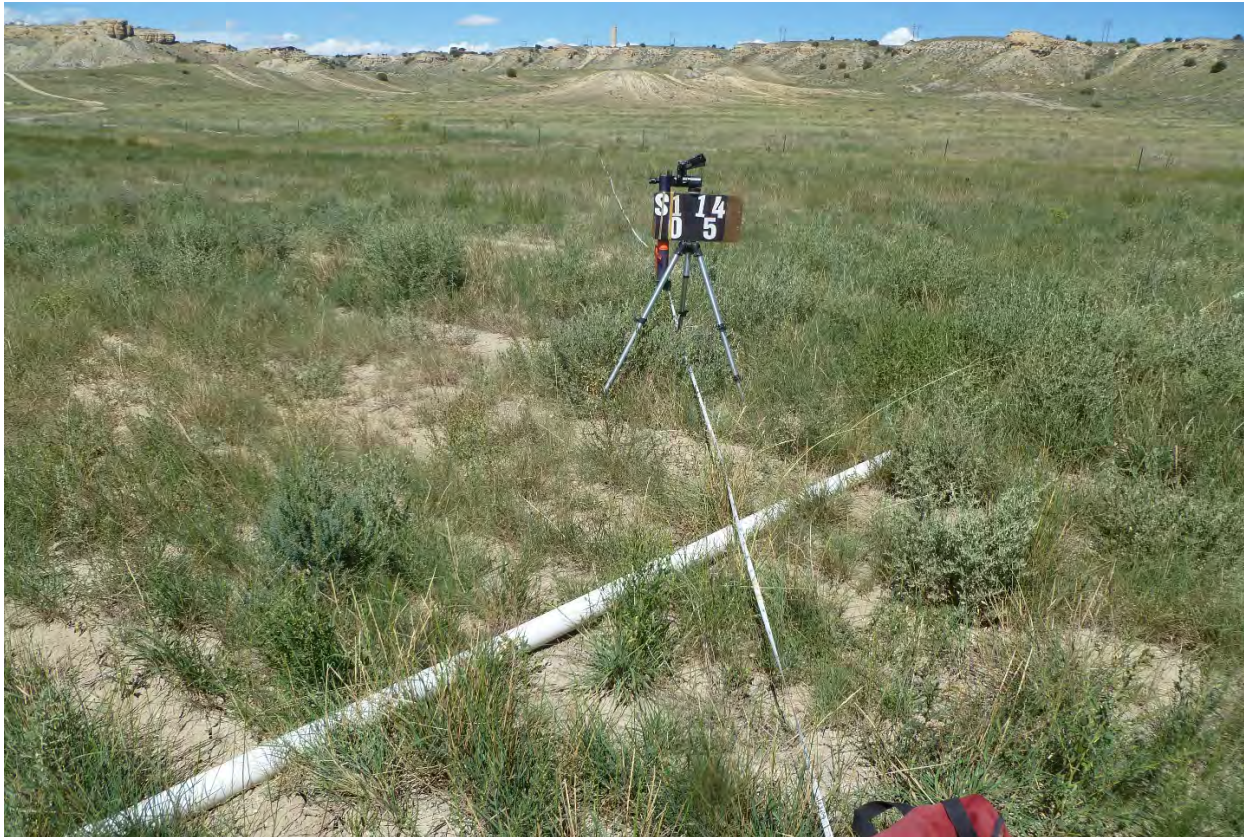


Colorado Springs Utilities Southern Delivery System

Restored Vegetation Cover Monitoring – Work Segment S1



Prepared for:

**Colorado Springs Utilities
Southern Delivery System
Colorado Springs, CO
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Cover Photo: Sample site 5 on Soil Group D (Midway – Shale complex, Shingle series) in work package S1 (by ESCO Assoc. Inc.)



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Executive Summary

The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed post-construction monitoring of restored vegetation along the Colorado Springs Utilities' Southern Delivery System (SDS) pipeline. Construction of the S1 segment of the pipeline route was completed in 2013 and the disturbed areas were re-graded to pre-construction contours, seeded, and planting completed by May 24, 2013.

Assessment of Vegetative Cover and the frequency of Acceptable Species in revegetated and irrigated areas along the SDS Pipeline in Pueblo County was completed in late August and early September 2014 as per the Protocol developed for the project. Prior to this assessment, the density of seedlings (July 2013) and revegetation cover (late September 2013) had been assessed along these same reaches of revegetated right-of-way and were reported separately.

Beginning with the pre-construction vegetation surveys, results of sampling in this work package have been grouped by soil series with similar potential for plant growth and revegetation suitability. The average revegetated cover of acceptable species was calculated for each soil group and compared to the 90% standards. The area weighted average of the revegetated cover values from the different soil groups within a work segment was also calculated to determine if the performance standards for the work segment as a whole were met. The weighted average was calculated using the proportion of area each soil group occupied within the work segment.

In all soil groups, post-construction vegetation cover exceeded the 90% revegetation performance standards (see Table below). As an area weighted average, revegetation cover within the S1 work segment is 38.5% and exceeded the 90% performance standard (15.8%) by 22.7%.

Table 1: Vegetation Cover by Soil Group for S1

Map Code	Soil Group	% of Work Unit	% Base Veg. Cover	90% Revegetation Cover Perf. Std. (0.9 x Base)	%Cover by Acc. Spp
A	Soils shallow over shale and limestone (Penrose, Manvel and Minnequa series)	88.8	17.2	15.5	38.6
B	Soils on clay-rich, salt-affected alluvial material (Limon and Heldt Series)	3.8	26.5	23.9	41.8
D	Soils on Weathered Shales (with active erosional removal) (Midway – shale complex; Shingle series)	7.4	17.0	15.3	36.0
All Soil Groups Weighted Average		100%	17.5	15.8	38.5

In conformance with the provisions of the Protocol, the goal of the frequency assessment was to determine the average presence of at least two acceptable species per square meter (i.e. an average frequency of acceptable species of at least 200%). Results in the table below show that for all soil groups in the work package, the average presence of acceptable species

exceeded two per square meter.

Table 2. Average Frequency of Acceptable Species by Soil Group for S1

Work Package	Soil Group	Cumulative Frequency Percentage	Average No. of Acceptable Species per Square Meter
S1	A	290	2.9
	B	310	3.1
	D	330	3.3
Work Package Weighted Average		294	2.9

The results of revegetation monitoring on S1 support the conclusion that the restored vegetation exceeds the 90% performance standard and that the currently observable positive revegetation trends will continue. That the cover by acceptable species after two growing seasons is over 60% greater than pre-existing cover suggests that, barring unforeseen events, the re-established vegetation will be persistent for years to come.

Introduction

The Colorado Natural Heritage Program, in cooperation with ESCO Associates, completed post-construction monitoring of restored vegetation along the Colorado Springs Utilities' Southern Delivery System (SDS) pipeline. This report documents the vegetation cover established after the second growing season within the S1 segment of the SDS pipeline route in Pueblo County.

The report compares the restored vegetation cover values to the revegetation standards prescribed by the Pueblo County 1041 permit in order to evaluate revegetation success within this work segment. It also reports frequency-based quantitative measures of the presence of acceptable species in comparison to a pre-determined standard.

The following sections include the methods used, the results, and a discussion of factors affecting revegetation cover on the sites. Maps, tabular data, and photographs of work segment S1 are contained in separate Appendices A, B, and C, respectively. Appendix D includes applicable portions of the Pueblo County Revegetation Cover Establishment Protocols (Protocols).

The study area is in a tributary valley of the Arkansas River downstream (east) from its emergence from the mountain front. Construction on the S1 segment of the pipeline route was completed in early 2013 and the disturbed areas were re-graded to pre-construction contours, seeded, and replanted by May 24, 2013.

Methods

Assessment of Vegetative Cover and the Presence of Acceptable Species in revegetated and irrigated areas along the SDS Pipeline in Pueblo County was completed in late August and early September 2014 as per the Protocol developed for the project. Prior to this assessment, the density of seedlings (July 2013) and revegetation cover (late September 2013) were assessed along these same reaches of revegetated right-of-way. The July assessment provided an early look into revegetation results, whereas the September 2013 effort included evaluation of two different parameters that were applicable to vegetation somewhat more mature than in July 2013. The results of those assessments are provided in CNHP 2013a and CNHP 2013b.

As set forth in the Revegetation Protocol, the primary parameter assessed is percent vegetative cover by acceptable species. This measure relates to the Pueblo County 1041 permit requirement that cover on revegetated areas comprise at least 90% of pre-existing levels. Pre-existing levels of cover on the Pueblo County work package reaches were established by quantitative sampling prior to the start of construction in October 2011. Further details on the pre-construction sampling effort can be found in CNHP 2011.

