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# Memo

**To:** Mark Pifher, Southern Delivery System (SDS) Program

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**CC:** Allison Mosser, Colorado Springs Utilities, SDS Program,  
Alec Hart, MWH Americas, Inc.,  
Ed Redente, Redente Ecological Consultants

**Date:** August 30, 2013

**Re:** Pueblo County Revegetation Cover Establishment Protocol for the Southern Delivery System Pipeline Project

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## Purpose

This memo describes the protocol to be used to assess and document revegetation success on the Southern Delivery System (SDS) pipeline alignment in Pueblo County. These protocols will serve as the basis for determining that revegetation meets the requirements of the stormwater permit issued by the Colorado Department of Public Health and Environment (CDPHE) and the 1041 permit issued by Pueblo County. Those permits require that revegetation of the disturbed areas contains at least 70 percent and 90 percent, respectively, of the cover existing on the site prior to construction, together with similar species diversity.

The protocol uses a point-intercept method with a stratified random sampling design to assess percent ground cover and species richness. The post-revegetation sampling will be stratified by work package and functional soil type, and will include ten (10) samples in work package/soil unit areas up to one mile in length, and fifteen (15) samples in areas greater than one mile in length. Compiled data will be compared to the applicable standard (90 percent of pre-existing vegetation cover) using a one sample t-test to evaluate confidence level of the determination of revegetation success.

The memo includes a discussion of the underlying permit language, describes the management and sampling objectives of the protocol, explains the likely progression of vegetation development, describes how progress and sustainable growth will be evaluated over the two year revegetation period, and describes the methods for determining final revegetation success. In support of the protocol, three Technical Memos are attached describing the procedure for point-intercept cover and seedling density sampling (Technical Memo 1), the pre-disturbance sampling methods (Technical Memo 2), and the post revegetation sampling methods and statistical evaluation (Technical Memo 3).

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the Pueblo County 90 percent of pre-existing cover criterion, the full sampling design described below will be implemented.

### **Introduction**

The Southern Delivery System Program has conducted pre-disturbance vegetation surveys to document the density and type of vegetation that existed on the pipeline work packages (S1, S2 and S3) prior to construction-related work activities starting. These evaluations were completed by the Colorado Natural Heritage Program (CNHP), a research unit within the Warner College of Natural Resources at Colorado State University. The data were acquired for the purpose of establishing performance standards for post-construction revegetation.

CNHP used a point-intercept method developed by ESCO Associates for establishing percent vegetation cover by species and determining species richness. Pre-disturbance vegetation sampling was conducted by soil type within the SDS work packages. A copy of the methodology used is attached to this memo as Technical Memo 1. CNHP will use this same point-intercept protocol for evaluating reclamation progress and final reclamation success determination. Post-revegetation sampling will occur at randomly located and oriented transects to establish an estimate of the mean cover of plant species by soil types within work packages. CNHP has determined that a sample size of ten (10) transects in each soil unit cumulatively less than one mile in length, or fifteen (15) transects in each soil unit cumulatively longer than one mile in length is sufficient to estimate the mean and variance to confidently determine post-restoration revegetation success in accordance with Pueblo County 1041 Permit number 2008-002. The following describe in more detail the level of effort for both progress and final cover evaluations. A detailed description of the Pre-Construction vegetation survey and the establishment of Cover Performance Standards from those data are attached in Technical Memo 2.

## **Background**

### **SDS Permit Language**

In addition to the Bureau of Reclamation's 2009 Record of Decision (GP-2009-01), regulations requiring reclamation of disturbed lands by the SDS Project include the CDPHE Construction General Stormwater Permit (COR 030000) and Pueblo County Resolution P&D 09-22 approving 1041 Permit 2008-002.

