component of the desert scrub community in the Coso area.

On the basis of these trials, the three most successful species (which also are important components of the shrub layer in the Coso KGRA) will comprise 70 percent of the seed mix. The remaining 30 percent will be composed of species which also are important structural components of the natural communities present. Although these species may not establish themselves in high numbers, it is anticipated that at least some of them will become established.

The native seed mix is as follows (percentages are by weight):

Atriplex polycarpa	30%
Atriplex canescens	30%
Eriogonum fasciculatum	10%
Hymenoclea salsola	10%
Oryzopsis hymenoides	5%
Ephedra nevadensis	5%
Grayia spinosa	5%
Stipa speciosa	3%
Eurotia lanata	2%

This mix will be used assuming commercial availability. The recommended seeding rate is based on percent live seed. Seed will be custom collected from the vicinity of the Coso area (within 25 miles, if possible, and from an elevation range of 3000 to 4500 ft elevation). If seed production is poor for certain species which are commercially available, a portion of the seed mix may be obtained from existing stock, provided it originated from the Mohave Desert.

Initially, this choice of seed mix is based on successful tests nearby in the Mohave Desert. It will be modified as the results of seeding tests become available for the Coso site, and as more information is collected on the habitat requirements of the Mohave ground squirrel as part of the Coso Grazing Exclosure mitigation program.

Annual forb (broadleaf) seed is not recommended for the initial stages of this revegetation program, although it might be considered at a later time. The reasons are: forbs used in initial seeding may present more competition for shrub seedlings; and the presence of forbs may attract herbivores before the shrub seedlings are able to tolerate browsing. Forb seeding will be reconsidered when the shrub layer is well established. Cal Energy will seed with forbs as directed by the agencies responsible for the Coso Mohave ground squirrel mitigation plan, since this action would be undertaken principally as a habitat enhancement action for this threatened species.

Post-treatment maintenance. This revegetation plan is designed to require a minimum of post-treatment care. The plant species selected for use are adapted to prevailing conditions. Irrigation is not planned because plants watered during their early establishment develop a root and leaf structure dependent on continued water. Kay and Graves (1983) found no benefit from irrigation when suitable species are planted in the fall or early winter and normal amounts of rainfall followed.

Re-treatment. In the event that rainfall is extremely unfavorable, retreatment similar to initial treatment will be required, including broadcast seeding and/or spot seeding. Retreatment will also be required after maintenance grading; annual inspections by Cal Energy and NWC (and BLM as appropriate) will determine the advisability of regrading slopes, taking revegetation efforts into account.

Criteria for success. As an initial standard, shrub densities on sites treated for revegetation should after 5 years support a density of shrubs equal to about 60 percent of the density found at the benchmark monitoring sites (see monitoring section). Shrub size will obviously be less on revegetation sites. If the density standard is not met, spot seeding or other measures will be repeated to achieve the desired shrub density.

3. Testing of Treatments

The most important treatments to be tested at this stage are as follows: 1) mulching with straw; 2) use of herbivore protectors; 3) use of fertilizer; and 4) broadcast seeding with a native seed mix on newly completed slopes. Appendix I shows the experimental design of treatments. Two replicates, as similar as possible, were selected for each treatment, with the exception of straw mulch and broadcast seeding. These treatments must be applied to newly-completed slopes and replicates will be designated as they become available.

It should be noted that the monitoring program will also provide an opportunity for comparison of treatments, such as the success of the seeding mix on different slopes and exposures, the success of surface soil spreading against direct seeding, and a comparison of revegetation rates on different soil types, slopes and exposures. This type of information, while not testing in the experimental sense, will provide valuable information for future planning in revegetation.

4. Implementation

Much construction activity has been initiated in the calendar year 1988, and a large number of previously untreated slopes must be addressed. Implementation in 1988 will include:

- Evaluate soils further;
- Collect local seed;
- Engage contractor(s) to apply stockpiled surface soil, carry out broadcast seeding, spot seed, and install rodent protectors, straw mulch, and fertilizer;
- Identify a monitor for revegetation evaluation; and
- Establish an information data base on each revegetation site.

