PLANT ESTABLISHMENT ON RECLAIMED MOLYBDENUM TAILINGS, QUESTA TAILINGS FACILITY, QUESTA, NEW MEXICO[1]

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Abstract: Molycorp, Inc. operates a molybdenum mine and associated tailings facility, near the Village of Questa, New Mexico. Neutral tailings are pumped 5.6 km from the mine to the Questa Tailings Facility where interim reclamation activities have been conducted for over 30 years. Four interim reclamation areas of the tailings facility, widely ranging in age, were evaluated for the effect of cover soil depth on plant communities. Sampling of various plant community components was conducted along random transects. The plant community components include; plant cover, shrub density, and species diversity. The evaluations suggested that depth of cover soil has little influence on the plant community components.

Additional Key Words: tailings basins revegetation, cover depth, and reclamation.

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Introduction

Molycorp, Inc. (Molycorp) operates the Questa Mine and Tailings Facility, which are located near the town of Questa, in Northern New Mexico. The molybdenum ore extracted at the Questa Mine is comprised of approximately 27 percent aplite, 70 percent andesite, and 3 percent mixed volcanics (Robertson, 1988). The ore is crushed to a particle size less than 0.2 mm for processing. Molybdenum is removed from the ore resulting in a slurry composed of fine residual crushed rock and water, or tailings. In general, the tailings produced at the Questa Mine are net acid consuming and generally has a pH of 7. From the mill, the tailings are pumped via pipeline 5.6 km to large engineered tailings facility that covers about 810 hectares.

The tailings facility has been divided into small operational areas. When an area, or basin has reached the current capacity or during times of inactivity an interim cover soil, composed of gravelly alluvium excavated from onsite borrow pits, is applied to the surface of the tailings. The cover soil is placed on the exposed tailings in single applications ranging in depths of 20 to 30 cm. Each application constitutes a "lift" of cover soil. Multiple lifts may be applied to achieve the desired reclamation cover thickness. The cover soil is applied to reduce potential wind and water erosion during periods of inactivity. Native and some non-native plants have been seeded into the cover soil to establish plant cover and further alleviate erosion. Typical interim revegetation species include: yellow sweetclover (*Melilotus officinalis*), western wheatgrass (*Pascopyrum smithii*), and blue grama (*Bouteloua gracilis*).

Previous studies have been conducted at the tailings facility evaluating the effects of cover soil depth on the seeded plant communities. In 1980 and 1981, the United States Department of Agriculture, Soil Conservation Service, Los Lunas Plant Materials Center (Wolfe and Oaks, 1986) constructed numerous study plots to evaluate the plant community establishment on the reclaimed tailings at the tailings facility. In 1985, monitoring was conducted to determine the plant establishment and vigor within the study plots. Plant vigor was determined on a qualitative scale ranging from 1 to 10, one being excellent vigor and ten being no vigor. The 1980 studies evaluated the establishment of different native species on various depths of cover soil (0, 10, 20, and 30 cm) on treated (plots previously sprayed with a surfactant) and non-treated tailings. After six growing seasons, plant vigor on the treated tailings with no cover soil (0 cm) were significantly greater than the 20 and 30 cm cover soil depths. The vigor between the 0 and 10 cm cover soil depths were not significantly different. Plant vigor between the 10, 20, and 30 cm depths were not significantly different. Vigor on the non-treated tailings was not significantly different for the 0 and 20 cm cover soil depths. The vigor of the 30 cm cover soil depth was significantly greater than all other depths, and vigor on the 10 cm cover soil depth was significantly lower than all other cover soil depths. The 1981 studies evaluated the effects of cover soil depth (15, 30, and 45 cm) and native seed mixes on revegetation. After 5 growing seasons, plant vigor on the 15 cm cover soil depth was statistically lower than the 30 and 45 cm cover depths. The plant vigor on the 30 and 45 cm cover soil depths were not significantly different. From the results of the 1980 and 1981 studies, it was concluded that 20 cm of cover soil would be sufficient for reclamation and deeper cover soil depths (30, 40, and 45 cm) were unjustified.

In August 2004, a monitoring study was conducted to evaluate the plant communities and the effects of cover soil depth on plant community establishment on four interim reclamation areas. The ages of these reclaimed areas date from 1970 to present (2004). This information was collected in part to assist in designing and implementing future reclamation activities at the tailings facility.