Beyond the return of adequate plant cover (detailed in the Protocol document), measures of the presence of Acceptable Species in the reconstructed vegetation were also made as per provisions in the protocol. Acceptable species had been determined in consultation with the Pueblo County vegetation representative to include all native species and all introduced perennial species other than those included on the current State of Colorado A, B or C-lists of noxious species.

The distribution of acceptable species was assessed using frequency plots. Along each 50 meter cover transect, ten 1 meter by 1 meter plots were placed at 5 meter intervals along the right side of the transect as viewed from the origin. Within each plot the presence of all acceptable species (as per the Protocol) was tallied. Further details on the pre-construction sampling effort can be found in CNHP 2011.

Beginning with the pre-construction vegetation surveys, results of sampling in this, and other work packages, have been grouped by broad soil types. These groups, established to simplify the process, include soil series of similar nature as plant growth media. Within each soil type, sample transects (See Protocol Technical Memos 1 and 3, Appendix D) were placed at random locations in an effort to capture the variability of vegetative cover present. At each representative sample location, vegetation cover and ground cover were measured via observation at 100 locations spaced at 1 meter intervals along the transect length. Maps showing the extent of the soil groups present within the alignment of the work package and the location of sample transect origin points are included in Appendix A.

The average revegetated cover of acceptable species was calculated for each soil group and compared to the 90% standard. The area weighted average of the revegetated cover values from the different soil groups within a work segment was also calculated to determine if the performance standards for the work segment as a whole were met. The area weighted average was calculated using the proportion of distance each soil group occupied within the work segment.

Results

A total of 37 transects were sampled in the work package S1 area during the post-construction survey. The various soils across the extent of the work package were grouped for simplicity into three units that differed in their nature as plant growth media and as to the means by which it will be necessary to salvage and replace them during construction. The three groups are as follows:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Table 1, Appendix B). Represents 88.8% of Work Segment.

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Table 2, Appendix B). Represents 3.8% of Work Segment.

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series; Table 3, Appendix B). Represents 7.4% of Work Segment.

The distribution of these Soil Groups is indicated on the maps of S1 included in Appendix A.

Plant cover observed from pre-construction sampling within the above soil groups established the base values from which revegetation performance standards were calculated.

Base Cover Values for Evaluation of Revegetation Success

The following are the base vegetation cover values measured prior to construction. Multiplying these base values by 0.9 determines the revegetation standard in accordance with the Pueblo County 1041 protocol.

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series): **17.2%**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series): **26.5%** (Note that this represents the level found on Limon soils in ungrazed S1)

D. Soils on Weathered Shales (with active erosional removal) (Midway – Shale complex, Shingle series): **17.0%**.

Post Construction Results

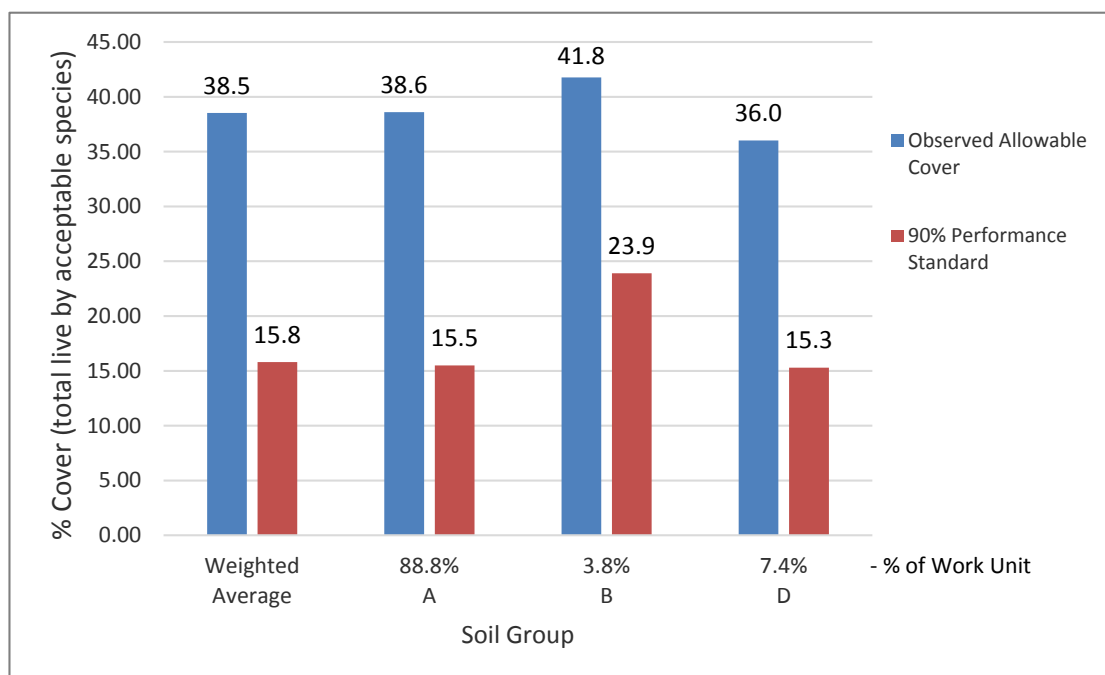
A total of 37 transects were sampled in work segment S1 during the 2014 post-construction revegetation survey. In all soil groups, revegetation cover by acceptable species exceeded the 90% revegetation performance standards. As an area weighted average, vegetation cover within the S1 work segment is 38.5% and exceeded the 90% performance standard (15.8%) by 22.7%.

Table 1 (below) displays the base vegetation cover, revegetation cover values at the 90% level established under Pueblo Co. 1041 permit and the post-construction percent cover values for the respective soil groups. Figure 1 graphically represents this information.

Table 1: Vegetation Cover by Soil Group for S1

Map Code	Soil Group	% of Work Unit	% Base Veg. Cover	90% Revegetation Cover Perf. Std. (0.9 x Base)	%Cover by Acc. Spp
A	Soils shallow over shale and limestone (Penrose, Manvel and Minnequa series)	88.8	17.2	15.5	38.6
B	Soils on clay-rich, salt-affected alluvial material (Limon and Heldt Series)	3.8	26.5	23.9	41.8
D	Soils on Weathered Shales (with active erosional removal) (Midway – shale complex; Shingle series)	7.4	17.0	15.3	36.0
All Soil Groups Weighted Average		100%	17.5	15.8	38.5

Figure 1. SDS Work Segment S1 Restoration Cover Values vs. Restoration Standards



In conformance with the provisions of the Protocol, the goal of the frequency assessment was to determine the average presence of at least two acceptable species per square meter (i.e. an average frequency of acceptable species of at least 200%). Results in Table 2 below show that for all soil groups in the work package, the average presence of acceptable species well exceeded two per square meter (200% cumulative frequency).

Table 2. Average Frequency of Acceptable Species by Soil Group for S1

Work Package	Soil Group	Cumulative Frequency Percentage	Average No. of Acceptable Species per Square Meter
S1	A	290	2.9
	B	310	3.1
	D	330	3.3
Work Package Weighted Average		294	2.9

Discussion

Post-Construction Revegetation Performance

Beginning with seedling density and early revegetation data (2013), cover measurements from S1 had consistently shown good results and a positive trend over time. Seedling density measurements completed in July of 2013 indicated all areas of S1 surpassed the criterion of 2 acceptable species per square meter in the developing revegetation (CNHP 2013a). Revegetation cover measurements made at the end of the first growing season (September 2013) indicated that revegetation cover on all soil groups exceeded the 90% performance standard (CNHP 2013b) at that time. The 2014 revegetation cover results presented in this report confirm that trend and indicate that work segment S1 exceeds the 90% revegetation cover standard required under the

Pueblo County 1041 permit.

The presence of an average of approximately three acceptable species per square meter suggests that the young vegetation of the rehabilitated areas is comprised of a diverse mix of native plants and that a monoculture does not exist. With an average of three species present per square meter, it is unlikely that less than two of those will survive over the near-term of several years and relatively certain that the revegetation will continue to mature and will persist into the long-term.

Note that the cover addressed in these assessments does not count any of the locally prominent cover by Russian thistle (*Salsola* spp.) or summer cypress (*Kochia* sp., aka *Bassia* sp.). These two introduced opportunistic plants are very common components of areas that have been disturbed and can be expected to persist for a few years after the disturbance regardless of whether or not re-establishment of desirable perennial plants has been undertaken. In the case of Segment S1, the measured cover by acceptable species alone well exceeds pre-existing cover values, and as those acceptable species mature the cover of Russian thistle and summer cypress will decline.