5. Monitoring

Criteria for evaluation. The monitoring phase of the revegetation program will include a comparison of revegetation sites against undisturbed sites for which vegetation characteristics are well known. The "benchmark" reference sites may consist of adjacent undisturbed vegetation, or of nearby sites which resemble the soil, slope, and exposure of the revegetation site. However, the characteristics of sites known to support high densities of Mohave ground squirrels may also be used as reference sites against which revegetation success is measured. Ultimately, success of the revegetation program is achieved when the species composition, frequency, density, cover and biomass approximates that of the benchmark reference site. An interim measure of success is to achieve within 5 years a shrub density which is 60 percent of the benchmark site.

Methods. Reference sites will be selected on the basis of the pre-existing vegetation and desired characteristics for Mohave ground squirrel habitat. One reference site may serve for several revegetation sites, if the site characteristics are reasonably similar. The exact size and location of the reference site will be chosen in the field, but will approximate the size of a wellpad fill slope. The species composition, frequency, density and cover of benchmark reference sites will be measured. The species, size and location of the shrub layer will be mapped on 10 by 10 meter squares. Five to 10 such quadrats will be used for a reference site, depending on the variability of the site. Standing crop, species composition, and estimated cover will be measured for the herb layer using 50 square-foot plots.

Monitoring at the revegetation sites will be characterized in a similar manner. However, care must be taken in the initial years not to allow excessive foot traffic on the cut and fill slopes. Treading breaks the crust formed on the soil surface, encouraging wind and water erosion. At first, only the shrub layer will be characterized using 10 by 10 meter areas. This can be done by observers standing on the upper and lower edges of most fill slopes. Herbaceous vegetation will be noted as to species composition for each site, but intensive measurement is not recommended initially because of the erosion hazard.

Monitoring will be carried out annually at the revegetation sites. After the initial survey, the reference sites will be re-surveyed every five years until project abandonment. Productivity will be estimated from limited plant clipping, as feasible without adversely affecting the progress of the revegetation process.

Establishing a data base for revegetation efforts. Over two dozen graded sites, several soil types and exposures, and a number of experimental treatments will quickly become unwieldy to track without a systematic means of recording and updating information. A data base will be established, with the following elements:

1) A site map showing each graded site at 1:200, and a master site map showing each wellpad, by section;
2) Oblique photographs of each pad, taken every two years;
3) A record of the "as-built" areas of disturbance for each pad;
4) Information on slope, rill and gully erosion, and the physical and chemical composition of the soils, as this information is available;
5) Records of the date of pad construction, dates of any pad maintenance as it relates to revegetation efforts; and
6) A record of the date and type of revegetation treatments.

The most important aspect of monitoring is the feedback loop it provides for future planning. The relative success of various methods can be used to achieve optimum revegetation strategies for the future. As a result, the monitoring results will be written up annually and attached to the annual revegetation plan.

6. Review, Evaluation and Planning

An evaluation of revegetation actions and monitoring results will be conducted annually. Cal Energy will submit an updated revegetation plan for NWC, BLM and CDFG approval. The most useful time for a review would be in late summer or early fall, when seedling germination and establishment for the year is known, and prior to treatments required during late October.

REFERENCES CITED

Chan, Franklin J., Richard W. Harris, and Andrew Leiser. 1977. Direct seeding woody plants in the landscape. University of California Agricultural Extension Leaflet 2577. 12 pp.

Clary, Raimond F. and Richard Slayback. 1984. Revegetation in the Mojave Desert using native woody plants. In: Proceedings of the symposium on native plant revegetation, November 15, 1987, San Diego, CA. Pp. 42-47.

Environmental Monitoring and Services Center. 1980. Air quality technical report on the Coso geothermal study ara. In support of Coso geothermal development environmental statement. Bureau of Land Management, Bakersfield, CA. 173 pp.

Holland, Robert F. 1986. Preliminary descriptions of the terrestrial natural communities of California. California Department of Fish and Game, Sacramento, CA. 156 pp.

Kay, Burgess L. and Walter Graves. 1983. Revegetation and stabilization techniques for disturbed desert revegetation. Chapter 17 in Environmental effects of off-road vehicles, impacts and management in arid regions. Webb, R.H. and H.G. Wilshire (eds.) Springer-Verlag. 534 pp.

Leitner, Barbara Malloch and Philip Leitner. 1987. Report on biological resources, China Lake Joint Venture's BLM 1 field development and power plant construction program, China Lake Naval Weapons Center, California. Prepared for McClenahan and Hopkins Associates, Kensington, CA 45 pp.

