0005 Act/007/012 Mine file L. Kunzler CB

COAL SYSTEMS, Inc.

CONSULTANTS/ENGINEERS

L. G. MANWARING, P.E.
President

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SALT LAKE CITY, UTAH 84117

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March 1, 1990

Mr. Lowell Braxton, Assoc. Director
UTAH DIVISION OF OIL, GAS, & MINING
3 Triad Center, #350
Salt Lake City, Utah 84180-1203

re: Submittal of New Test Plot Designs
Per Stipulation UMC 788.14-(1)-SLC
Castle Valley Resources, Inc.
ACT/007/012

Dear Mr. Braxton:

Relative to Castle Valley Resources, Inc. (formerly known as Genwal Coal Company - Wellington Preparation Plant), and per the above noted stipulation to the Mid-term Permit Review, the attached report entitled "Revegetation Test Plots: Wellington Coal Cleaning Plant - Utah" is submitted on schedule per the Permit Renewal schedule of activities.

According to a discussion with Mr. Lynn Kunzler January 26 regarding the scope of this submittal, it was my impression that this submittal would provide a basis for discussion during the next several months resulting in an agreement for the final program design; it is understood that the test plot work and planting is to be done yet this year.

We just yesterday received the report from Messrs. Sabey and Nelson and have had little time to review it ourselves; nevertheless, cursory review does indicate that considerable work will be required to accomplish the activities described in the report and the cost will be substantial. Further, there is concern regarding the irrigation requirements and the pumping/piping/labor required to accomplish the irrigation.

We are fully aware that a responsible program must be undertaken to develop this important information. But because of Dr. Sabeys' need for immediate travel, we have had no opportunity to discuss his recommendations.

Thus, it is requested that this submittal be considered as a "basis for discussion" between parties and that a meeting between parties be held in about one month. This will give us a chance to meet with Dr. Sabey and to consider the problems associated with implementing the program. *

Please give me a call regarding your thoughts on the above.

Sincerely,

COAL SYSTEMS, INC.

L.G. Manwaring, Jr., P.E.
President

LGM/lc
cc: R. Mower, V.P. Castle Valley Resources, Inc. w/report
D. Schwehr, Mgr. Environmental Affairs. w/report

* Lynn please fill me in on the ramifications of this. Do you want to set a meeting, or hold for Gen to do so?

Lmw 3-1

REVEGETATION TEST PLOTS: WELLINGTON COAL CLEANING PLANT - UTAH

Recommendations for Monitoring Existing
Test Plots and Creating New Test Plots

to

Coal Systems Inc.
P.O. Box 17117
Salt Lake City, UT 84117

who are retained by

Castle Valley Resources Inc.
a subsidiary of
Nevada Electric Investment Corporation

by

Burns R. Sabey and Sheldon D. Nelson

MARCH 1, 1990

INTRODUCTION

Revegetation test plots were established in 1984 at three (3) locations on the Coal Cleaning Plant Property near Wellington, Utah, owned at that time by U.S. Steel Mining Co. Inc. These plots were designed by Dr. Patrick Collins of Mt. Nebo Scientific Research and Consulting from Springville, Utah. They were designed to produce data that could be used to guide in developing viable reclamation and revegetation at some future date.

The property was sold to Kaiser Coal Corporation who subsequently filed for bankruptcy. Nevada Power Co. purchased the property and are now required by the Utah Department of Oil, Gas and Mining to develop guidance for future reclamation.

It appears to us that the plots as originally designed could have resulted in useful data for giving guidance and direction for future revegetation practices. Unfortunately the plots were not established as per design (according to Lynn Kunzler of DOGM). There were serious problems with the irrigation systems prohibiting irrigation applications as designed. Additionally shrub tubling plantings in the East Facing Refuge Plots were omitted. There is no record which we can find specifying the organic matter application rate. Other problems of which there is no documentation may have also existed that could confound the analysis of the scarce data that are available presently.