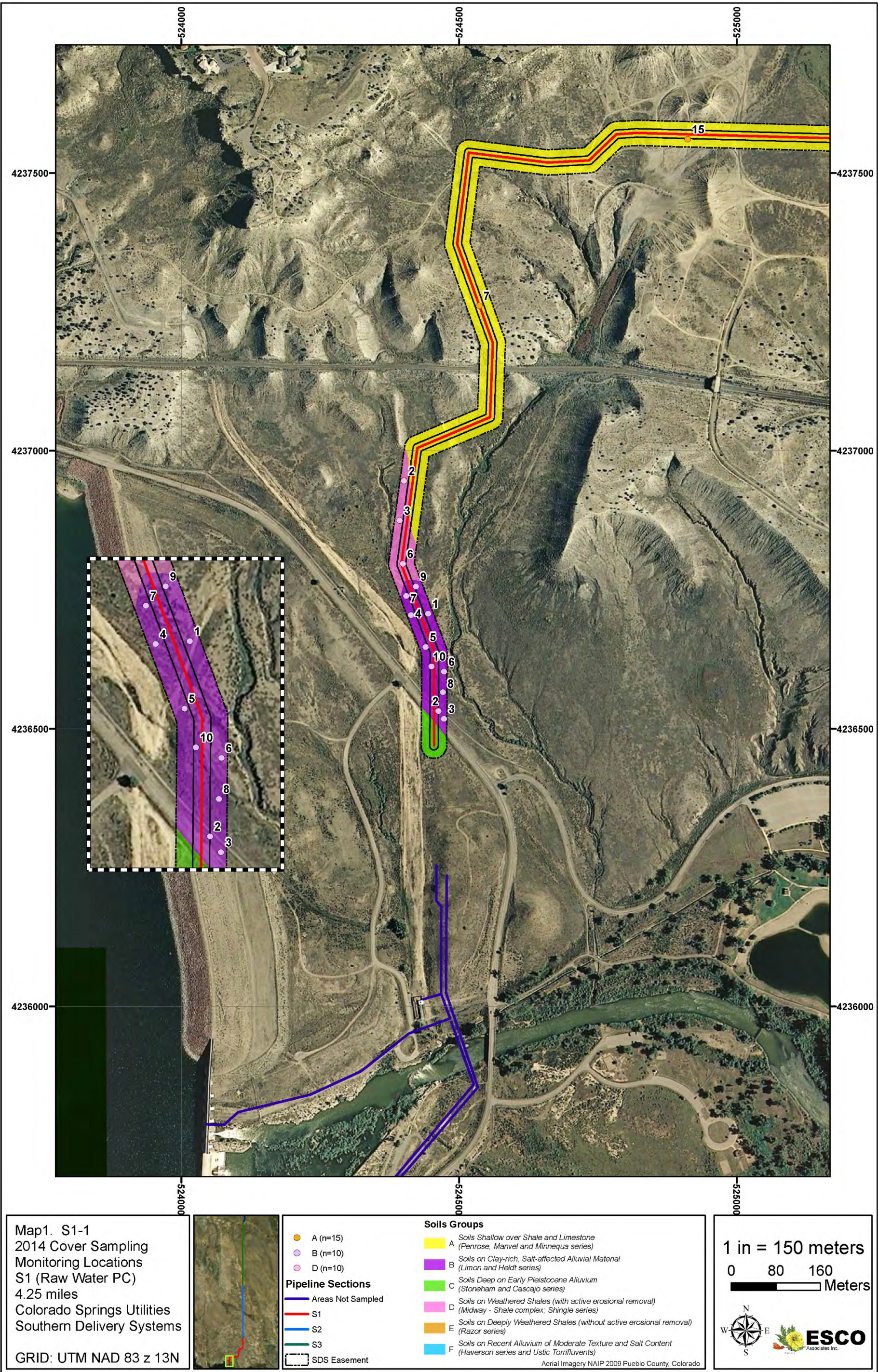
The two-year (two-growing season) performance period in the Pueblo County 1041 permit for work segment S1 commenced on May 24, 2013. From a growing season standpoint, the second season was effectively spring and summer of 2014. Hence the assessment of conditions in late August/early September. Per the Pueblo County 1041 permit the 90% revegetation cover performance standard is required to be achieved by May 24, 2015.

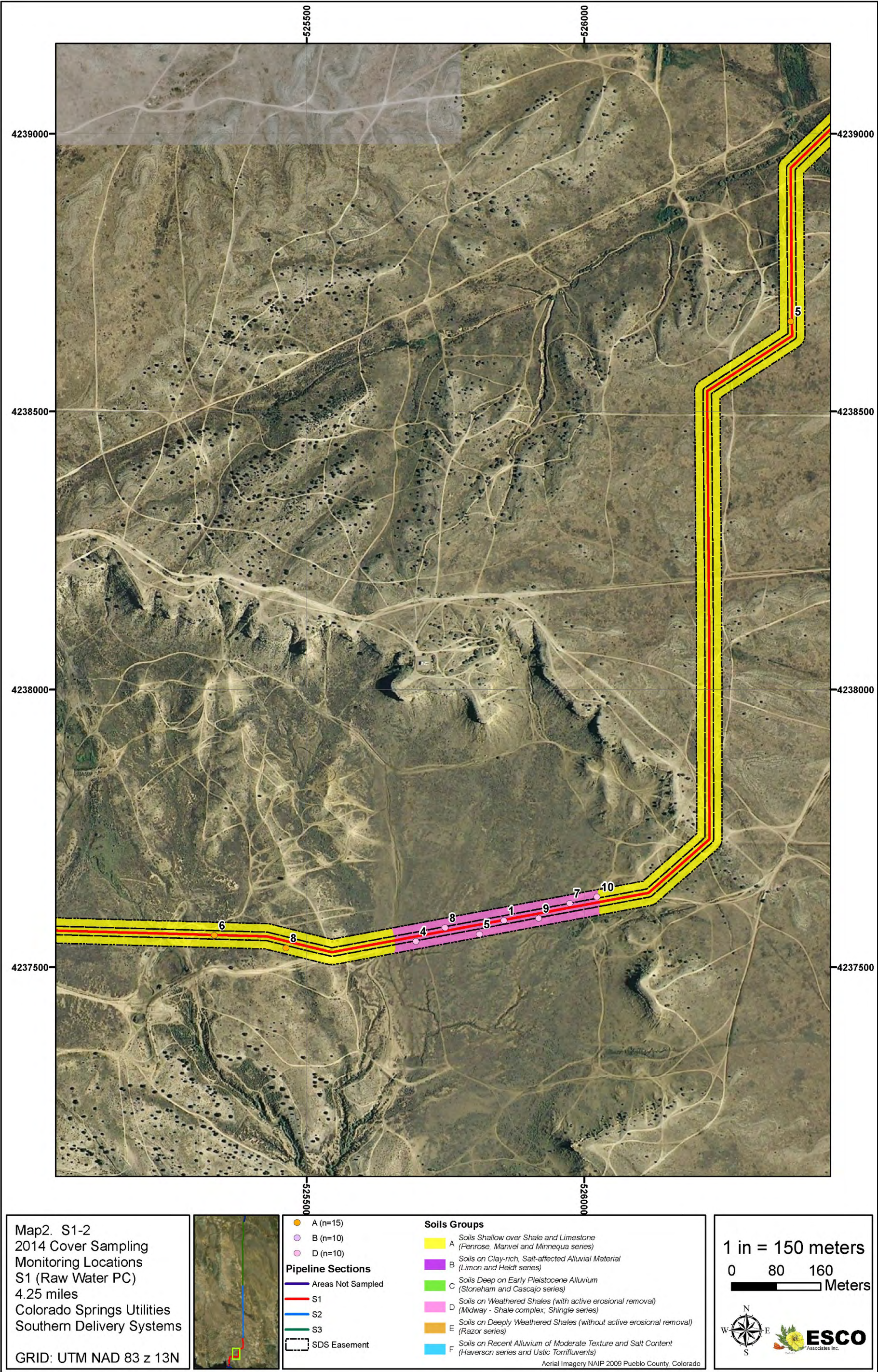
The results of revegetation monitoring on S1 support the conclusion that the restored vegetation currently meets the 90% performance standard and that currently observable positive revegetation trends and conditions will persist.