WESCO. 1980. Soils technical report on the Coso geothermal area. In support of Coso geothermal development environmental statement. Bureau of Land Management, Bakersfield, CA. 256 pp.

APPENDIX I. SPECIFIC REVEGETATION ACTIONS FOR UNVEGETATED SITES

Table I-A. Navy 1 operating area erosion control and revegetation measures.

Facility	Site Conditions*: Surface	Exposure	Test soils	Erosion	Natural reveg.	Short-term erosion control: Barley seeding (lbs/ac)	Long-term: Spot seed natives	Spread surface soil	Test Measures: Fertilizer	Perimeter fence	Plant protectors	Straw mulch	Broadcast + native mix
Navy 1 power plant	Cut	N		-	+		x						
	Fill	NW	+	-	+		x						
Fill disposal	Fill	N		+	-	or 300	x						
Wellpad 78-6	Cut	N		-	-		x		Control for 61-7,63-7				
	Fill	N		-	-	100	x						
Wellpad 52-7	Cut	SE		-	-		x		Control for 54-7				
	Fill	SE		-	-	Dec. 1987	x						
Wellpad 54-7	Cut	N		-	-		x		x				
	Fill	N	+	-	-	100	x		x				
Wellpad 61-7	Cut	N		-	-		x						
	Fill	N		-	-	100	x			x			
Wellpad 63-7	Cut	N		-	-		x						
	Fill	N		-	-	100	x				x		
Wellpad 71-7	Cut	N		-	+				Control, no treatment				
	Fill	N		-	+								
Wellpad 73-7	Cut	N		-	-		x						
	Fill	N		-	-	100	x						
Wellpad 75-7, 76-7, 77-7, 87-7, 15-8	Cut	SW		-	-		x		Compare with 41-8, poor soil				
	Fill	SW	+	+	-	300		in 1989					
Wellpad 78-7	Cut	S		-	-		x						
	Fill	S		-	-	100	x						x
Wellpad 11-8, and 31-8	Cut	N		-	+		x						
	Fill	N		-	+		x						
Wellpad 41-8	Cut	N		-	-		x		x				
	Fill	N	+	-	-	100	x		x				
Wellpad 47-8	Cut	S		-	-		x						
	Fill	S		-	-	100	x		Compare with 78-7				
New developments	Cut						x						
	Fill					100		x	Test		x		x

*Present site conditions:
Exposure: N=north; S=south; E=east; W=west;
Test soils: "+" indicates physical and chemical testing to be done;
Erosion: "-" indicates erosion hazard not significant; "+" indicates maintenance may be required;
Natural revegetation: "+" indicates natural revegetation is evident; "-" indicates little or no natural revegetation.

Table I-B. Navy 2 wellfield and power plant erosion control and revegetation measures.

Facility	Site Conditions*: Surface	Exposure	Test soils	Erosion	Natural reveg.	Short-term erosion control: Barley seeding (lbs/ac)	Long-term: Spot seed natives	Spread surface soil	Test Measures: Fertilizer	Perimeter fence	Plant protectors	Straw mulch	Broadcast native seed
Wellpad 37-17	Cut	NE		-	-		x						
	Fill	NE		-	-	100	x						
Wellpad 63-18	Cut	S		-	-		x						
	Fill	S		-	-	100	x				x		
Wellpad O	Cut	S		-	-		x		Control,				
	Fill	S		-	-	100	x		pads P, 63-18				
Wellpad P	Cut	S	+	-	-		x						
	Fill	S		-	-	100	x			x			
Wellpad U	Cut	S		-	-		x						
(in progress)	Fill	S		-	-			x		test			x
Wellpad R	Cut	N	+				x						
(in progress)	Fill	N				100		x					
Wellpad Y	Cut	S					x		Compare with				
(in progress)	Fill	S				100		x	Wellpad R,U				
Future devel-	Cut						x						x
opments	Fill					100		x	test			x	

*Present site conditions:
Exposure: N=north; S=south; E=east; W=west;
Test soils: "+" indicates physical and chemical testing to be done;
Erosion: "-" indicates erosion hazard not significant; "+" indicates maintenance may be required;
Natural revegetation: "+" indicates natural revegetation is evident; "-" indicates little or no natural revegetation.