Available data or lack thereof may indicate that sampling of both plants and soil materials was not adequate to draw firm conclusions as guidelines for revegetation of the site. Lack of consistent sampling and management of the plots have rendered them less useful than might have been with consistent and careful management.

Based on the above and after visiting the test plots at the Wellington Coal Plant location the following conclusions were agreed upon by Lynn Kunzler, Henry Saver,

Candido Manzanares, Sheldon Nelson and Burns Sabey.

A. Species Plots (near the coal plant on disturbed soil surface)

1. Sampling of the plants for the final time in 1990, then abandonment of the few remaining plots.

2. Establishment of a species nursery garden with 20-30 species planted in rows to evaluate germination, seedling development, subsequent growth, and persistence (survival). This will be done in a site near the coal plant that has been disturbed by plant operation but the soil profile is essentially in place.

B. Refuse Pile Plots (East side of the refuse pile)

1. Leave the present plots in place and plan to do minimal soil and plant sampling to determine if the course slurry has had significant effects on controlling capillary rise and salt movement into the soil cover from the refuse pile. Also soil samples could be obtained to determine what effect irrigation has had on salt accumulations.

2. Establish a new set of plots on the south side of the refuse pile and on top of the refuge pile with two (2) variables each in organic matter addition, irrigation application, soil depth thickness, slope and aspect. Plant and soil samples will be taken on a yearly basis, at a time when identification of species and measurement of plant growth are near optimum. Plant sampling will be done by and/or under the close supervision of a qualified, practicing range scientist. Soil samples will be

obtained by and/or under the direction of a qualified and practicing soil scientist. The soil samples will be analyzed by an established and reliable testing laboratory.

C. Slurry Plots (North of the Price River)

1. Existing plots will be monitored this summer for plant cover and density by life form and species. Plant diversity will be evaluated. Soil samples would be obtained during the Spring 1990 to evaluate any salt movement differences due to irrigation (and capillary barrier) treatments.

2. A new shrub tubling garden will be established on the slurry plot area with and without soil added on the surface. The garden will contain 10-15 native shrub species transplanted and watered during the Summer of 1990. Survival counts will be made in the late Fall 1990 and again in the Summer 1991 and annually in the future.

DETAILED PLANS

A. Species Garden (Near the coal plant)

1. Existing Plots (Near the coal plant)

The existing plots have some remaining dimensions of the original design and some data has been collected from this area. Assessment of the surviving species will be made in Spring and Summer 1990 by qualified range scientists. After this period, there may not be a necessity to maintain the integrity of these plots.

2. Establishment of a Species Plot on disturbed soils near the coal plant. A species nursery garden will be established on plots which have the similar soil characteristics as the disturbed surfaces near the existing buildings and roads near the coal storage piles. The plots will consist of grasses, forbes and shrubs in three distinct but proximate areas. Three plots sizes are needed since the space requirements for growth of the three kinds of plants are different.

Plots should be prepared by discing the soil surface to remove existing vegetation. The Grass plot will contain 12 grasses, the Forbes plot will contain 14 forbes and the Shrub plot will have 10 shrubs. (See Table 1) Seeds will be drilled or hand planted in rows in a randomized block split-plot design containing 4 replications. (See Fig. 1, 2, 3)

Soil moisture conditions will most likely be inadequate for seed germination after the plots are prepared. Therefore, a portable sprinkler system will be required to irrigate the soil during the germination and emergence period. Water will be applied to moisten the soil profile adequately to establish seedling growth but will not be used to sustain plant growth throughout the summer. Thereafter supplemental irrigation will not be used on these plots so that plant survival can be evaluated during actual site conditions.

B. Refuse Pile Plots (East side of the refuse pile)

1. Existing Plots: The existing plots will be left in place. Soil samples

will be taken from the 0-3" and 3-6" layers from the six plots that had course slurry between the refuse material and the 6" soil layer. Three replicates of the above plots were irrigated and three were not irrigated. A similar number of samples will be taken from the plots with similar treatments without the course slurry between the refuse and the soil.