The CDPHE General Stormwater Permit associated with construction activities stipulates, *"Final stabilization is reached when all ground surface disturbing activities at the site have been completed, and uniform vegetative cover has been established with an individual plant density of at least 70 percent of pre-disturbance levels..."*

Under the Pueblo County 1041 permit, SDS is required to conduct a pre-construction evaluation of existing vegetation to be disturbed during construction of the SDS project within Pueblo County and upon reclamation of the site, vegetative cover is required to be, *"... of the same seasonal variety native to the area of the disturbed land, or species that support the post-construction land use ..."*

The revegetated area will be considered acceptable if its cover is not less than 90 percent of the pre-construction vegetation cover with similar species diversity. SDS will achieve this objective by utilizing a seed mixture that reflects pre-construction species diversity and which, as more fully explained below, is anticipated to result in a re-establishment of the required percent vegetative cover which will, in turn, through time experience a natural succession in species dominance until the original conditions are duplicated.

### **Management Objectives and Sampling / Monitoring Objectives**

The management objective of the revegetation effort in Pueblo County is to ensure that by the earliest opportunity the average cover of native and non-noxious opportunistic plant species occurring on each soil type within each work package is at least 90 percent of the vegetation cover that existed on those same soils prior to disturbance for construction.

The sampling objective is to quantitatively document whether revegetation has achieved the requirements of the permit standard of 90 percent of pre-disturbance vegetation cover. The monitoring objective is to quantitatively assess and document progress toward the management objective.

### **Likely Progression of Vegetation Development**

The reality of revegetation in the arid west is that the period following seeding until treated areas are fully re-established with the same species mix, as compared to undisturbed areas, is generally longer than two years. Usually, a minimum of five years will pass before the main perennial plants comprise the bulk of cover and the prevalence of early successional species that initially colonized the disturbance area diminish. At the end of two years, even with irrigation, it is likely that species other than the target shortgrass species will dominate the seeded community. As an example, slender wheatgrass (*Elymus*

*trachycaulus*) was included in the seed mixture to perform the function of occupying space and pre-empting weeds while blue grama (*Bouteloua gracilis*), galleta (*Pleuraphis jamesii*), and other perennials slowly establish and begin to dominate. Slender wheatgrass is short-lived and will disappear from the community after three to four years, allowing the cover of the long-term desired warm season grasses to achieve dominance. This natural maturation of the ecosystem will allow for the re-planted areas to achieve the same seasonal variety with similar species diversity as required by Pueblo County.

In addition to the seeded species, it can be expected that opportunistic early-seral species will have colonized the area naturally and will establish at varying densities. The seeds of most of these species were in the soil prior to disturbance and were suppressed by perennial competition. Irrigation will enhance the seeded species, but it will also allow development of these naturally present opportunists. Most of these opportunistic plants are native species and do not represent the potential for long-term weed problems. Noxious weed species listed by the State or County, if identified on the work package alignment, will be controlled as detailed in each work packages' contract documents and specifications and in accordance with Colorado Department of Agriculture noxious weed management regulations. Typically, the non-noxious opportunistic species will not damage the growth of the long-term native species and will not be treated. It is inevitable that they will be present and visually conspicuous for two or more years as the perennial species expand their presence. As native perennial species increase, the opportunistic species will be suppressed by competition and will decline to insignificant levels. In recognition of the natural processes described here and their inherent rates of progress, all non-noxious species will be included in the assessment of cover during quantitative evaluations of revegetation success.

### **Protocol**

#### **Progress Evaluations**

To ensure revegetation is progressing as planned and to communicate the status to the SDS Program, regular progress meetings will be held with the revegetation contractor(s) and periodic site inspections will be coordinated with Pueblo County, U.S. Bureau of Reclamation and other stakeholder representatives. The frequency of progress evaluations will be every other month (bi-monthly) during the growing season (April through September) and quarterly in the non-growing season (October through March). Quantitative sampling of the vegetation will be conducted during the first and second growing season to determine the progress of revegetation.

Quantitative sampling and evaluations (Seedling Density and Cover evaluations) for the SDS project pipeline work packages (S2 and S3) are expected to be undertaken as per the following schedule (subject to change):

- July 2013 - Seedling Density assessment,
- September 2013 - Seedling density assessment and cover evaluation for CDPHE stormwater permit evaluation for determination of 70 percent of pre-existing cover,

- At the discretion of SDS, evaluation for assessment of 90 percent of pre-existing cover will also be completed during the September 2013 assessment,
- July/August 2014 - Evaluation for assessment of 90 percent of pre-existing cover if not achieved in 2013 and/or to demonstrate 90 percent cover is being maintained.