Table I-C. BLM 1 wellfield and power plant erosion control and revegetation measures.

Facility	Site Conditions* Surface	Exposure	Test soils	Erosion	Natural reveg.	Short-term erosion control Barley seeding (lbs/ac)	Long-term Spot seed natives	Spread surface soil	Test Measures Fertilizer	Perimeter fence	Plant protectors	Straw mulch	Broadcast natives
Wellpad A	Cut	S	+	-	-		x		Compare with				
	Fill	S		-	-	100	x		33-19, 73-19				
Wellpad 33-19	Cut	S		-	-		x						
(=C)	Fill	S		-	+		x			x			
Wellpad 72-19	Cut	S		-	-		x						
(=D)	Fill	S	+	+	+	300	in 1989						
Wellpad 73-19	Cut	S		-	-		x						
(=E)	Fill	S	+	-	+		x				x		
Wellpad 46-19	Cut	N		-	-		x						
(=F)	Fill	N		-	+		x						
Wellpad 24-20	Cut	SE		-	-		x						
(=G)	Fill	SE	+	+	-	300	in 1989						
Wellpad P	Cut	S					x						
(in progress)	Fill	S				100		x					
Wellpad Q	Cut	E											
(in progress)	Fill	E				100		x as feasible					
Future devel-	Cut						x						
opments	Fill					100		x	Test			x	X

*Present site conditions:
Exposure: N=north; S=south; E=east; W=west;
Test soils: "+" indicates physical and chemical testing to be done;
Erosion: "-" indicates erosion hazard not significant; "+" indicates maintenance may be required;
Natural revegetation: "+" indicates natural revegetation is evident; "-" indicates little or no natural revegetation.

APPENDIX II. DISCUSSION OF REVEGETATION PRACTICES

SITE PREPARATION

Slope

Within a given soil type, slope is a determining factor for the rate of soil erosion. Although runoff-caused erosion can occur on slopes as gentle as 20 percent (5:1) (Kay and Graves 1983a), soil erosion accelerates with increasing slope. Under experimental rainfall conditions, Kay (1984) found that gravelly sandy loam lost five times more soil from 2:1 slopes than from 5:1 slopes.

The loose soils and unconsolidated parent material at the Coso site rapidly assume their angle of repose, probably about 30 percent, as can be seen from alluvium collecting at the bases of cut slopes. The loose material is an ideal site for plant establishment. Revegetation will take place more rapidly on less steep slopes. Rill erosion is also less severe. The recommendation for future grading is to grade both cut and fill slopes at 2:1 or, preferably, 3:1 slopes whenever feasible. Determination of acceptable slopes will be made on a case-by-case basis.

Cross-drains or contour trenches on fill and cut slopes reduce sheet erosion hazards and provide more favorable sites for plant establishment while presenting little extra graded surface. They reduce the flow and force of water moving downslope, and increase infiltration (Kay and Graves 1983b). They are especially useful in arid lands, and are recommended at this site when feasible.

Surface roughness and other final grading practices. Burgess L. Kay, an authority on revegetation in the Mohave Desert, believes that encouraging natural revegetation is the most economical and effective approach in arid lands (Kay, pers comm., October, 1987). Wind is a natural seed dispersal agent, and a rough surface captures wind-blown seed. Eliminating the final smoothing of graded surfaces encourages seed capture. For slopes already smoothed, "trackwalking" will enhance the effects of natural seedfall (CARCD 1986). Compacted surfaces no longer in use should be ripped to a depth of 18 inches to relieve compaction.

Conserving surface soil. To avoid possible confusion as to whether topsoil (in the usual sense of a discernable surface layer high in organics) actually exists in the Coso region, the term surface soil will be used to refer to the uppermost 4 inches of soil.

An inexpensive source of local seed and beneficial microorganisms is surface soil. When surface soil is conserved at the onset of grading operations and spread on unvegetated areas, it can be an effective means of encouraging natural revegetation (Tom Dayak, CalTrans, pers. comm., October, 1987). Lack of oxygen, too much or too little moisture, high temperature or prolonged storage brings loss of seed viability and a reduction in microorganisms (Kay 1987). Spreading surface soil immediately on a completed grade is least damaging to the living portion of the soil. Dust control specifications require that only the uppermost 2 inches of soil may be conserved during initial grading, but it may be spread to greater depth, such as 4 inches.