Additional soil samples will be taken from the 0-3", 3-6", 6-9", and 9-12" layers from the 6 plots that had course slurry between the refuse material and the 12" soil layer. Again three replicates of the above plots were irrigated and three were not irrigated. A similar number of samples will be taken from the plots with similar treatment without course slurry between the refuse pile and the soil. The following table will illustrate.

Table 2. Plots to be sampled and number of soil samples to be obtained from the existing east facing refuge study.

Sampling Depths	Soil depths	Irrigated	Non-Irrigated	Course Slurry Barrier	No Barrier	Number of Plots	Number of samples
0-3, 3-6	6"	X		X		3	6
0-3, 3-6	6"	X			X	3	6
0-3, 3-6	6"		X	X		3	6
0-3, 3-6	6"		X		X	3	6
0-3, 3-6, 6-9, 9-12	12"	X		X		3	12
0-3, 3-6, 6-9, 9-12	12"	X			X	3	12
0-3, 3-6, 6-9, 9-12	12"		X	X		3	12

0-3, 3-6, 6-9, 12" 9-12	X	X	3	12
		Total Plots	**24**	
		Total Samples		**72**

The soil analyses of each sample will involve the determination of ECe and the SAR. These 2 values should be sufficient to determine if the course slurry barrier and if the irrigation had significant effects on the movement of salts from the refuse or the course slurry into the soil cap placed on the surface.

Evaluation of the existing plant cover will be monitored periodically to determine changes in cover, above ground biomass, diversity by accepted evaluation procedures by Stan Kitchen, a knowledgeable and practicing Range Scientist, and/or associates that he would supervise and check for consistency and accuracy.

2. New Plot Establishment

A new set of plots will be established on the south side of the refuse pile and on the tope of the refuse pile with two (2) variables in sewage sludge addition [0 and 50 tons per acre (T/A)], two (2) variable in irrigation application [0 and 1"/week added as o.5" twice a week], two (2) variables in slope and aspect [20% south facing slope and 5% top of the refuse pile]. See Figure 4 with accompanying calculations. The area on the refuse pile that will be used for the plots will be graded to provide the proper surface soil thickness and the appropriate slopes on the two (2) aspects. Soils will be hauled and dumped as the plot surface, then smoothed to the proper depth and slope. If the plots have been unduly compacted they will be chiselled to provide aeration and to prevent slippage of the soil especially on the steeper slope. The

designated plots will be treated with the equivalent of 50 T/A of sewage sludge which will be mixed into the surface soil by discing. The equivalent of 2000#/A of straw will be spread over the plots, then crimped into the soil, as an erosion protection practice. A fertilizer application of 120#/A of phosphorus and 80#/A of nitrogen will be added to the plots without sewage sludge added. The area will then be gouged or pitted as a water harvesting practice. Especially in the 6" soil application plots, the pitting will partially remove the soil from over the refuse. Hand and shovel adjustments will have to be made to rectify this situation. The plots should then be ready for broadcast seeding with the seed mix shown in Table 2 at two (2) times the rates shown in the table.

An alternative to this procedure could be to drill seed before gouging or pitting, then hand broadcast in the pit areas after the soil is prepared in the pits.

Containerized stock will be used for transplanting the shrubs at this rate of about 700 per acre. This is about 8 shrubs per plot. This rate could be realized by transplanting 2 plants of each of four wing saltbush, shadscale, winterfat, and rubber rabbit brush in each plot. Each transplanted shrub will be labelled to distinguish it from the shrubs derived from the seed mixture.

The plots will be drilled or broadcast in the late fall (October) of 1990, and the transplanted shrubs will be added in the spring of 1991.

The sprinkler irrigation system will then be constructed using pumped

water from the Price River. Determination of the pumping rate and time to add water at the designated application rate will be made at the time of construction of the system.

The plot will be irrigated during the growing season of 1991, then a decision will have to be made about continuing the irrigation on a limited basis during the growing season of 1992.