Quantitative sampling and evaluations for the SDS project S1 pipeline work package will have the same milestones on a schedule anticipated to be one year following those shown for the S2 and S3 work packages, which were planted earlier. All evaluations (both seeding density and cover assessment) for S1, S2 and S3 are subject to change and somewhat dependent on soil and air temperature and occurrence of natural precipitation, which drive the timing of each growing season.

Qualitative evaluations, using photo documentation, will be completed in conjunction with quantitative sampling events described above. Qualitative sampling will occur at the same locations of the randomly selected sampling points. GPS coordinates will be used to relocate photo points each year. The photos will serve to provide visual indication of the progress of plant community development.

For seedling density evaluation, CNHP will use a 0.5 square meter plot frame to assess and report seedling density (see Technical Memo 1, Seedling Density Sampling). For the separate cover evaluations, CNHP will use the same point-intercept protocol as the pre-disturbance survey (see Technical Memo 1, Cover Sampling Methods). A summary memorandum will be prepared with photographs to document the site conditions, findings, and percent cover established after each evaluation. For progress evaluations during the first growing season, three (3) transects from each soil type identified in the pre-disturbance report will be conducted within each work package. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described below will be implemented.

Milestones of specific interest for all Pueblo County pipeline work packages include:

- Initial application of irrigation water
- Successful germination and seedling stand establishment
- Revegetation reaches 70 percent of pre-existing cover
- Revegetation reaches 90 percent of pre-existing cover

As mentioned above, dates will vary by work package and irrigation schedule with the start of irrigation being driven by soil and air temperature. SDS staff will coordinate with Pueblo County representatives during assessment of achievement of 70 percent pre-existing cover. Under the CDPHE construction stormwater permit program, the revegetation contractor(s) can be released from their construction stormwater permit once this percent of pre-existing cover has been reached.

### **Sustainable Growth**

The seedling density data from the first growing season will be used as evidence of sustainable growth of the established community, as will cover and species diversity data from the second growing season. Pursuant to third party (CNHP) recommendations and contract specifications, the target to ensure sustainable growth will be the presence of an average of at least four seedlings per square foot of planted or otherwise desirable perennial species. At this density, the likelihood of continued development toward a mature shortgrass prairie vegetation cover is high. The progression of that target to a mature prairie grassland assumes management by landowners is not deleterious to long-term health of the plant community. The early presence of an adequate number of plants per square foot is the best available basis for predicting sustainability.

### **Final Cover Evaluations**

To document re-establishment of cover across each work package, trained ecologists will randomly locate sample points within separate soil types utilizing the random point generating tool in the ESRI ArcMap GIS software application. CNHP will use the same point-intercept sampling protocol as the pre-disturbance surveys and will prepare a summary memorandum with photographs, tables, and calculations to document site conditions and findings concerning percent vegetation cover established.

To make this determination, CNHP will complete a minimum of 10 sample transects in work package/soil units that cumulatively comprise a small area (a length of one mile or less), and fifteen (15) transects in each soil unit that cumulatively comprise a larger area (greater than one mile in length). The completion of sampling in each work package/soil type identified during the pre-disturbance surveys will provide Pueblo County adequate data to determine whether the 90 percent of pre-existing cover standard has been met. Pueblo County and the U.S. Bureau of Reclamation will be invited to participate in these evaluations. Other stakeholder representatives (e.g. land owners or agencies) may be notified of these evaluations and Pueblo County provided the opportunity to review and accept the report(s) and will eventually be required to certify compliance with the terms and conditions of the 1041 Permit. Details of the post-construction evaluation procedure are provided in Technical Memo 3.