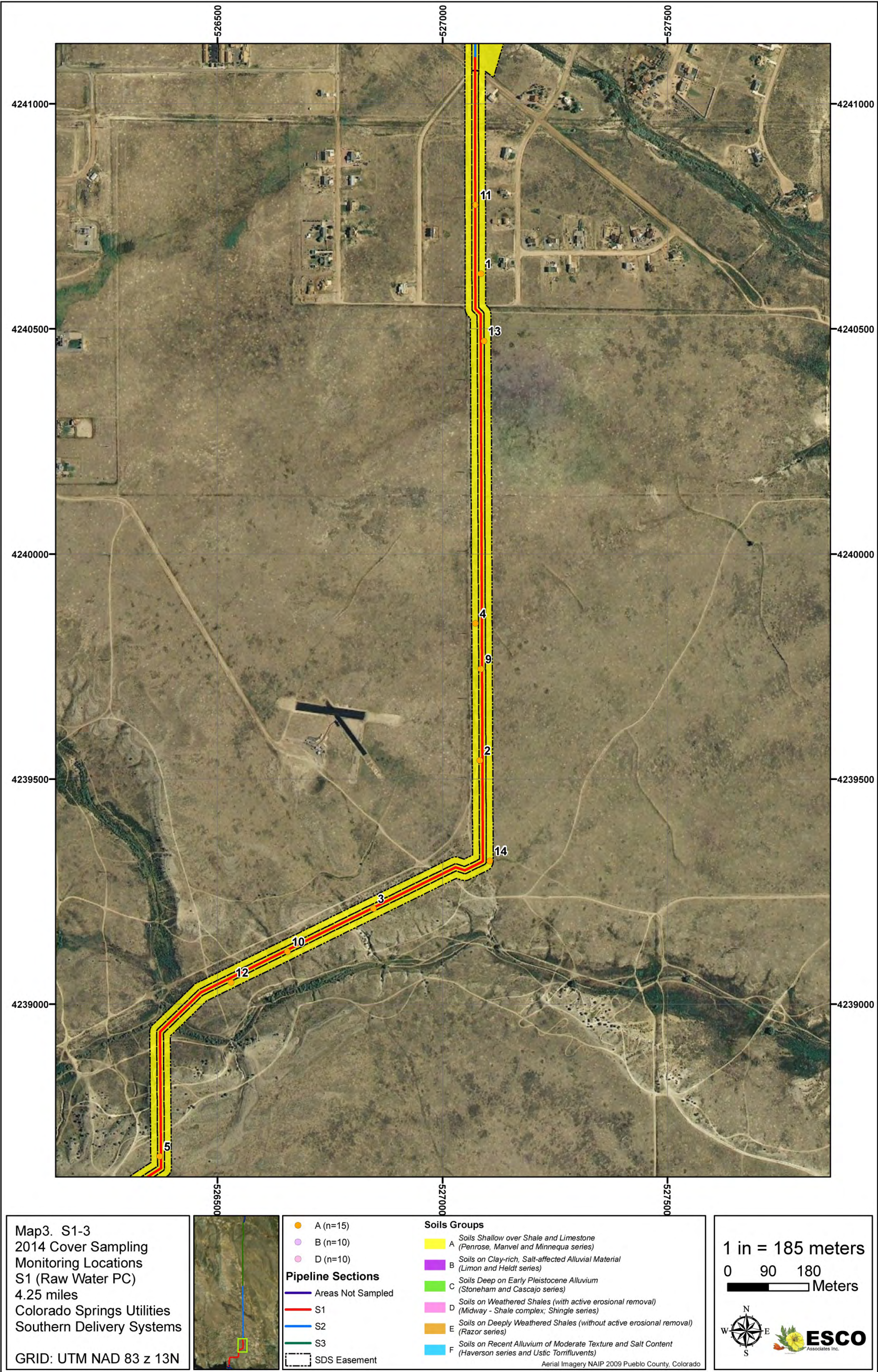
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- CNHP 2011. Colorado Springs Utilities Southern Delivery System: Measurements of Pre-existing Vegetation Cover for Pueblo County Work Packages S1, S2, and S3. Unpublished report prepared for Colorado Springs Utilities by Colorado Natural Heritage Program. November, 2011. 63pp.
- CNHP 2013a. Colorado Springs Utilities Southern Delivery System: Measurements of Post-restoration Seedling Density for Pueblo County Work Package S1. Unpublished report prepared for Colorado Springs Utilities by Colorado Natural Heritage Program. October, 2013. 9pp.
- CNHP 2013b. Colorado Springs Utilities Southern Delivery System: Measurements of Post-restoration Vegetation Cover for Pueblo County Work Package S1. Unpublished report prepared for Colorado Springs Utilities by Colorado Natural Heritage Program. October, 2013. 42pp.

Appendix A: Sampling Maps for Work Segment S1







Appendix B: Tabular Data for Work Segment S1
Table 1. Work Package S1 Cover Data on Penrose, Manvel and Minnequa Series Soils (Soil Group A)

PLANT SPECIES	AVERAGE COVER	FREQUENCY	RELATIVE VEGETATION COVER	AVERAGE COVER-ALL	RELATIVE VEGETATION COVER-ALL	- Sample Number -																
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NATIVE ANNUAL & BIENNIAL FORBS																						
Chamaesyce sp.	0.06	5.88	0.11	0.06	0.11	1																
Conyza canadensis	0.12	29.41	0.23	0.12	0.22	1									P	1	P			P		
Conyza coulteri	0.00	5.88	0.00	0.00	0.00	P																
Erigeron divergens	0.00	17.65	0.00	0.00	0.00	P									P	P						
Gaura parviflora	0.00	5.88	0.00	0.00	0.00	P																
Grindelia squarrosa	0.06	11.76	0.11	0.06	0.11	1										P						
Helianthus annuus	0.00	5.88	0.00	0.00	0.00															P		
Machaeranthera tanacetifolia	0.00	11.76	0.00	0.00	0.00									P						P		
Oenothera villosa	0.00	5.88	0.00	0.00	0.00															P		
Solanum rostratum	0.00	5.88	0.00	0.00	0.00															P		
Suaeda sp.	0.00	11.76	0.00	0.00	0.00						P									P		
TOTAL NATIVE ANN. & BIEN. FORBS	0.2	41.2	0.5	0.2	0.4	3	---	---	---	---	P	---	---	P	P	1	P	---	---	P	---	---
INTRODUCED ANNUAL & BIENNIAL FORBS																						
Bassia sieversiana	5.12	76.47	9.99	5.59	10.34	21(2)	4		3	P	32(4)		4(1)		P	15(1)	1	4	2		1	P
Malva neglecta	0.00	5.88	0.00	0.00	0.00	P																
Salsola australis	8.59	94.12	16.76	9.12	16.87	5(1)	6	3	8(2)	3		19	15(2)	4	2	2	2	33	12	27(4)	5	P
Salsola collina	10.29	70.59	20.09	11.35	21.00		17(3)	10(1)	5	17(1)			7	20	14(1)		34(6)		15(1)	1	14(3)	21(2)
TOTAL INTRO. ANN. & BIEN. FORBS	24.0	100.0	46.8	26.1	48.2	26(3)	27(3)	13(1)	16(2)	20(1)	32(4)	19	26(3)	24	16(1)	17(1)	37(6)	37	29(1)	28(4)	20(3)	21(2)
NATIVE PERENNIAL FORBS																						
Engelmannia peristenia	0.00	5.88	0.00	0.00	0.00										P							
Gaillardia pinnatifida	0.00	5.88	0.00	0.00	0.00					P												
Glandularia bipinnatifida	0.35	47.06	0.69	0.35	0.65	2	1	P	P					P	P	1			2			
Machaeranthera pinnatifida	0.00	17.65	0.00	0.00	0.00	P										P			P			
Quincula lobata	0.00	5.88	0.00	0.00	0.00	P																
Sphaeralcea angustifolia	0.00	5.88	0.00	0.00	0.00											P						
Verbena bracteata	0.00	5.88	0.00	0.00	0.00											P						
TOTAL NATIVE PERENNIAL FORBS	0.4	52.9	0.7	0.4	0.7	2	1	P	P	P	---	---	---	P	P	1	---	---	2	---	---	---
INTRODUCED PERENNIAL FORBS																						
Cirsium arvense	0.00	5.88	0.00	0.00	0.00											P						
Taraxacum officinale	0.00	5.88	0.00	0.00	0.00	P																
TOTAL INTRO. PERENNIAL FORBS	0.0	11.8	0.0	0.0	0.0	P	---	---	---	---	---	---	---	---	---	P	---	---	---	---	---	---
NATIVE PERENNIAL GRASSES (cool)																						
Achnatherum hymenoides	0.00	5.88	0.00	0.00	0.00															P		
Elymus trachycaulus	2.88	94.12	5.63	2.94	5.44	P	3	6	2	4	1	2	16	P	1(1)	P	1		5	5	1	2