3. New Plot Sampling

Subsequent to the establishment of the new plot in the Fall 1990 (October-November) soil samples will be taken from each plot at the 0-3" depth from the surface and from the 0-3" zone above the refuse-soil interface. Similar soil samplings will be taken once each year at about the same time (October). Analytical determinations on the first set of soil samples should be quite complete including: total nitrogen, available nitrogen, available phosphorus, available potassium, calcium, magnesium, sudrin, carbonates (ECe), sodium absorption ratio (SAR), electrical conductivity, organic matter and texture. Soil samples for the next four years need only be analyzed for SAR and ECe., then in the fifth year samples, another more complete analysis should be done similar to the 1990 samples.

During the summer of 1991 at the optimum evaluation time, plant growth will be evaluated. Either the ocular method using square meter quadrats or the line intercept method will be used to determine plant parameters. Relative frequency and composition by life form and

species will be measured. Above ground annual production will be estimated by clipping in the field and drying and weighing in the laboratory.

C. Slurry Plots (North of the Price River)

1. Existing plots: The existing plots will be left in place. Soil samples will be collected in Spring 1990 to assess the movement of salts from the buried slurry material into the surface soil and the plant nutrient status of the organic treated plots. Soil Samples will be taken from in 3 inch depth increments through the soil material and 3 inches into the buried slurry on three replicates of the irrigated and non-irrigated plots. Soil samples will be analyzed from Electrical conductivity of the saturated extract (ECe) and to determine the sodium adsorption ratio (SAR).

Soil samples will also be taken in 6 inch increments to the soil/slurry boundary in the organic treated and non-organic treated plots from three replicates. These samples will be analyzed for pH, nitrogen, phosphorus, potassium.

Evaluation of the existing plant cover will be evaluated in Spring and Summer 1990 periodically to determine the species survival on the plots.

These plots could be used in future evaluations. This site could be used to plant seeds from plants surviving on the new plots recommended in this report. In this manner, this area could serve as a valuable seed increase area for species that have become adapted to

this harsh environment.

2. Establishment of a new Shrub Garden

A new set of plots will be established on slurry material by planting shrub tublings. The purpose of this plot is to evaluate the adaptability of shrub species to coal slurry and slurry covered with top soil. Since it is difficult to imagine a recommendation that would require covering the 400+ acres of slurry material with top soil depths greater than 6 inches, it is recommended that the shrub garden be established directly on the slurry material and on slurry covered with 6 inches of top soil.

A randomized split-plot design with four replications consisting of sub-plots 25 ft. x 40 ft. will be used to evaluate 14 shrubs. (See Table 4) that have capabilities of adapting to this environment. (See Fig. 5).

Survival rate on these plots is expected to be extremely low but plants that do survive will be valuable sources of genetic material that could be used to revegetate larger areas in the future. Hopefully some adaptable plants will be found that can survive directly on the slurry material. This is not impossible as a grass and a shrub have adapted to small areas of the slurry material at this time.

Irrigation of tublings at the time of planting will probably be required since it is unlikely that rainfall will have been sufficient to provide adequate soil moisture to prevent injury to the transplanted shrubs. This could be accomplished with a portable sprinkler irrigation system and/or by hand watering individual plants at the time of planting. Tubling transplants will be placed at approximately 5 ft.

intervals with 30 tublings per 25 ft. x 40 ft. plot. In addition to the tublings, one plot will be seeded with a seed mixture used on the other study plots recommended in this document (See Table 5).

CONCLUSION

This report outlines some plans for test plot continuation in brief with possible alternatives to be negotiated with the Utah Department of Oil, Gas and Mining. There are still some details to be developed as evaluations and alternatives can be further considered. This report constitutes only a preliminary plan to be used as a springboard to final plans to be implemented this fall.

It is important for all to realize that in an environment such as exists in the considered area of the disturbance, it will be difficult to reach the regulatory goal of 90% of the pre-disturbance plant condition and impossible to reach the pre-disturbance soil conditions. We can only try. There are no guarantees that any management practice or combination will result in reaching the desired goal-primarily due to the change in the original environment and due to the vagaries of climate and weather.