Following receipt and acceptance of the Final Cover Evaluations document, Pueblo County representatives will provide SDS with a letter concurring with SDS's written request to close out 1041 Construction Conditions. A separate request will be submitted for each specific pipeline work package segment (S1, S2 or S3).

### **Species Diversity**

Species diversity will be determined from simple counts of species present by plant-life form as obtained from the sampling data.

# Technical Memo 1

## *Sampling Procedure for Point Intercept Cover and Seedling Density Data Collection*

*The following procedure establishes baseline levels of plant cover in areas affected by the Southern Delivery System Project and will be used to determine seedling density following revegetation.*

Within an area that was disturbed, vegetation will be quantitatively sampled as described below to establish:

- 1) The percent cover by species as well as total vegetation cover and
- 2) Species richness

These data will provide a basis for assessment of the percent of vegetation cover re-established in post-revegetation evaluations.

### **Vegetation Unit Identification**

As vegetation varies along the length of the proposed area of disturbance, variations in plant community at the "alliance" level of the US National Vegetation Classification system (FGDC 2008) will be documented. Association and alliance level classification is based on the premise that a vegetation type represents a group of stands that have similar plant composition and physiognomy enabling their recognition. Should such significant soil variation as might substantially affect plant cover growth potential be encountered within a single alliance in a particular reach, these will be subdivided and the number of sample measurements adjusted accordingly.

This mapping methodology addresses both the need to document natural variation in the pre-existing vegetation and the need to set plant cover standard levels consistent with the varying potentials of varying environments.

### **Sample Location**

Samples will be placed in locations representative of the general vegetation type and condition.

### **Cover Sampling Methods**

At each sample site, cover data will be collected using a point-intercept method in which data are tabulated as interceptions of a projected point with plant species, bare ground, litter, standing dead vegetation, or rock. The cover sampling points will be optically projected using a Cover-Point Optical Point Projection Device. Sampling will occur along 50 meter transects. At each meter from one to fifty along the transect, a point will be vertically projected from a location 50 centimeters (cm) to the left of the transect and a point will be vertically projected from a location 50 cm to the right of the transect (avoiding harm to vegetation along the tape itself). Thus, data from a total of 2 x 50, or 100 points will be recorded. Plant interceptions will be tallied by species upon interception of the projected point with any attached plant part produced during the current growing season. "First hit" data (the first interception of any of the

materials listed below) will be recorded. In addition to this, "additional hit" data (any additional live species intercepted between the first hit and the ground) will also be collected.

- Litter will be considered to be any organic material that had fallen, or had begun to fall to the soil surface.
- Standing dead vegetation will be any dead plant material that was produced in previous years but which was still standing and had not lodged or broken off to become litter.
- Rock will be considered to be any inorganic fragment with the largest diameter greater than or equal to 1 cm.
- Bare soil will be considered to be inorganic fragments with a diameter less than 1 cm largest diameter or organic debris too small to be of readily identifiable origin.

First hit interceptions will be used to calculate absolute top layer (first hit) foliar cover by dividing the number of interceptions for a particular species or material by the total number of points taken (100). First hit relative vegetation cover will be calculated by dividing first hit absolute cover for each species by the total first hit vegetation cover. All-layer absolute cover will be calculated by dividing all hits for particular species by the total number of points taken (100). In addition, all-layer relative cover will be calculated using all hits for particular species divided by the total vegetation hits accumulated during sampling of the transect.

### **Seedling Density Sampling (Post-Revegetation Analyses)**

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meters (5.37 square feet) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

### **References**

FGDC. 2008. Vegetation Classification Standard, Version 2. Federal Geographic Data Committee, Vegetation Subcommittee. FGDC Secretariat, U.S. Geological Survey. Reston, VA. FGDC-STD-005-2008 (Version 2). 62p. plus Appendices.



## Technical Memo 2

### *Pre-construction Survey*

This Technical Memo describes the general conditions and methodology CNHP used to sample and assess pre-construction vegetation cover and describes the results.