	AVERAGE COVER	FREQUENCY	RELATIVE VEGETATION COVER	AVERAGE COVER-ALL	RELATIVE VEGETATION COVER-ALL	- Sample Number -																
PLANT SPECIES	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Pascopyrum smithii	9.00	100.00	17.57	9.53	17.63	10	11	30(1)	3(1)	13(2)	1	6	2	3	11	12(2)	15(1)	5	10(1)	3	7	11(1)
TOTAL NATIVE PERENNIAL GRASSES (c)	11.9	100.0	23.2	12.5	23.1	10	14	36(1)	5(1)	17(2)	2	8	18	3	12(1)	12(2)	16(1)	5	15(1)	8	8	13(1)
NATIVE PERENNIAL GRASSES (warm)																						
Bouteloua curtipendula	0.76	47.06	1.49	0.76	1.41	2				1		9	1		P		P		P	P		
Chondrosum gracile	2.94	94.12	5.74	3.00	5.55	4	2	P	7	2	4	3		2	2	7	3	2	2	2	5	3(1)
Pleuraphis jamesii	1.24	82.35	2.41	1.24	2.29		3	1	4	1	1	P	3	1	1		1		1	2	1	1
Sporobolus airoides	3.76	100.00	7.35	3.82	7.07	16(1)	2	P	6	1	4	5	2	P	3	11	2	4	1	3	2	2
Sporobolus cryptandrus	0.88	29.41	1.72	0.88	1.63				3		3			1	7		1					
TOTAL NATIVE PERENNIAL GRASSES (w)	9.6	100.0	18.7	9.7	18.0	22(1)	7	1	20	5	12	17	6	4	13	18	7	6	4	7	8	6(1)
NATIVE SUBSHRUBS																						
Atriplex confertifolia	0.00	5.88	0.00	0.00	0.00							P										
TOTAL NATIVE SUBSHRUBS	0.0	5.9	0.0	0.0	0.0	---	---	---	---	---	---	P	---	---	---	---	---	---	---	---	---	---
NATIVE SHRUBS																						
Atriplex canescens	5.18	100.00	10.10	5.24	9.68	4	7	5	8	13	1	2	2	7	6(1)	6	3	1	7	P	7	9
Krascheninnikovia lanata	0.00	5.88	0.00	0.00	0.00								P									
TOTAL NATIVE SHRUBS	5.2	100.0	10.1	5.2	9.7	4	7	5	8	13	1	2	2	7	6(1)	6	3	1	7	P	7	9
Standing dead	0.94	52.94		0.94				2	2	1				2	2	4	1		1			1
Litter	17.41	100.00		17.41		18	24	12	36	13	17	11	13	27	23	25	23	11	8	7	6	22
Bare soil	24.06	100.00		24.06		14	12	10	13	17	33	30	35	32	20	15	13	33	31	44	38	19
Rock	6.35	82.35		6.35		1	8	21		14	3	13		1	8	1		7	3	6	13	9
TOTALS	100.0			102.8		100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	51.2 (s=7.4)		100.0	54.1 (s=8.4)	100.0	67(4)	56(3)	55(2)	49(3)	55(3)	47(4)	46	52(3)	38	47(3)	55(3)	63(7)	49	57(2)	43(4)	43(3)	49(4)
GROUND COVER (Litter+Rock+Veg+St.Dead)	75.9			78.8		86(4)	88(3)	90(2)	87(3)	83(3)	67(4)	70	65(3)	68	80(3)	85(3)	87(7)	67	69(2)	56(4)	62(3)	81(4)

Table 2. Work Package S1 Cover Data on Limon and Heldt Series (Soil Group B)

PLANT SPECIES	AVERAGE		RELATIVE	AVERAGE	RELATIVE	- Sample Number -									
	COVER	FREQUENCY	VEGETATION	COVER-ALL	VEGETATION	1	2	3	4	5	6	7	8	9	10
	(%)	(%)	(%)	(%)	(%)										
NATIVE ANNUAL & BIENNIAL FORBS															
Cirsium undulatum	0.00	10.00	0.00	0.00	0.00										P
Conyza canadensis	0.30	70.00	0.66	0.30	0.63		P	2	P	P			P	P	1
Conyza coulteri	0.00	30.00	0.00	0.00	0.00		P						P	P	
Coreopsis tinctoria	0.00	10.00	0.00	0.00	0.00			P							
Dyssodia papposa	0.00	20.00	0.00	0.00	0.00		P								P
Gaura parviflora	0.00	10.00	0.00	0.00	0.00					P					
Grindelia squarrosa	1.40	80.00	3.06	1.50	3.17		4	P		P	1	6	P	P	3(1)
Helianthus annuus	0.00	10.00	0.00	0.00	0.00										P
Machaeranthera tanacetifolia	0.00	40.00	0.00	0.00	0.00		P	P					P		P
Oonopsis foliosa	0.10	10.00	0.22	0.10	0.21								1		
TOTAL NATIVE ANN. & BIEN. FORBS	1.8	90.0	3.9	1.9	4.0	---	4	2	P	P	1	6	1	P	4(1)
INTRODUCED ANNUAL & BIENNIAL FORBS															
Alyssum desertorum	0.00	10.00	0.00	0.00	0.00			P							
Bassia sieversiana	4.30	100.00	9.41	4.30	9.09	2	2	5	2	4	5	1	18	P	4
Erodium cicutarium	0.00	20.00	0.00	0.00	0.00			P					P		
Halogeton glomeratus	0.00	30.00	0.00	0.00	0.00	P			P				P		
Melilotus alba	0.30	60.00	0.66	0.30	0.63			P	2			1	P	P	P
Melilotus officinalis	0.00	40.00	0.00	0.00	0.00	P		P	P			P			
Salsola collina	0.50	100.00	1.09	0.60	1.27	2	P	1	(1)	P	1	P	P	1	P
TOTAL INTRO. ANN. & BIEN. FORBS	5.1	100.0	11.2	5.2	11.0	4	2	6	4(1)	4	6	2	18	1	4
INTRODUCED ANNUAL GRASSES															
Bromus tectorum	0.00	30.00	0.00	0.00	0.00		P			P				P	
TOTAL INTRO. ANN. GRASSES	0.0	30.0	0.0	0.0	0.0	---	P	---	---	P	---	---	---	P	---
NATIVE PERENNIAL FORBS															
Astragalus sp.	0.00	20.00	0.00	0.00	0.00							P		P	
Glandularia bipinnatifida	0.00	30.00	0.00	0.00	0.00				P	P		P			
Machaeranthera sp.	0.00	10.00	0.00	0.00	0.00			P							
Quincula lobata	0.00	70.00	0.00	0.00	0.00		P	P	P	P	P	P	P		
Ratibida columnifera	0.00	20.00	0.00	0.00	0.00		P	P							
Sphaeralcea angustifolia	0.90	100.00	1.97	0.90	1.90	P	P	1	1	P	P	2	P	2	3
Verbena bracteata	0.20	40.00	0.44	0.40	0.85		1(1)					(1)	1		P
TOTAL NATIVE PERENNIAL FORBS	1.1	100.0	2.4	1.3	2.7	P	1(1)	1	1	P	P	2(1)	1	2	3
INTRODUCED PERENNIAL FORBS															
Daucus carota	0.00	10.00	0.00	0.00	0.00		P								

PLANT SPECIES	AVERAGE		RELATIVE	AVERAGE	RELATIVE	- Sample Number -									
	COVER	FREQUENCY	VEGETATION	COVER-	VEGETATION										
	(%)	(%)	COVER	ALL	COVER-ALL	1	2	3	4	5	6	7	8	9	10
Rumex crispus	0.00	30.00	0.00	0.00	0.00		P	P					P		
TOTAL INTRO. PERENNIAL FORBS	0.0	30.0	0.0	0.0	0.0	---	P	P	---	---	---	---	P	---	---
NATIVE PERENNIAL GRASSES (cool)															
Danthonia spicata var. pinetorum	0.10	40.00	0.22	0.10	0.21		P				P		1	P	
Elymus elymoides	0.00	10.00	0.00	0.00	0.00										P
Elymus trachycaulus	3.00	80.00	6.56	3.10	6.55	P	5(1)	7	P		1	2	3		12
Pascopyrum smithii	5.50	100.00	12.04	5.70	12.05	6	6	4(1)	2	7	3	13(1)	10	1	3
TOTAL NATIVE PERENNIAL GRASSES (c)	8.6	100.0	18.8	8.9	18.8	6	11(1)	11(1)	2	7	4	15(1)	14	1	15
INTRODUCED PERENNIAL GRASSES (cool)															
Schedonorus arundinaceus	0.30	20.00	0.66	0.30	0.63			3					P		
TOTAL INTRO. PERENNIAL GRASSES (c)	0.3	20.0	0.7	0.3	0.6	---	---	3	---	---	---	---	P	---	---
NATIVE PERENNIAL GRASSES (warm)															
Chondrosum gracile	8.10	100.00	17.72	8.30	17.55	7	7	18	3	14	3	3(2)	12	3	11
Muhlenbergia arenicola	0.00	10.00	0.00	0.00	0.00							P			
Schedonnardus paniculatus	0.00	10.00	0.00	0.00	0.00										P
Sporobolus airoides	17.80	100.00	38.95	18.20	38.48	16	20(1)	19	20	6	28(1)	14	22(2)	31	2
Sporobolus cryptandrus	2.30	90.00	5.03	2.60	5.50	2	2	3(1)	3		7	P	1(1)	2	3(1)
TOTAL NATIVE PERENNIAL GRASSES (w)	28.2	100.0	61.7	29.1	61.5	25	29(1)	40(1)	26	20	38(1)	17(2)	35(3)	36	16(1)
NATIVE SUBSHRUBS															
Atriplex confertifolia	0.00	10.00	0.00	0.00	0.00							P			
Gutierrezia sarothrae	0.00	30.00	0.00	0.00	0.00		P						P		P
TOTAL NATIVE SUBSHRUBS	0.0	40.0	0.0	0.0	0.0	---	P	---	---	---	---	P	P	---	P
NATIVE SHRUBS															
Atriplex canescens	0.60	100.00	1.31	0.60	1.27	P	P	P	1	1	P	P	1	1	2
Chrysothamnus nauseosus	0.00	20.00	0.00	0.00	0.00								P		P
TOTAL NATIVE SHRUBS	0.6	100.0	1.3	0.6	1.3	P	P	P	1	1	P	P	1	1	2
Standing dead															
Litter	5.40	90.00		5.40		6		7	9	10	4	4	3	8	3
Bare soil	26.40	100.00		26.40		36	27	21	28	37	27	28	16	20	24
Rock	20.90	100.00		20.90		21	24	6	28	21	20	23	11	30	25
	1.60	70.00		1.60		2	2	3	1			3		1	4
TOTALS	100.0			101.6		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	45.7			47.3		35	47(3)	63(2)	34(1)	32	49(1)	42(4)	70(3)	41	44(2)
GROUND COVER (Litter+Rock+Veg+St.Dead)	79.1			80.7		79	76(3)	94(2)	72(1)	79	80(1)	77(4)	89(3)	70	75(2)