Methods and Materials

Random sampling locations were selected in each of the four reclaim areas, using a geographical information system (GIS). The four reclaim areas are identified by the ages of reclamation; 1970 Reclaim, 1980 Reclaim, 1993-1994 Reclaim, and 1998-2004 Reclaim, Fig. 1. These sampling locations were located in the field using global positioning satellite (GPS) technology. Sampling was conducted sequentially on a minimum of 15 and a maximum of 40 sampling locations in each of the four reclaimed areas. The total number of locations sampled would be determined by utilizing a running mean sample adequacy technique (Clark, 2001). This sample adequacy technique utilizes the stabilization of the running mean as a method of evaluating sample adequacy. Sample adequacy is achieved when the running mean has stabilized within 10% of the true mean. If sample adequacy was not met with the first 15 sample locations, additional sample locations, in groups of five, were added to the previous sample set. The additional sample locations would continue to be added until sample adequacy was met or 40 locations were sampled.

Plant community components and cover soil depth were measured using a line intercept transect method at each of the sampling locations. The plant community components sampled included; total plant cover, perennial plant cover, non-vegetated ground cover, shrub density, and number of species per transect.

Plant Cover

Plant cover was determined at 0.5 meter intervals along a 50-meter transect (Knight 1978; Barbour et al. 1980), Fig. 2. This resulted in a total of 100 primary hits per transect. A primary hit is defined as the first interception of a vertical projection from the tape to either vegetation, litter, rock, or bare ground.

Shrub Density

Shrub density was estimated at each sampling location by counting the numbers of shrubs rooted within a 50x2 meter ($100m^2$) belt transect. The belt transect was increased to a 4 meter belt ($200m^2$), if no shrubs were observed within the 2 meter belt. The shrub density estimation from the 4 meter belt transect were then converted back to a $100m^2$ base unit for analysis.

Number of Species Per Transect

The number of species per transect were calculated by counting the occurrence of each individual species along each transect. This number provides an approximation of species diversity within the reclaim area.

Cover Soil Depth

Cover soil depth was determined at one end of each transect. The cover soil was excavated with hand tools until the interface between tailings and cover soil was identified. This depth was recorded and associated with the entire sampling transect. As a quality check, occasionally cover depth was determined at both ends of a transect. In every instance the depth of cover soil was the same at both ends of the transect.