One noted scientist has expressed his opinion that the only valid approach to revegetation of disturbed lands is to develop a mixture of species with a very broad-based gene pool through plant breeding of species that are adapted to the new environment irrespective of what that environment may be. He advocates manipulation of genes through plant breeding to meet the existing environment and not worry about changing the environment to meet the needs of the existing plants. With a narrow gene pool in our present seed sources any seedling will eventually fail when extremes of weather and climate

condition present themselves as they surely will over the years.

This is one scientist's opinion and many do not subscribe to his philosophy.

Our approach has been to determine what management practices will provide an acceptable environment for the most adapted plant species that are available for revegetation. We think this approach is more practical and less costly but we, like the rest, do not know what will work for certain, in this very harsh and unaccommodating environment.

Table 1 : Plant species list for the Species plots located on the surface of the disturbed soils near the buildings and coal pile storage area.

GRASSES

BOTANICAL NAME	COMMON NAME
1. Agropyron cristatus	Crested Wheatgrass hycrest
2. Agropyron elongatum	Tall wheatgrass
3. Agrophyron intermedium	Intermediate wheatgrass
4. Agropyron trachycaulum	Slender wheatgrass
5. Bouteloua gracilis	Blue grama
6. Distichilis spicata	Saltgrass
7. Hilaria jamesii	Galleta
8. Oryzopsis hymenoides	Indian ricegrass
9. Sprobolus flexuosus	Mesa dropseed
10. Sporobolus airoides	Alkali sacatoon
11. Elymus cimereus	Basin wildrye
12. Sitanion hystrix	Bottlebrush squireltail

FORBES

BOTANICAL NAME	COMMON NAME
1. Asclepia speciosus	Milkweed
2. Atriplex powellii	Powell saltbrush
3. Chenopodium fremontii	Fremont goosefoot
4. Convolvulus arvensis	Bindweed
5. Eriogonium sp.	Buckwheat
6. Helianthuys annus	Sunflower
7. Sphaeralcea coccinea	Globemallow
8. Stanleya pinnata	Pincesplume
9. Melilotus officianalis	Yellow sweet clover
10. Medicago sativa	Alfalfa spreador II
11. Achillea lanulosa	Western yarrow
12. Linum lewisii	Lewis flax
13. Penstomon palmerii	Palmer penstomon
14. Trifolium	Castle valley clover

SHRUBS

BOTANICAL NAME	COMMON NAME
1. Artemisia nova	Black sagebrush
2. Atriplex canescens	Fourwing saltbrush
3. Atriplex confertifolia	Shadscale
4. Ceratoides lanata	Winterfat
5. Chrysothamnus nauseosus	Rubber rabbitbrush
6. Ephedra viridis	Mormon tea
7. Kochia prostrata	Summer cypress
8. Artemesisa tridentata	Big sagebrush
9. Sarcobatus vermiculatus	Greasewood
10. Chrysothamnus linifolius	Spreading rabbitbrush

Table 3 : Plant Species for Revegetation of the Refuse Pile.

BOTANICAL NAME	COMMON NAME	SEED RATE (lb / acre)
Grasses		
Agropyron trachycaulum	Slender wheatgrass	3.0
Agropyron cristatus	Crested wheatgrass Hycrest	1.0
Bouteloua gracilis	Blue grama	0.5
Hilaria jamesii	Galleta	3.0
Oryzopsis hymenoides	Indian ricegrass	2.0
Sporobolus airoides	Alkali sacatoon	0.25
Elymus cirnereus	Basin wildrye	1.0
		10.75
Forbes		
Sphorelcea coccinea	Globe mallow	0.5
Melsilotus officianalis	Yellow sweet clover	1.0
Medicago sativa	Alfalfa Spreador II	1.0
Eriogonum umbellatum	Sulphur buckwheat	1.0
Oenothera caespitosa	Evening primrose	0.25
		3.75
Shrubs		
Artemisia nova	Black sagebrush	0.75
Atriplex canescens	Fourwing saltbrush	3.0
Atriplex confertifolia	Shadscale	3.0
Ceratoides lanata	Winterfat	3.0
Chrysothamnus nauseosus	Rubber rabbitbrush	1.0
Ephedra viridis	Mormon tea	2.0
Kochia prostrata	Summer cypress	0.75
Artemesisa tridentata	Big sagebrush	0.75
Sarcobatus vermiculatus	Greasewood	1.0
Chrysothamnus linifolius	Spreading rabbitbrush	1.0
		16.25
	Total	30.75