Mulching. Mulch nearly always shortens the time needed to establish a suitable plant cover (Kay 1978). The benefits of mulch in erosion control and revegetation include:

1) Mulch intercepts raindrops, reducing their erosional force;
2) Some mulches also intercept runoff. This reduces the quantity of soil carried away;
3) Mulches with surface roughness, such as punched straw or gravel, tend to catch and hold wind-carried soil and seed;
4) Many types of mulches encourage water infiltration; and
5) Mulches tend to moderate soil temperatures and retain soil moisture, both critical factors in the arid Mohave Desert.

Available mulching materials include: wood fiber, paper mulch, straw mulch, gravel, hydromulch and chemical stabilizers (Kay and Graves (1983b).

Straw is the recommended mulch material whenever it can be applied (Clary 1983; Kay 1978; Kay and Graves 1983b). The recommended method is punching in 2 to 4 tons/acre in two applications (Bud Kay, pers. comm., November 1987, and Ken Nelson, pers. comm., November 1987). The longest straw has the most stabilizing effect. Rice or other grain straw is better than wild hay because fewer weed seeds are contained. To punch in straw on very steep slopes, a roller must be raised and lowered by a winch (Kay 1978).

In windy sites, straw and other mulches are at risk of blowing away. Chemical stabilizers, or tackifiers, may be used to hold straw in place. However, these are expensive, and are effective only if the straw is well worked into the soil. Another method is broadcast seeding barley or other domesticated grain, which then grows and dies in place, forming a rooted mulch. Since barley is non-persisting in the desert, it does not compete with native species after the first year. The recommended rate is 200-300 lbs/acre alone, or 100 lbs/acre in combination with shrub seed.

For troublesome sites, other types of mulches may be considered. Gravel or rock mulches and jute netting or fiberglass mats are highly effective in reducing erosion. While much more expensive than straw mulch (Kay 1978), these alternatives might be considered for small areas.

ADDING PLANT MATERIAL

Spreading surface soil

As indicated earlier, spreading conserved surface soil is a cheap and complete means of re-introducing local seed and microorganisms to newly graded slopes. Surface soil should be spread to a minimum depth of 4 inches as soon as possible after removal from a graded site. It is preferable to move soil between May and December. If initial grading takes place between January and April, most seedlings will be killed, but microorganisms and dormant seed are still of value.

Direct seeding

Several methods may be used for applying seed to soil. Placing seed in, rather than on top of, the soil reduces predation by birds and rodents. Covering seeds by less than 1 cm (0.5 in) encourages maximum emergence (Kay and Graves 1983b). On level ground, the rangeland drill is an ideal tool for applying and covering seed. Rough or steep sites may be seeded by hand, and the seed covered by simply dragging a chain behind a tractor (Clary and Slayback 1984), hand-raking, or allowing the wind to carry in soil to cover (Kay, pers. comm., December 1987).

Where some natural revegetation has already taken place, it is undesirable to disturb the site with mechanical equipment, risking additional erosion. In this case, spot-seeding, a procedure in which a small hole or trench is dug and a small amount of seed is placed just below the soil surface (Chan et al. 1977). This method is advantageous in that it requires very little seed, and can be used any time after final site preparation has taken place.

Hydroseeding, a method in which seeds, wood fiber, water, and fertilizer are sprayed onto bare ground, is generally considered unsuitable for desert applications (Kay 1985; Packer and Aldon 1978; Kay and Graves 1983ba; Clary and Slayback 1984). This method deposits the seeds above ground level. Rainfall followed by a dry spell will cause seeds to germinate, then die from lack of access to soil moisture.

Planting Container Stock

Although using container stock improves establishment and initial rate of growth, the high cost makes it unfeasible to use to any large extent at Coso. A 1977 feasibility study by

Southern California Edison showed that replacing lost desert shrubs with comparable density and species composition of container stock would cost $29,000 per acre; in 1987 dollars, this figure should be doubled, or $55,000 to $60,000 per acre (Dan Pearson, SCE, pers. comm., November, 1987). This figure was corroborated by an estimate that container stock presently costs $4 to $12 per plant installed; and if planted on 3 foot centers, the per-acre cost would be $20,000 to $58,000 (Ken Nelson, pers. comm., November, 1987).