Table 3. Work Package S1 Cover Data on Midway-Shale Complex; Shingle Series Soils (Soil Group D)

PLANT SPECIES	AVERAGE		RELATIVE	AVERAGE COVER- ALL	RELATIVE	- Sample Number -									
	COVER	FREQUENCY	VEGETATION		VEGETATION										
	(%)	(%)	(%)		COVER-ALL	1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS															
Chenopodium berlandieri	0.00	30.00	0.00	0.00	0.00	P				P			P		
Conyza canadensis	0.00	40.00	0.00	0.00	0.00		P	P			P				P
Conyza coulteri	0.00	30.00	0.00	0.00	0.00		P	P			P				
Grindelia squarrosa	0.00	60.00	0.00	0.00	0.00	P			P	P			P	P	P
Helianthus annuus	0.00	20.00	0.00	0.00	0.00	P						P			
Suaeda sp.	0.00	30.00	0.00	0.00	0.00	P								P	P
TOTAL NATIVE ANN. & BIEN. FORBS	0.0	100.0	0.0	0.0	0.0	P	P	P	P	P	P	P	P	P	P
INTRODUCED ANNUAL & BIENNIAL FORBS															
Bassia sieversiana	3.10	90.00	6.65	3.60	7.30	4		P	5(2)	1	P	8	11(3)	1	1
Halogeton glomeratus	0.00	10.00	0.00	0.00	0.00			P							
Melilotus alba	0.00	20.00	0.00	0.00	0.00			P			P				
Melilotus officinalis	0.00	10.00	0.00	0.00	0.00						P				
Salsola australis	5.80	70.00	12.45	6.50	13.18	9(1)			5	7		7(1)	6(1)	9	15(4)
Salsola collina	2.20	90.00	4.72	2.40	4.87	1	P	P		1	1	10(1)	1	3	5(1)
TOTAL INTRO. ANN. & BIEN. FORBS	11.1	100.0	23.8	12.5	25.4	14(1)	P	P	10(2)	9	1	25(2)	18(4)	13	21(5)
INTRODUCED ANNUAL GRASSES															
Bromus tectorum	0.10	30.00	0.21	0.10	0.20		P	P			1				
TOTAL INTRO. ANN. GRASSES	0.1	30.0	0.2	0.1	0.2	---	P	P	---	---	1	---	---	---	---
NATIVE PERENNIAL FORBS															
Astragalus sp.	0.00	10.00	0.00	0.00	0.00						P				
Glandularia bipinnatifida	0.00	20.00	0.00	0.00	0.00			P			P				
Quincula lobata	0.10	60.00	0.21	0.10	0.20		P	P	1	P	P			P	
Ratibida columnifera	0.00	10.00	0.00	0.00	0.00						P				
Sphaeralcea angustifolia	0.10	40.00	0.21	0.10	0.20		1	P			P	P			
TOTAL NATIVE PERENNIAL FORBS	0.2	70.0	0.4	0.2	0.4	---	1	P	1	P	P	P	---	P	---
INTRODUCED PERENNIAL FORBS															
Daucus carota	0.00	10.00	0.00	0.00	0.00						P				
TOTAL INTRO. PERENNIAL FORBS	0.0	10.0	0.0	0.0	0.0	---	---	---	---	---	P	---	---	---	---
NATIVE PERENNIAL GRASSES (cool)															
Danthonia spicata var. pinetorum	0.00	10.00	0.00	0.00	0.00						P				
Elymus elymoides	0.00	20.00	0.00	0.00	0.00				P	P					
Elymus trachycaulus	8.10	100.00	17.38	8.40	17.04	5	5	2	20(1)	11(2)	4	7	2	16	9
Pascopyrum smithii	3.00	100.00	6.44	3.20	6.49	2(1)	8	2	1	2	6	2(1)	1	1	5

PLANT SPECIES	AVERAGE		RELATIVE	AVERAGE	RELATIVE	- Sample Number -									
	COVER	FREQUENCY	VEGETATION	COVER-ALL	VEGETATION										
	(%)	(%)	(%)	(%)	(%)	1	2	3	4	5	6	7	8	9	10
TOTAL NATIVE PERENNIAL GRASSES (c)	11.1	100.0	23.8	11.6	23.5	7(1)	13	4	21(1)	13(2)	10	9(1)	3	17	14
INTRODUCED PERENNIAL GRASSES (cool)															
Schedonorus arundinaceus	0.00	10.00	0.00	0.00	0.00		P								
TOTAL INTRO. PERENNIAL GRASSES (c)	0.0	10.0	0.0	0.0	0.0	---	P	---	---	---	---	---	---	---	---
NATIVE PERENNIAL GRASSES (warm)															
Bouteloua curtipendula	0.50	30.00	1.07	0.50	1.01				4	P					1
Chondrosum gracile	3.00	100.00	6.44	3.10	6.29	3	5(1)	1	2	4	4	2	2	4	3
Pleuraphis jamesii	2.80	80.00	6.01	3.20	6.49	3			9(1)	2(1)	P	2	5(1)	5	2(1)
Sporobolus airoides	13.30	100.00	28.54	13.50	27.38	2	23	36	11(1)	6	24	6	22(1)	2	1
Sporobolus cryptandrus	2.70	100.00	5.79	2.80	5.68	3	12(1)	3	P	2	P	3	P	3	1
TOTAL NATIVE PERENNIAL GRASSES (w)	22.3	100.0	47.9	23.1	46.9	11	40(2)	40	26(2)	14(1)	28	13	29(2)	14	8(1)
NATIVE SHRUBS															
Atriplex canescens	1.80	100.00	3.86	1.80	3.65	1	2	1	1	4	1	1	4	P	3
Krascheninnikovia lanata	0.00	30.00	0.00	0.00	0.00				P			P			P
TOTAL NATIVE SHRUBS	1.8	100.0	3.9	1.8	3.7	1	2	1	1	4	1	1	4	P	3
Standing dead	1.70	70.00		1.70			2	10	1	1	1	1		1	
Litter	15.10	100.00		15.10		8	19	16	8	16	35	6	10	13	20
Bare soil	35.30	100.00		35.30		59	21	28	31	42	22	44	35	39	32
Rock	1.30	90.00		1.30			2	1	1	1	1	1	1	3	2
TOTALS	100.0			102.7		100	100	100	100	100	100	100	100	100	100
TOTAL VEGETATION COVER	46.6														
GROUND COVER	(s=7.9)		100.0	49.3 (s=9.3)	100.0	33(2)	56(2)	45	59(5)	40(3)	41	48(3)	54(6)	44	46(6)
(Litter+Rock+Veg+St.Dead)	64.7			67.4		41(2)	79(2)	72	69(5)	58(3)	78	56(3)	65(6)	61	68(6)

Table 4. Work Package S1 Frequency Data on Penrose, Manvel and Minnequa Series Soils (Soil Group A)