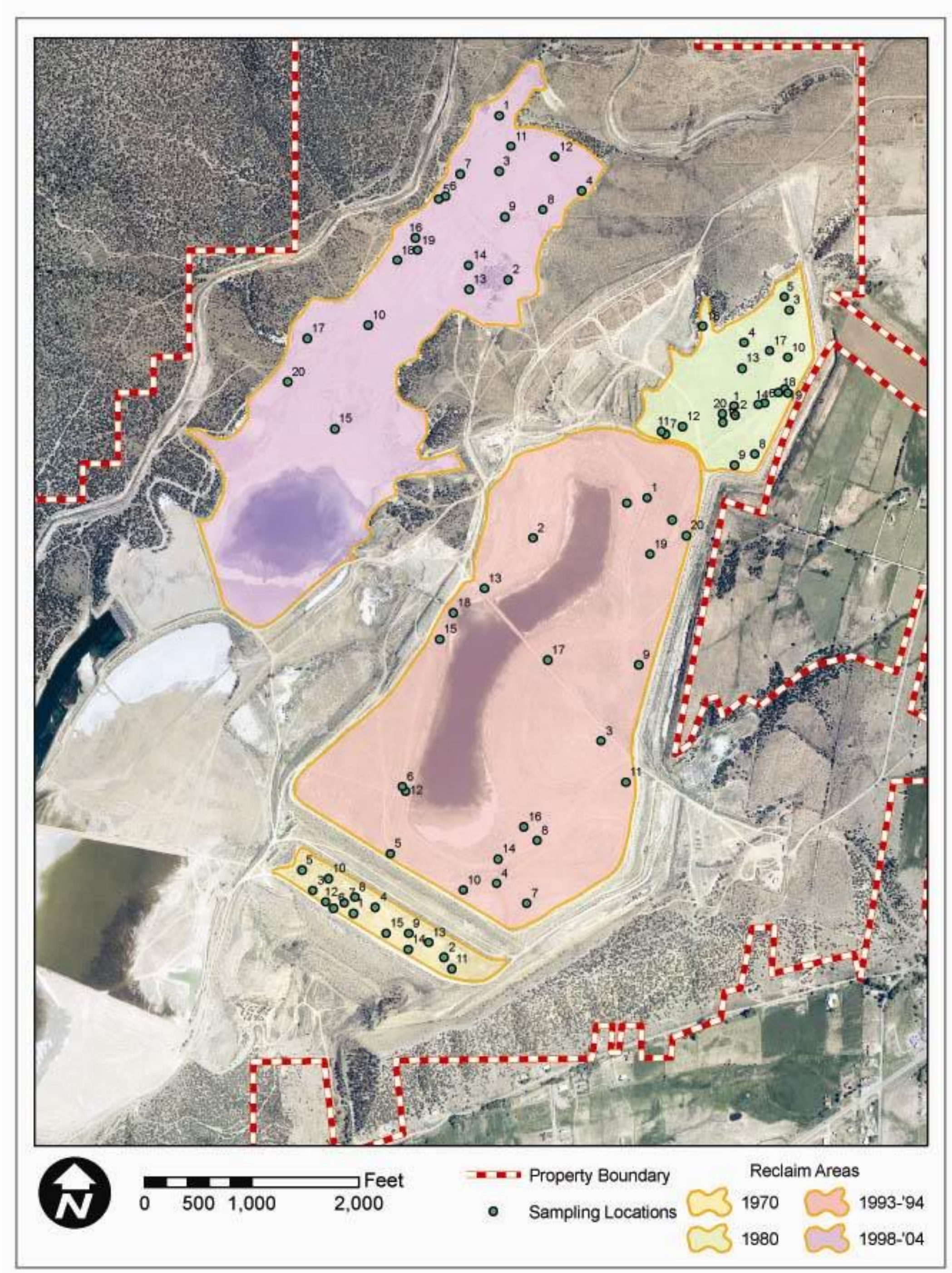

Figure 1. Reclaimed Areas of the Questa Tailings Facility, Questa, New Mexico.

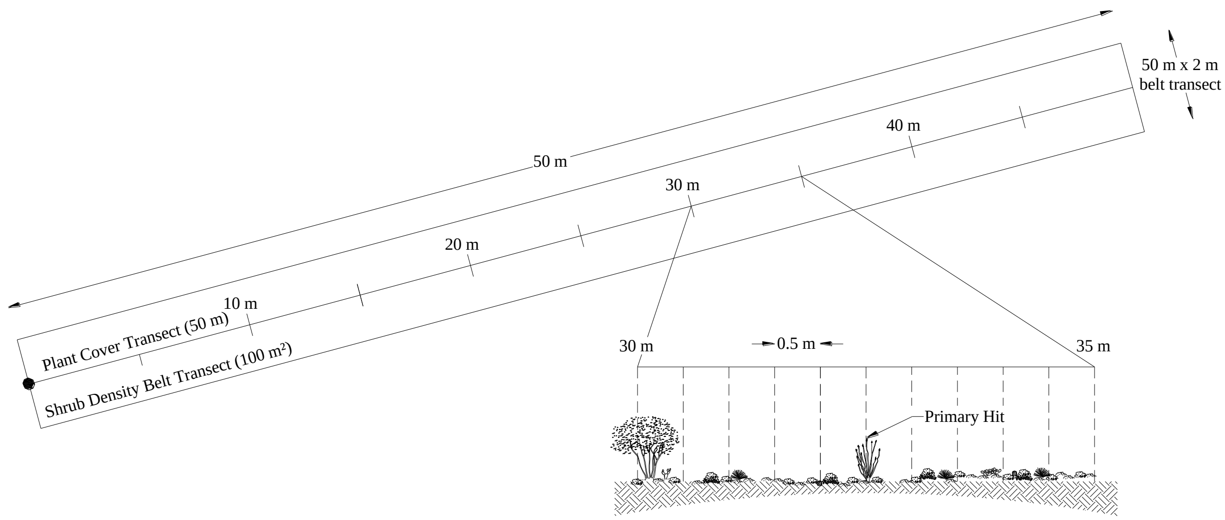

Figure 2. Sampling Location Transect Diagram

Results and Discussion

The results from the four individual reclaim areas are summarized in Table 1. The plant community components (cover, shrub density, and number of species per transect) were compared to cover soil depth to discern if any relationship existed. Identifying relationships between cover soil depth and plant community components was intended to assist in future reclamation design and implementation.