Table 4 : Shrub species list for the Shrub Garden located at the slurry site.

BOTANICAL NAME	COMMON NAME
1. Artemisia nova	Black sagebrush
2. Artemisia tridentata	Big sagebrush
3. Atriplex confertifolia	Shadscale
4. Artriplex corrugata	Mat saltbush
5. Deratoides lanata	Winterfat
6. Chrysothamnus linifolius	Spreading rabbitbrush
7. Chrysothamnus nauseosus	Rubber rabbitbrush
8. Chrysothamnus viscidiflorus	Low rabbitbrush
9. Ephedra viridis	Mormon tea
10. Kochia prostrata	Summer cypress
11. Sarcobatus vermiculatus	Greasewood
12. Tamarix ramosissima	Tamarisk
14. 13. Atriplex canescens	Fourwing saltbush
15. Seed Mixture	(See Table 5)

Table 5 : Seed mixture for Species Plot and Shrub Garden.

BOTANICAL NAME	COMMON NAME	SEED RATE (lb / acre)
Grasses		
1. Agropyron trachycaulum	Slender wheatgrass	3.0
2. Agropyron cristatus	Crested wheatgrass Hycrest	1.0
3. Bouteloua gracilis	Blue grama	0.5
4. Hilaria jamesii	Galleta	3.0
5. Oryzopsis hymenoides	Indian ricegrass	2.0
7. Elymus cirnereus	Basin wildrye	1.0
		10.75
Forbes		
1. Sphorelcea coccinea	Globe mallow	0.5
2. Melsilotus officianalis	Yellow sweet clover	1.0
3. Medicago sativa	Alfalfa Spreador II	1.0
4. Eriogonum umbellatum	Sulphur buckwheat	1.0
5. Oenothera caespitosa	Evening primrose	0.25
		3.75
Shrubs		
1. Artemisia nova	Black sagebrush	0.75
2. Atriplex canescens	Fourwing saltbrush	3.0
3. Atriplex confertifolia	Shadscale	3.0
4. Ceratoides lanata	Winterfat	3.0
5. Chrysothamnus nauseosus	Rubber rabbitbrush	1.0
6. Ephedra viridis	Mormon tea	2.0
7. Kochia prostrata	Summer cypress	0.75
8. Artemesisa tridentata	Big sagebrush	0.75
9. Sarcobatus vermiculatus	Greasewood	1.0
10. Chrysothamnus linifolius	Spreading rabbitbrush	1.0
		16.25
	Total	30.75

Fig. 1 GRASS SPECIES PLOT

Randomized Block Split-Plot Design

BLOCK 1	M. DROP SEED	C. WHEAT GRASS	SALTGRASS	T. WHEATGRASS	A. SACATON	I. RICEGRASS	SQUIRELTAIL	I. WHEATGRASS	GALLETA	B. WILDRYE	BLUE. GRAMA	S. WHEATGRASS		
BLOCK 2	BLUE GRAMA	SALTGRASS	SACATON	S. WHEATGRASS	I. RICEGRASS	I. WHEATGRASS	T. WHEATGRASS	MDROT SEED	SQUIRELTAIL	BWILDRYE	GALLETA	CWHEATGRASS		
BLOCK 3	T. WHEATGRASS	M. DROP SEED	B. WILDRYE	SALTGRASS	S. WHEATGRASS	C. WHEATGRASS	GALLETA	BLUE. GRAMA	A. SACATON	I. RICEGRASS	I. WHEATGRASS	SQUIRELTAIL		
BLOCK 4	SQUIRELTAIL	A. SACATON	S. WHEATGRASS	GALLETA	I. WHEATGRASS	C. WHEATGRASS	SALTGRASS	I. RICEGRASS	BWILDRYE	BLUE GRAMA	T. WHEATGRASS	MDROT SEED		