PLANT SPECIES	Average # of Acceptable Plant Spp. Per 1 sq. m.	Number of Acceptable Plant Spp. Per 10 sq. m.																
		----- Sample Number -----																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NATIVE ANNUAL & BIENNIAL FORBS																		
Conyza canadensis	0.024	1										3						
Conyza coulteri	0.006	1																
Erigeron divergens	0.006											1						
Grindelia squarrosa	0.012	1										1						
Machaeranthera tanacetifolia	0.006									1								
Solanum rostratum	0.006															1		
Suaeda sp.	0.006						1											
TOTAL NATIVE ANN. & BIEN. FORBS	0.060	3					1			1		5				1		
NATIVE PERENNIAL FORBS																		
Glandularia bipinnatifida	0.047	2	2	1	2					1								
Sphaeralcea angustifolia	0.006												1					
TOTAL NATIVE PERENNIAL FORBS	0.050	2	2	1	2					1		1						
NATIVE PERENNIAL GRASSES (cool)																		
Elymus trachycaulus	0.235	1	5			4	1		8	1	3	1	4			7	3	2
Pascopyrum smithii	0.694	6	10	10	5	10		9	2	7	8	6	8	8	10	2	7	10
TOTAL NATIVE PERENNIAL GRASSES (c)	0.930	7	15	10	5	14	1	9	10	8	11	7	12	8	10	9	10	12
NATIVE PERENNIAL GRASSES (warm)																		
Bouteloua curtipendula	0.076	1						8			1		1		1	1		
Chondrosum gracile	0.500	5	2	6	2	8	3	6	5	4	2	6	4	7	9	6	5	5
Pleuraphis jamesii	0.259		2	2	6	3	3	2	4	2	1		1		4	8	3	3
Sporobolus airoides	0.282	6	3	1	4		7	1	3	1	2	7	2		1	4	1	5
Sporobolus cryptandrus	0.129				6		4			1	8		3					
TOTAL NATIVE PERENNIAL GRASSES (w)	1.250	12	7	9	18	11	17	17	12	8	14	13	11	7	15	19	9	13
NATIVE SHRUBS																		
Atriplex canescens	0.594	3	7	10	7	10	1	5	6	2	9	4	5	7	8	2	7	8
TOTAL NATIVE SHRUBS	0.590	3	4	10	7	10	1	5	6	2	9	4	5	7	8	2	7	8
TOTAL DENSITY	2.9	27	28	30	32	35	20	31	28	20	34	30	28	22	33	31	26	33

Table 5. Work Package S1 Frequency Data on Limon and Heldt Series (Soil Group B)

PLANT SPECIES	Average # of Acceptable Plant Spp. Per 1 sq. m.	Number of Acceptable Plant Spp. Per 10 sq. m. -----Sample Number-----									
		1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS											
Conyza canadensis	0.110		2	4			1		1		3
Gaura parviflora	0.010					1					
Grindelia squarrosa	0.180		2	3		1	1	2	2		7
Machaeranthera tanacetifolia	0.030								1		2
TOTAL NATIVE ANN. & BIEN. FORBS	0.330		4	7		2	2	2	4		12
NATIVE PERENNIAL FORBS											
Glandularia bipinnatifida	0.010							1			
Machaeranthera sp.	0.020			2							
Quincula lobata	0.010							1			
Ratibida columnifera	0.010		1								
Sphaeralcea angustifolia	0.270	5		1	4	2		4		7	4
Verbena bracteata	0.030		2				1				
TOTAL NATIVE PERENNIAL FORBS	0.350	5	3	3	4	2	1	6		7	4
INTRODUCED PERENNIAL FORBS											
Daucus carota	0.010		1								
Rumex crispus	0.020		1						1		
TOTAL INTRO. PERENNIAL FORBS	0.3		2						1		
NATIVE PERENNIAL GRASSES (cool)											
Danthonia spicata var. pinetorum	0.060		3				3				
Elymus trachycaulus	0.200	1	5	2	1			3	3		5
Pascopyrum smithii	0.490	2	4	7	6	7	3	6	6	4	4
TOTAL NATIVE PERENNIAL GRASSES (c)	0.750	3	12	9	7	7	6	9	9	4	9

PLANT SPECIES	Average # of Acceptable Plant Spp. Per 1 sq. m.	Number of Acceptable Plant Spp. Per 10 sq. m. -----Sample Number-----									
		1	2	3	4	5	6	7	8	9	10
INTRODUCED PERENNIAL GRASSES (cool) <i>Schedonorus arundinaceus</i>	0.040			2					2		
TOTAL INTRO. PERENNIAL GRASSES (c)	0.040			2					2		
NATIVE PERENNIAL GRASSES (warm)											
<i>Chondrosium gracile</i>	0.500	3	6	8	1	9	1	5	8		9
<i>Muhlenbergia arenicola</i>	0.010							1			
<i>Schedonnardus paniculatus</i>	0.030										3
<i>Sporobolus airoides</i>	0.750	7	8	4	9	10	9	6	8	10	4
<i>Sporobolus cryptandrus</i>	0.180	2	1	1	2		1	1	3		7
TOTAL NATIVE PERENNIAL GRASSES (w)	1.470	12	15	13	12	19	11	13	19	10	23
NATIVE SHRUBS											
<i>Atriplex canescens</i>	0.090	2	1		1	1		1	1		2
TOTAL NATIVE SHRUBS	0.090	2	1		1	1		1	1		2
TOTAL DENSITY	3.1	22	37	34	24	31	20	31	36	21	50

Table 6. Work Package S1 Frequency Data on Midway-Shale Complex; Shingle Series Soils (Soil Group D)

PLANT SPECIES	Average # of Acceptable Plant Spp. Per 1 sq. m.	Number of Acceptable Plant Spp. Per 10 sq. m.									
		----- Sample Number -----									
		1	2	3	4	5	6	7	8	9	10
NATIVE ANNUAL & BIENNIAL FORBS											
<i>Coryza canadensis</i>	0.040		1	1			1				1
<i>Coryza coulteri</i>	0.020			1			1				
<i>Grindelia squarrosa</i>	0.010	1									
<i>Helianthus annuus</i>	0.010	1									
<i>Suaeda</i> sp.	0.020									1	1
TOTAL NATIVE ANN. & BIEN. FORBS	0.100	2	1	2			2			1	2
NATIVE PERENNIAL FORBS											
<i>Astragalus</i> sp.	0.010						1				
<i>Glandularia bipinnatifida</i>	0.010						1				
<i>Quincula lobata</i>	0.120		1	2	2	2	4			1	
<i>Ratibida columnifera</i>	0.010						1				
<i>Sphaeralcea angustifolia</i>	0.120		1	4			7				
TOTAL NATIVE PERENNIAL FORBS	0.270		2	6	2	2	14			1	
INTRODUCED PERENNIAL FORBS											
<i>Daucus carota</i>	0.010						1				
TOTAL INTRO. PERENNIAL FORBS	0.010						1				
NATIVE PERENNIAL GRASSES (cool)											
<i>Elymus trachycaulus</i>	0.530	5	4	2	8	9	2	4	3	9	7
<i>Pascopyrum smithii</i>	0.290	2	6	4	1		3		4	5	4
TOTAL NATIVE PERENNIAL GRASSES (c)	0.820	7	10	6	9	9	5	4	7	14	11
INTRODUCED PERENNIAL GRASSES (cool)											
<i>Schedonorus arundinaceus</i>	0.010		1								
TOTAL INTRO. PERENNIAL GRASSES (c)	0.010		1								
NATIVE PERENNIAL GRASSES (warm)											
<i>Bouteloua curtipendula</i>	0.070				4	1					2
<i>Chondrosum gracile</i>	0.420	4	5	6	2	6	4	5	2	1	7
<i>Pleuraphis jamesii</i>	0.400	4			7	5		5	4	9	6
<i>Sporobolus airoides</i>	0.550	1	8	8	6	5	8	2	9	5	3
<i>Sporobolus cryptandrus</i>	0.170	1	2		2		2	7	1		2
TOTAL NATIVE PERENNIAL GRASSES (w)	1.610	10	15	14	21	17	14	19	16	15	20
NATIVE SHRUBS											

PLANT SPECIES	Average # of Acceptable Plant Spp. Per 1 sq. m.	Number of Acceptable Plant Spp. Per 10 sq. m.									
		----- Sample Number -----									
		1	2	3	4	5	6	7	8	9	10
Atriplex canescens	0.410	5	2	2	6	7	2	1	4	7	5
Krascheninnikovia lanata	0.020				1			1			
TOTAL NATIVE SHRUBS	0.430	5	2	2	7	7	2	2	4	7	5
TOTAL DENSITY	3.25	24	31	30	39	35	38	25	27	38	38