Table 1. Reclaim Area Plant Community Components Results, Questa Tailings Facility, Questa, New Mexico.

	1970 Reclaim	1980 Reclaim	1993-1994 Reclaim	1998-2004 Reclaim
Number of Transects	15	20	20	20
Total Plant Cover (%)	30.3	32.0	29.5	27.0
Perennial Plant Cover (%)	29.8	31.2	28.2	24.1
Shrub Density (shrubs/ha.)	3,593	2,061	4,104	1,255
Number of Species per Transect	4.1	4.9	5.5	5.5
Mean Cover Soil Depth (cm)	21.0	17.8	34.0	23.0

Plant Cover

The four reclaim areas had a mean total plant cover of 29.6% (SD 8.6) and mean perennial plant cover of 28.2% (SD 8.3), respectively. Scatter diagrams were created to compare the total and perennial plant cover to the depth of cover soil at the 75 sample locations. Polynomial regression analysis for both the total plant cover (r=0.105, P=NS) and perennial plant cover (r=0.044, P=NS) suggests that neither total (Fig. 2) nor perennial plant cover (Fig. 3) are related to cover soil depth.

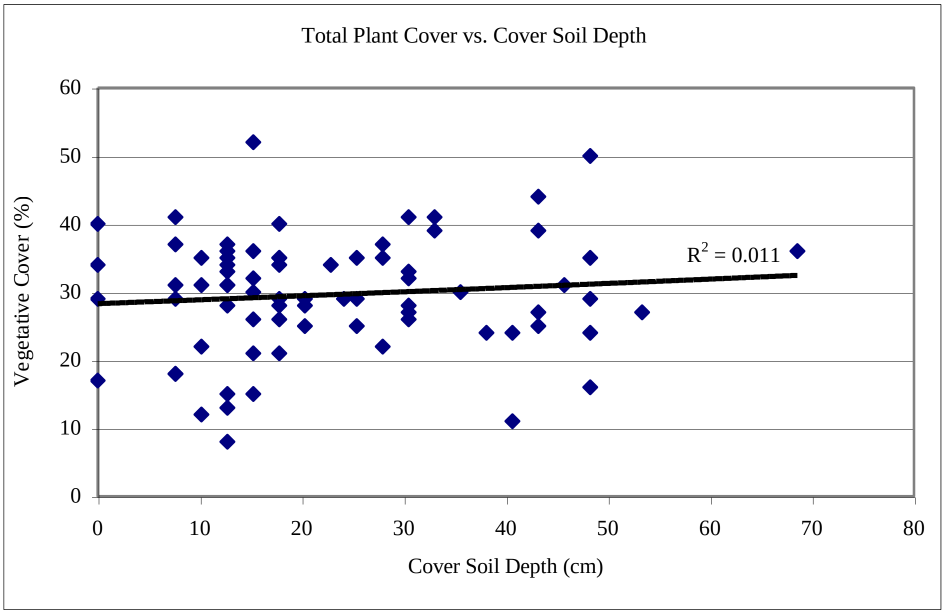

Figure 2. Total Plant Cover vs. Cover Soil Depth, Questa Tailings Facility, Questa New Mexico.