#### **Measurements of Pre-existing Vegetation Cover in Pueblo County**

As per a pre-established Protocol (attached Technical Memo 1) pre-existing vegetation cover was measured along the planned alignment of the SDS raw water pipeline in Pueblo County, Colorado. Quantitative sampling was conducted at intervals along the alignment to document percent cover by live plants. All observations took place between October 5, 2011 and October 21, 2011. Locations of quantitative samples are indicated on Maps S1-1 and 2, S2-1 through 4 and S3-1 through 4 (see attached).

The study area is in the valley of the Arkansas River downstream (east) from its emergence from the mountain front. Along some reaches of the pipeline route, exposed shale and limestone are the predominant soil parent materials, while on other reaches recent alluvium predominates and on high terrace sites older deposits of Arkansas River alluvium in the form of sands and gravels predominate.

#### **2010-2011 Drought**

The study area receives on average about 12.5 inches of precipitation per year. During the 12 months prior to the observations reported here, precipitation in the subject area was less than 50 percent of the long term average (Western Regional Climate Center 2012).

#### **Other Environmental Effects on Vegetation**

There are two particularly important variables that locally affect the magnitude of live vegetation cover. These are soils and the presence of prairie dogs. The soil/geologic conditions with the least potential production of vegetation are likely those that are shallow (less than one foot) over limestone and shale bedrock in the south portion of the Pueblo County portion of the SDS pipeline (i.e. S1 and the southern portion of S2). Soils possessed of these characteristics include the Penrose, Manvel and Minnequa series. Soils of recent very fine grained and salt-rich alluvia along active drainages are of the Limon and Heldt series. Heavy clay texture, high salt content and frequent overbank flood disturbance are factors that affect vegetation growth on these soils. Haverson soils also developed on comparatively recent alluvium but are of more moderate texture and are much less salt-affected.

In the central and northern portions of S3, soils developed from shale are prevalent. On some areas (Midway- Shale complex), erosional removal of weathered material is sufficiently active that soils are shallow and poorly developed. On some other areas deeply weathered shale has remained in place and moderately deep soils with clay-rich texture and gypsum accumulations in the subsoil prevail (Razor series). In the far north portion of S3 are limited areas of early Pleistocene age alluvium with deep well-developed soils of moderate texture in the Stoneham series. These soils support the most well-developed vegetation growth of any upland areas included along the SDS in Pueblo County.

Recent history of grazing use of these areas can substantially limit the extent of vegetation cover in addition to drought and soil limitations. Especially in the S1 portion of the SDS alignment, very heavy grazing by prairie dogs (*Cynomys ludovicianus*) has strongly limited, and to a large degree destroyed, herbaceous perennial vegetation cover. In combination with soil limitations and drought the percent of the ground covered by perennial herbaceous vegetation in these areas is in the low single digits and much of what exists is fourwing saltbush (*Atriplex canescens*) that prairie dogs avoid. Historical season-long grazing of vegetation by livestock in the S3 portion of the route has also strongly limited the extent of vegetation cover.

Observance during pre-disturbance evaluations identified some sampled areas in Soil Groups A and B below that had experienced prior land use which degraded, and in some areas eliminated, vegetation cover. In these areas, what remained was deemed un-representative of healthy vegetation and cover and values from these areas were not included when CNHP developed the quantitative pre-existing percent cover base levels reported in 2011. Therefore, base values are biased high, representing healthy cover in those areas where over-grazing or previous land development/disturbance was observed.

### **Base Values for Evaluation of Revegetation Success**

The following are suggested base vegetation cover values (to be multiplied by 0.9 in accordance with 1041 permit requirements for 90 percent revegetation). They are to apply to the listed soils wherever they occur (in S1, S2 and S3). For work on the Federal land associated with connection of the SDS project to the Pueblo Dam North Outlet Works (PDC1A and PDC1B), Juniper Pump Station (JPS) and the portion of S1 on Federal land, the base cover values will also be multiplied by 0.9 in accordance with governing documents and bonds for this work.