50 TONS / ACRE INCORPORATED SEWAGE SLUDGE

3 ft. X 15 ft. sub-plots

Fig. 2 FORBES SPECIES PLOT

Randomized Block Split-Plot Design

BLOCK 1	SWEET CLOVER	MILKWEED	SUNFLOWER	P. SALT BUSH	TRIFOLIUM	ALFALFA	PINCES PLUME	LEWIS FLAX	F. GOOSEFOOT	GLOBEMALLOW	W. YARROW	PENSTOMON	BUCKWHEAT	BINDWEED
BLOCK 2	BUCKWHEAT	SUNFLOWER	ALFALFA	P. SALT BUSH	PLUME PINCES	GOOSEFOOT	BLINDWEED	SWEET CLOVER	LEWIS FLAX	PENSTOMON	W. YARROW	GLOBEMALLOW	MILKWEED	TRIFOLIUM
BLOCK 3	P. SALT BUSH	PENSTOMON	SWEET CLOVER	W. YARROW	SUNFLOWER	TRIFOLIUM	BINDWEED	F. GOOSEFOOT	MILKWEED	GLOBEMALLOW	BUCKWHEAT	ALFALFA	LEWIS FLAX	PINCES PLUME
BLOCK 4	LEWIS FLAX	ALFALFA	BINDWEED	GLOBEMALLOW	F. GOOSEFOOT	MILKWEED	TRIFOLIUM	SUNFLOWER	PINCES PLUME	W. YARROW	BUCKWHEAT	P. SALT BUSH	SWEET CLOVER	PENSTOMON

50 TONS / ACRE INCORPORATED SEWAGE SLUDGE

5 ft. X 25 ft. sub-plots

Fig. 3 SHRUBS SPECIES PLOT

Randomized Block Split-Plot Design

BLOCK 1	GREASEWOOD	BLACKSAGE	MORMONTEA	FOURWING	S. RABBITBRUSH	BIGSAGE	SHADSCALE	S. CYPRESS	R. RABBITBRUSH	WINTERFAT	SEEDMIX		
BLOCK 2	RRABBITBRUSH	MORMONTEA	SRABBITBRUSH	FOURWING	BIGSAGE	SHADSCALE	WINTERFAT	GREASEWOOD	SEEDMIX	S. CYPRESS	BLACKSAGE		
BLOCK 3	FOURWING	GREASEWOOD	SEEDMIX	MORMONTEA	WINTERFAT	SHADSCALE	BLACKSAGE	S. CYPRESS	R. RABBITBRUSH	S. RABBITBRUSH	BIGSAGE		
BLOCK 4	SRABBITBRUSH	WINTERFAT	S. CYPRESS	SHADSCALE	BLACKSAGE	MORMONTEA	BIGSAGE	SEEDMIX	RRABBITBRUSH	ECOTRWING	GREASEWOOD		

50 TONS / ACRE INCORPORATED SEWAGE
10 ft. X 30 ft. sub-plots

Figure 4 Experimental Design, Plot Layout and Calculations of area required, and amount of sludge and soil material required.

SOUTH FACING SLOPE (20%)

	Irrigated			Non-irrigated				
	6"	12"		12"		6"		
←←←←←30"→→→→→								
↑ 10" ↓	1. 15N6R	5. 3SN6R	9. 15012R	13. 35012R	17. 1SN120	21. 2SN120	25. 1SO60	29. 4SO60
	2. 1506R	6. 3S06R	10. 1SN12R	14 45012R	18. ISO120	22. 3SN120	26. ISN60	30. 2SN60
	3. 2506R	7. 4SN6R	11. 2SN12R	15. 4SN12R	19. 2SO120	23. 4SO120	27. 2SO60	31. 3SN60
	4. 2SN6R	8. 4SO6R	12. 2SO12R	16. 4SN12R	20. 3SO120	24. 4SN120	28. 3SO60	32. 4SN60