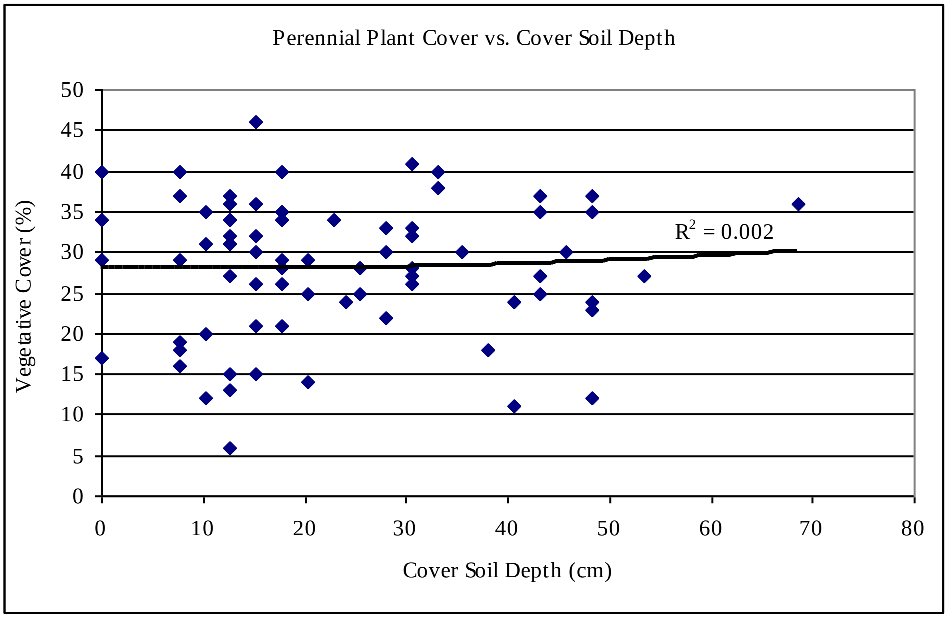

Figure 3. Perennial Plant Cover vs. Cover Soil Depth, Questa Tailings Facility, Questa New Mexico.

Shrub Density

The four reclaim areas had a mean shrub density of 2,731 shrubs/ha. (SD 2,543). Regression analysis, Fig. 4 (r=0.176, P=NS), suggests there is no relationship between shrub density and cover soil depth.

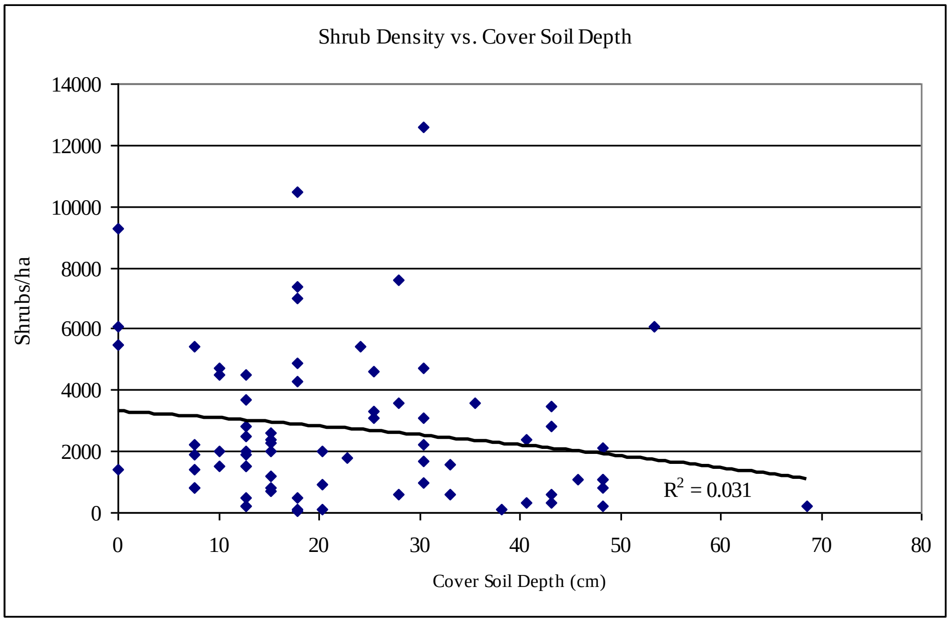

Figure 4. Shrub Density vs. Cover Soil Depth, Questa Tailings Facility, Questa New Mexico.

Cover Soil Depth

The mean cover soil depth for the four reclaim areas was 23.1 cm (SD 14.8). Cover soil depth ranged from 0 cm to 68.6 cm.

Number of Species per Transect

The four reclaim areas had a mean of 5 species (SD 1.9) per transect. The values ranged from a minimum of 2 species to a maximum of 10, Fig. 5. The regression analysis, (r=0.208, P=NS), indicates no effect of cover soil on number of species per transect.