The various soils of the Pueblo County portion of the SDS pipeline have been grouped by functional similarity into the following Soil Groups. These Groups are judged to be similar in their revegetation potential. The distribution of these units is indicated on Maps S1-1 and -2, S2-1, -2, and -3, and S3-1, -2, -3, and -4. All tables referenced are in the 2011 pre-disturbance survey report.

**A. Soils Shallow over Shale and Limestone** (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **17.2 percent**

**B. Soils on Clay-rich, Salt-affected Alluvial Material** (Limon and Heldt series; Tables 1, 5, and 11): **26.5 percent**

**C. Soils Deep on Early Pleistocene Alluvium** (Stoneham and Cascajo series; Tables 10 and 15): **35.0 percent**

**D. Soils on Weathered Shale (with active erosional removal)** (Midway – Shale complex; Shingle series; Tables 9 and 13): **17.0 percent**

**E. Soils on Deeply Weathered Shale** (without active erosional removal) (Razor series; Table 14): **23.3 percent**

**F. Soils on Recent Alluvium of Moderate Texture and Salt Content** (Haverson series and Ustic Torrifluvents; Table 6 and 16): **47.0 percent**

## LITERATURE CITED

Western Regional Climate Center. 2012. <http://www.wrcc.dri.edu/cgi-bin/cliMAIN.pl?co6765>

### **Pre Construction Cover Survey Maps for Work Packages S1, S2, and S3**

The attached maps depict the locations of the preconstruction cover survey transects completed on work segments S1, S2, and S3. The maps are oriented with north at the top and are organized from south to north, starting at the connection point of S1 with Pueblo Dam and ending at the northern end of S3 at the El Paso County line. Each map depicts the location of the survey transects and the various functional soil groups within the pipeline alignment overlain on aerial photography of the surrounding landscape.

## **Technical Memo 3**

### *Post-Revegetation Sampling*

This Technical Memo describes the design and methodology CNHP will use to sample and assess post-disturbance revegetation success.

#### **Creditable Vegetation Cover**

Cover provided by plants included in the Colorado A-, B-, or C-list of noxious plant species, if any, will not be acceptable in the evaluation of cover. Cover by all other plants will be acceptable in assessment of adequate revegetation cover, except as follows: cover by non-native annual / biennial plants in excess of half of the vegetation cover measured (i.e., any amount over 50 percent relative cover) will not be counted toward establishment of proof of successful revegetation.

#### **Sampling Design**

##### ***Cover Sampling Method***

Sampling to assess compliance with the standard of 90 percent of pre-existing cover will proceed separately within each work package (S1, S2 and S3) and separately within each soil functional group as identified during the pre-construction vegetation survey (see Technical Memo 2). All sample locations will be randomly located by delineating the soil functional groups in each work package in ESRI ArcMap GIS application and using the random point generation tool to place the correct number of random points in that area.

For sample units with a total (cumulative) length of one mile or less, ten (10) segments of equal length will be established and a randomly located and oriented sample placed in each. For units greater than one mile in cumulative length, fifteen (15) segments of equal length will be identified and a sample randomly located within each. Sample points will be located in the field using hand-held GPS units with coordinates of the random points pre-loaded.

Orientation of the 50-meter transect will be randomly selected by using a random number ranging from 1 to 360 as an azimuth. Sampling transects will not extend outside the Permanent Easement (PE), Temporary Construction Easement (TCE) or work limits areas. Should a boundary be encountered, a new orientation that remains within these limits will be chosen in the same manner. Ineligible sites (see below) will be excluded from sampling.

Sampling to assess compliance with the CDPHE criterion of 70 percent of pre-existing cover will proceed within separate work packages and soil reaches. However, when the 70 percent cover standard alone is being assessed, the sample intensity will be five (5) samples in reaches of one mile or less in cumulative length and eight (8) samples in those greater than one mile in cumulative length.