↑ 40 ↓ South Facing

TOP OF PILE (5%)

Irrigated			Non-irrigated				
6"	12"		12"		6"		
33. 1TN6R	37. 2TO6R	41. 1TN12R	45. 3TO12R	49. 1TN6O	53. 3TN60	57. 1TO120	61. 3TN120
34. 2TN6R	38. 4TN6R	42. 2TN12R	46. 4TO12R	50. 2TN60	54. 3TO60	58. 1TN120	62. 4TN120
35. 3TN6R	39. 3TO6R	43. 1TO12R	47. 3TN12R	51. 1TO60	55. 4TN60	59. 2TO120	63. 3TO120
36. 2TO60	40. 4TO6R	44. 2TO12R	48. 4TN12R	52. 2TO60	56. 4TO60	60. 2TN120	64. 4TO120

Label Designation and Sequence

Rep	Slope & Aspect	Organic Treat-ment	Soil Depth	Irrigation Treatment
1	S = South 20%	0 = organic matter treat	6"	0 = none
2				
3	T = Top 5%		12"	R = imgation added
4		N = none		

Experimental Design

2 slopes & aspects - S = South facing-20%, T = Top of Pile - 5%
2 organic matter rates - N = OT/A, O = 50 T/A
2 soil depths 6 = 6" 12 = 12:
2 irrigation rates 0 = none R = 1"/week or 0.5" twice/week
4 replications
64 total plots

Area Required

40 x 120 = 4800 ft^2 x 4 = 19200 ft^2 = 0.44 acres + buffer zone or about 0.5 acres

Sludge Required

0.22 A x 50 T/A = 11 Tons + extra - 12-13 Tons
11T x 2000 = 22000# - 32 plots = 690#/plot

Soil Material Required

6" plots 32 x 10' x 30' x 0.5' = 4800 ft^3 = 177.8 yds^3
4800 ft^3 x 62.5 x 1.25 = 374400# = 187.2 Tons

12" plots 32 x 10' x 30' x 1' = 9600 ft^3 = 355.6 yds^3
or 374.4 Tons

Total = **533.4 yds^3 or 561.6 Tons**

Fig 5. SHRUB NURSERY ON SLURRY

RANDOMIZED BLOCK SPLIT-PLOT

BLOCK 1	MORMON TEA	BLACKSAGE	S. RABBIT BRUSH	BIGSAGEBRUSH	SEEDMIX	S. CYPRESS	L. RABBIT BRUSH	TAMARISK	SHADSCALE	R. RABBIT BRUSH	GREASEWOOD	FOURWING SALT	WINTERFAT	MATSALTBUSH
BLOCK 2	WINTERFAT	S. RABBIT BRUSH	SCYPRESS	BIGSAGEBRUSH	L. RABBIT BRUSH	SHADSCALE	MATSALTBUSH	MORMON TEA	TAMARISK	SEEDMIX	GREASEWOOD	FOURWING SALT	R. RABBIT BRUSH	BLACKSAGE
BLOCK 3	BIGSAGEBRUSH	FOURWING SALT	MORMON TEA	GREASEWOOD	S. RABBIT BRUSH	SEEDMIX	MATSALTBUSH	SHADSCALE	BLACKSAGE	R. RABBIT BRUSH	WINTERFAT	S. CYPRESS	TAMARISK	L. RABBIT BRUSH
BLOCK 4	TAMARISK	SCYPRESS	MATSALTBUSH	R. RABBIT BRUSH	SHADSCALE	BLACKSAGE	FOURWING SALT	S. RABBIT BRUSH	L. RABBIT BRUSH	GREASEWOOD	WINTERFAT	BIGSAGE	MORMON TEA	SEEDMIX

6 INCH TOP SOIL OVER
25 FT. X 40 FT.