Conclusions

None of the plant community components (total plant cover, perennial plant cover, shrub density, and number of species per transect) sampled had a significant relationship to cover soil depth. The lack of any statistically significant relationships suggests cover soil depth within the ranges measured at the tailings facility has little affect on the plant community components. Analysis of the plant communities in 2004 indicated, that a mean cover soil depth of 23 cm is sufficient to provide approximately 30% total plant cover and 28% perennial plant cover. In addition, the cover soil depth of 23 cm sustains a shrub density of approximately 2,731 shrubs/ha and 5 species per transect. These conclusions are similar to work completed in the early 1980's by the Plant Materials Center (Wolfe and Oak, 1986).

Application of a shallower soil is consistent with the study conducted by Wolfe and Oaks (Wolfe, 1986). Their study in 1986 concluded that the vigor on all cover soil depths (except no cover soil) was good to excellent. From their observations, they suggested that 20 cm of cover soil would be adequate for reclamation, and the application of deeper cover depth was unnecessary. The two studies indicate that sustainable reclamation of the tailings facility can be achieved with approximately 23 cm of cover soil.

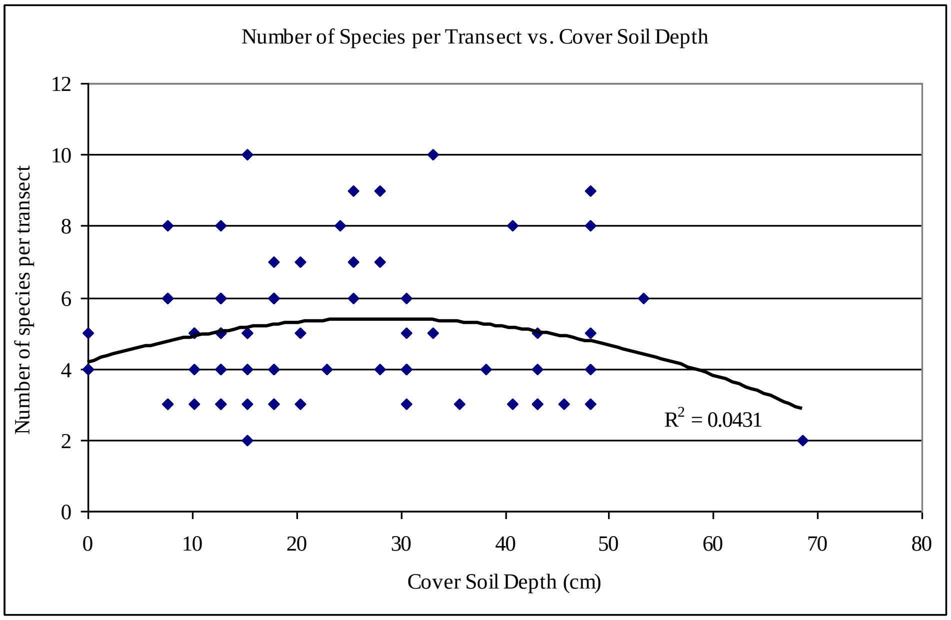

Figure 5. Number of Species per Transect vs. Cover Soil Depth, Questa Tailings Facility, Questa, New Mexico.

References Cited

Barbour, M.G., H.J. Burk, W.D. Pitts. 1980. Terrestrial Plant Ecology. The Benjamin/ Cummings Publishing Company, Inc. Menlo Park, California.

Clark, David L. 2001. Stabilization of the Mean as a Demonstration of Sample Adequacy. in Land Reclamation – A Different Approach, 2001 Proceedings, ASSMR June 3 – 7, 2001 Albuquerque, New Mexico. Vol. 1.

https://doi.org/10.21000/JASMR01010065

Knight, D. H. 1978. Methods for Sampling Vegetation – An Instructional Manual of Botany. Department of Botany, University of Wyoming, Laramie.

Robertson GeoConsultants Inc. 1998, Questa tailings Facility Revised Closure Plan, Prepared for Questa Mine, Molycorp, Inc. April 1998.

Wolf, H.G. and W.R. Oaks, 1986, 1984-1985 Progress Report Reclamation Studies, United States Department of Agriculture, Soil Conservation Service, Los Lunas Plant Materials Center, Los Lunas, NM.