Two species, Joshua trees and creosote bush, both important structural elements in the local vegetation, would benefit from planting as container stock. Due to their high visual impact and importance of Joshua trees to Mohave ground squirrels, small-scale planting of these species is recommended where consistent with surrounding vegetation. This recommendation will be addressed in future annual revegetation plans, as the focus in 1988-89 will be the first-time treatment of a large number of wellpads.

Availability of Seed

Nurseries and seed suppliers specializing in native plants carry a number of plant species indigenous to Coso. However, within-species genetic variation from region to region may be considerable. Custom collection of local seed is ideal. It can be arranged for any quantity of seed and virtually any species; the unit cost decreases with the volume required. Seed can be collected in quantity during productive seed years and stored under controlled conditions, thus reducing cost. The seed collector should report percent live seed.

If custom-collected seed is not available in the quantity required, stocked seed can be used if it has originated from the Mohave Desert from comparable elevation sites.

Which Species Work Best?

In revegetation studies carried out near Little Lake, Clary and Slayback (1984) found Atriplex polycarpa was highly successful in direct-seeding trials; its success was attributed to its relative unpalatability to jackrabbits. This species is the principal invading species at Coso as well. 'Marana' fourwing saltbush and Eriogonum fasciculatum also performed well in seeding trials at Little Lake. Other species have had limited to poor results, including Hymenoclea salsola, Ephedra nevadensis, Larrea tridentata, and Oryzopsis hymenoides. No seeding-trial information is available on Lycium, except that Kay et al. (1977) found that seed collection was difficult, but the seeds could be germinated and grown.

The choice of species in a seed mix should be determined by the revegetation objectives, as well as which species are likely to perform well. Atriplex polycarpa should be prominent in the seed mix, since it grows well on disturbed sites, is a major component of surrounding vegetation, and may be of value to the Mohave ground squirrel. Joshua trees should be planted in spot seedings experimentally. All other prominent shrub species should be included in the seed mix if feasible, and their performance evaluated. If erosion control is a persistent problem, use of rabbitbrush (Chrysothamnus nauseosus) should be considered, but it is not desirable. Rabbitbrush comprises an extremely minor part of the local flora and is quite successful and persistent in seedings, thus it might occupy a disproportionate part of the revegetation area.

Grasses have exceptionally good ability to hold surface soil, and are widely used in erosion control. However, annual grasses compete with shrub and forb seedlings and may diminish the success of other efforts. A sparse stand of non-persisting annual grass such as barley is recommended for erosion control and mulch. If barley is used alone, it should be applied at 200-300 lbs/acre. If used in combination with native shrub seed (recommended application rate of 20 lbs/acre or with spot seeding), barley should be applied at 100 lbs/acre.

Timing of revegetation efforts

Direct seeding is most successful in late fall (October-November) (Kay and Graves 1983a). Seeding is best carried out before winter rains but when risk of prolonged drought is minimal. Seeding immediately following grading must be done at any season, but it is preferable to do so during the dry months. Re-treatment may be required to achieve acceptable results.

FOLLOWUP CARE

Irrigation

The prevailing view on irrigation in the desert is that while it may help in the short term, it is of little benefit in the long run. Direct seedings are usually not irrigated. Most authors agree that if the correct species are planted in the fall or early winter and there is normal rainfall afterward, there is no benefit from irrigation (Kay and Graves 1983b).

Tyson (1984) explains the non-irrigation rationale as follows:

> "There is a widespread misconception that a native plant can be planted on any site, irrigated temporarily, and then left to "natural forces". In practice, temporary irrigation commonly produces a larger leaf area than without irrigation. If roots cannot absorb enough water to support the

leaves, the plant will decline or die. There is little or no theoretical or practical justification for temporary irrigation of long-lived vegetation".

Irrigation of revegetation sites is not recommended at this time. In fact, watering for dust control must be taken into account when planning seeding to avoid stimulating seeds at an inappropriate season into germination, as they are likely to perish when the watering ceases. The recommendation here is to seed barley on fill slopes within 24 hours following the final grading and watering.