##### ***Informational Cover Composition Sampling Method***

Data on species composition will be collected for informational purposes outside the scope of the 1041 permit requirements. Ten (10) 1 x1 meter plots will be placed at 5-meter intervals along the right side of the cover sampling transect (as viewed from the origin) beginning at the

5-meter mark. Within each of the resulting ten (10) plots the presence of desirable species will be noted by species. For this purpose, desirable species will mean any seeded species plus any other native annual, biennial, or perennial species plus any non-native perennial species. Native will mean species noted as native in and occurring in the Southeast ¼ of Colorado in Biota of North America Project distribution mapping. The resulting frequency data will be tabulated by species. For example, if Species A is noted as present in 7 of the 10 plots it will have a frequency value of 70 percent.

Frequency values from all transects within a given soil group will then be averaged. For these evaluations, average frequency values by species will be used as follows: The average frequencies of all acceptable species will be summed. A sum for all desirable species present that equals or exceeds 200 percent will be deemed adequate evidence of successful establishment of acceptable species. This supplemental criterion addresses the reality that vegetation at the time of evaluation will still be juvenile. Many planted or otherwise desirable species grow slowly and though they may be only a small percentage of the total plant cover at the time of measurement, will eventually become more abundant. This frequency evaluation allows documentation of the presence of the desirable species sought in the long term vegetation cover.

### ***Seedling Density***

Seedlings of seeded or perennial plant species will be counted within randomly placed 0.5 square meter (5.37 square foot) circular plots. The results will be averaged and divided by 5.37 to obtain number of seedlings per square foot.

Plots will be thirty per Work Package/Soil Group area. All sample points will be randomly located via GIS-generated coordinates.

### ***Sites Ineligible for Sampling***

Areas within the revegetation zone in which the vegetation cover has been negatively affected by land management of private owners after SDS construction or for which a waiver has been executed/granted will be excluded from the sample universe (i.e., no samples will be placed in these areas). Within the disturbed alignment no sampling will occur on access roads, trails, above-ground SDS infrastructure, other above-ground public or private infrastructure, waterways, or other areas where sampling is determined not to be practical, safe or meaningful. Such areas will be manually delineated in the GIS and excluded from the eligible sampling area when creating the random point coverage.

### ***Sampling Schedule***

During the first growing season following seeding, seedling density data will be collected. At the end of the first growing season (typically September) cover data will be collected for the purpose of assessing compliance with the CDPHE Stormwater Permit criterion of 70 percent of pre-existing cover. If in the judgment of the SDS Program, the extent of vegetation cover at that time might also satisfy the 90 percent of pre-existing cover criterion, the full sampling design described above will be implemented. If only the CDPHE criterion is being tested, sample intensity within a work package will be five samples in soil reaches one mile or less in cumulative length and eight in those greater than one mile in cumulative length. During the second growing

season, sampling intensity will be ten (10) samples in soil reaches one mile or less in cumulative length and fifteen (15) samples in those greater than one mile in cumulative length.

### **Hypothesis Testing**

Statistical evaluation of the success of revegetation for each soil functional group within a work package will be tested via a one-sample t-test of the following null hypothesis:

The (traditional) null hypothesis being tested would be that the revegetated area mean ( $\mu$ ) is indistinguishable from 90 percent of the pre-existing cover, stated as  $H_0: \mu = Q$ . If  $t_c$  is less than or equal to the 1-tailed t-table value for alpha error probability of 0.05, at (n-1) degrees of freedom, then  $H_0$  is accepted, and revegetation is deemed successful (i.e., indistinguishable from 90 percent of the standard).

The sample data will be evaluated for normality and transformed if appropriate. The formula for the one sample t-test is:

$$t_c = \frac{Q - \bar{x}}{S_{\bar{x}}}$$

- Where:  $\bar{x}$  = Revegetated Area Sample Mean  
Q = 90 percent of pre-existing cover  
 $S_{\bar{x}}$  = Standard error of mean [ $s/\sqrt{n}$ ]  
S = Sample standard deviation  
n = Sample size  
 $t_c$  = Calculated t-value  
 $t_t$  = Table t-value (alpha = 0.05)

### **Photographic Documentation**

Photo documentation will be conducted during the growing seasons and in conjunction with the point-intercept cover sampling. Photos will be taken at each transect location during all sampling. Photo points will be relocated using a handheld GPS receiver.