Fertilizer

Although fertilizer is usually applied with mulch to compensate for nitrogen removed from the soil by decomposition (Kay 1978), this process is very slow in the desert. However, one study (Clary 1983) showed that fertilizing freeway cut slopes in the desert speeded natural re-establishment of indigenous vegetation. This treatment might be tested, since cost is minimal.

Repeating treatments

Any revegetation effort is at the mercy of the weather. Plans should include a contingency for repeated seedings if weather conditions preclude success (Kay and Graves 1983b).

Protection from herbivores

Grazing by herbivores is the single greatest cause of failure of seeded shrubs to survive (Kay and Graves 1983a). Jackrabbits are a common culprit, although rodents also play a role. Wire cages are essential to achieve reasonable success with container stock, and may be helpful in direct seeding as well. The usual wire cage is 3 inches in diameter and 15 inches high. Larger cages are recommended by some (Racin and Dayak 1986), and perforated plastic cages are available which photodegrade in three to five years (Clary 1983). Since poison bait programs or trapping are unacceptable methods of herbivore control, the use of cages should be considered as protection against rodents and jackrabbits.

Wire cages may accelerate establishment of important food plants for the Mohave ground squirrel and help avoid repeated seeding. Their utility will be highest when used selectively on highly palatable species. They should be tested to determine cost-effectiveness.

The wire cages described here are useless against livestock. Until cattle and burros can reliably be kept away, revegetation efforts are at risk.

REFERENCES CITED

California Association of Resource Conservation Districts. 1986. California Interagency seeding guide for erosion control plantings. 6 pp.

California Energy Company. 1987. Plans of utilization and disposal for two 48 megawatt power plants. California Energy Company, Santa Rosa, CA. 36 pages plus attachments.

Chan, Franklin J., Richard W. Harris, and Andrew Leiser. 1977. Direct seeding woody plants in the landscape. University of California Agricultural Extension Leaflet 2577. 12 pp.

Clary, Raimond F., Jr. 1983. Planting techniques and materials for revegetation of California roadsides. U.S. Dept. of Agriculture, Soil Conservation Service, Lockeford, CA. 161 pp.

Clary and Slayback 1984. Revegetation in the Mojave Desert using native woody plants. In: Proceedings of the symposium on native plant revegetation, November 15, 1987, San Diego, CA. pp.42-47.

Kay, Burgess L. 1978. Mulches for erosion control and plant establishment on disturbed sites. University of California Agronomy Progress Report No. 87. University of California, Davis. 19 pp.

_________. 1979. Summary of revegetation attempts on the second Los Angeles aqueduct. Mohave Desert Revegetation Note No. 22. University of California, Davis, Department of Agronomy and Range Science. 24 pp.

_________. 1984. Cost and effectiveness of mulching practices. In: Proceedings of the Sixth High Altitude Revegetation Workshop, Colorado State University, Ft. Collins,. CO, March 5-6, 1984. 12 pp.

_________. 1985. Important revegetation concepts with emphasis on the Mohave-Tehachapi area. 7 pp.

_______. 1987. Considerations in revegetation planning. California Geology. January 1987. pp. 7-9.

________ and Walter Graves. 1983a. Revegetation and stabilization techniques for disturbed desert revegetation. Chapter 17 in Environmental Effects of Off-Road Vehicles, Impacts and Management in Arid Regions. Webb, R.H. and H.G. Wilshire (eds.). Springer-Verlag. 534 pp.

______________. 1983 b. History of revegetation studies in the California deserts. Chapter 16 in Environmental Effects of

Off-Road Vehicles, Impacts and Management in Arid Regions. Webb, R.H. and H.G. Wilshire (eds.). Springer-Verlag. 534 pp.

Kay, Burgess L., Catherine M. Ross, and Walter Graves. 1977. Mojave revegetation notes. University of California Cooperative Extension, Davis. (Twenty-one separate monographs of 2-10 pages each).

Packer, P.E. and E.F. Aldon. 1978. Revegetation techniques for dry regions. In: M. Stelly (ed.), Reclamation of drastically disturbed lands. American Society of Agronomy, pp. 425-450.

Racin, James A. and Tom Dayak. 1986. Revegetation of highway slopes in the high desert with native plant seedlings: interim report. California Department of Transportation, Sacramento, CA. 56 pp.

Tyson, Wayne. 1984. Revegetation by objectives. Proceedings from the conference on revegetation, San Diego,. CA. pp 10-14.