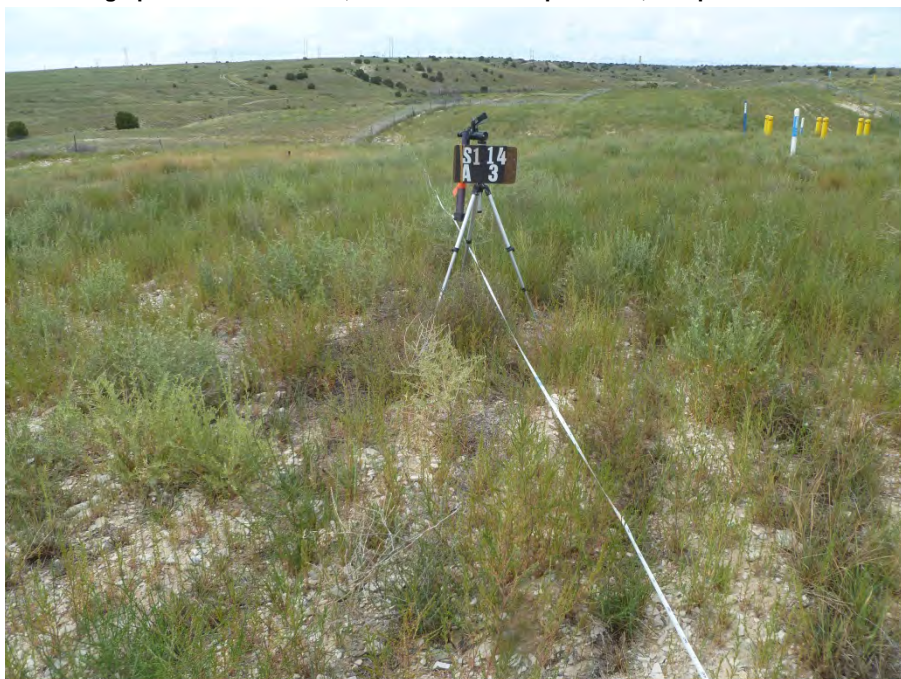
Appendix C: Site Photos for Work Segment S1



Photograph 1. S1 on Penrose, Manvel and Minnequa series, Sample 1 - 2014



Photograph 2. S1 on Penrose, Manvel and Minnequa series, Sample 2 - 2014



Photograph 3. S1 on Penrose, Manvel and Minnequa series, Sample 3 - 2014



Photograph 4. S1 on Penrose, Manvel and Minnequa series, Sample 4 - 2014



Photograph 5. S1 on Penrose, Manvel and Minnequa series, Sample 5 - 2014



Photograph 6. S1 on Penrose, Manvel and Minnequa series, Sample 6 - 2014



Photograph 7. S1 on Penrose, Manvel and Minnequa series, Sample 7 - 2014



Photograph 8. S1 on Penrose, Manvel and Minnequa series, Sample 8 - 2014



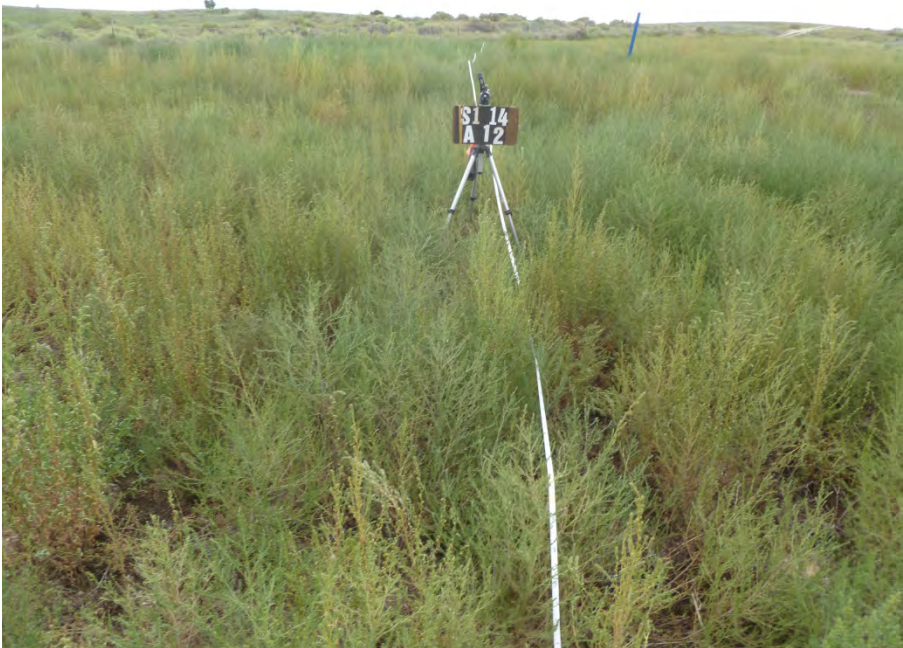
Photograph 9. S1 on Penrose, Manvel and Minnequa series, Sample 9 - 2014



Photograph 10. S1 on Penrose, Manvel and Minnequa series, Sample 10 -2014



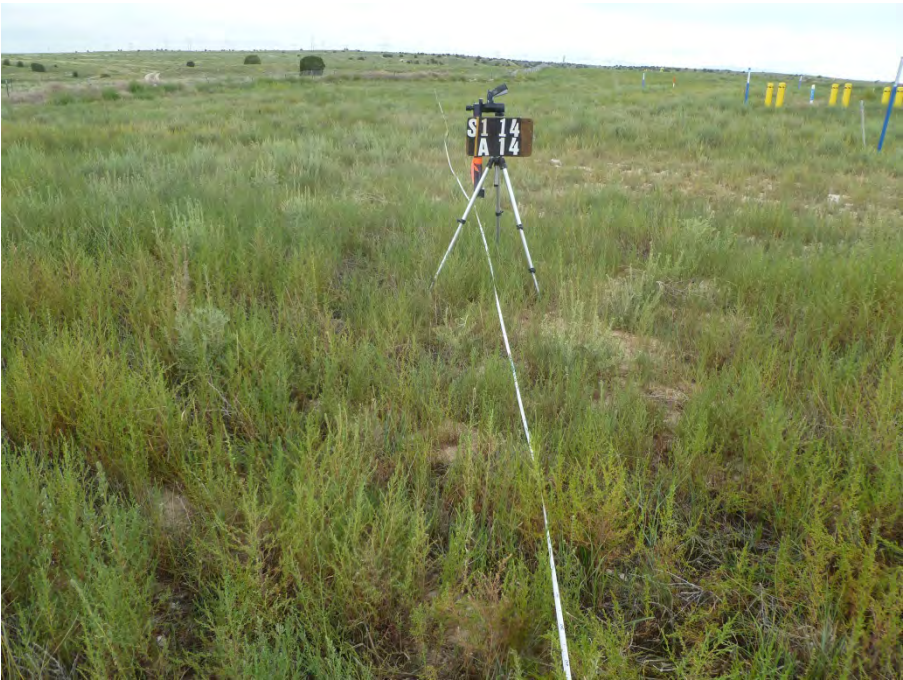
Photograph 11. S1 on Penrose, Manvel and Minnequa series, Sample 11 - 2014



Photograph 12. S1 on Penrose, Manvel and Minnequa series, Sample 12 - 2014



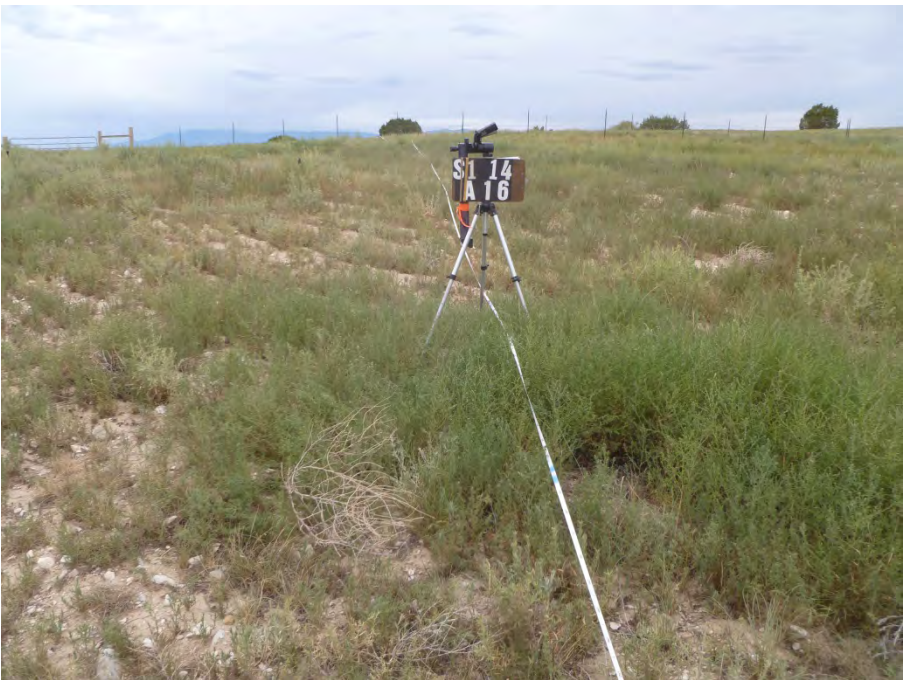
Photograph 13. S1 on Penrose, Manvel and Minnequa series, Sample 13 - 2014



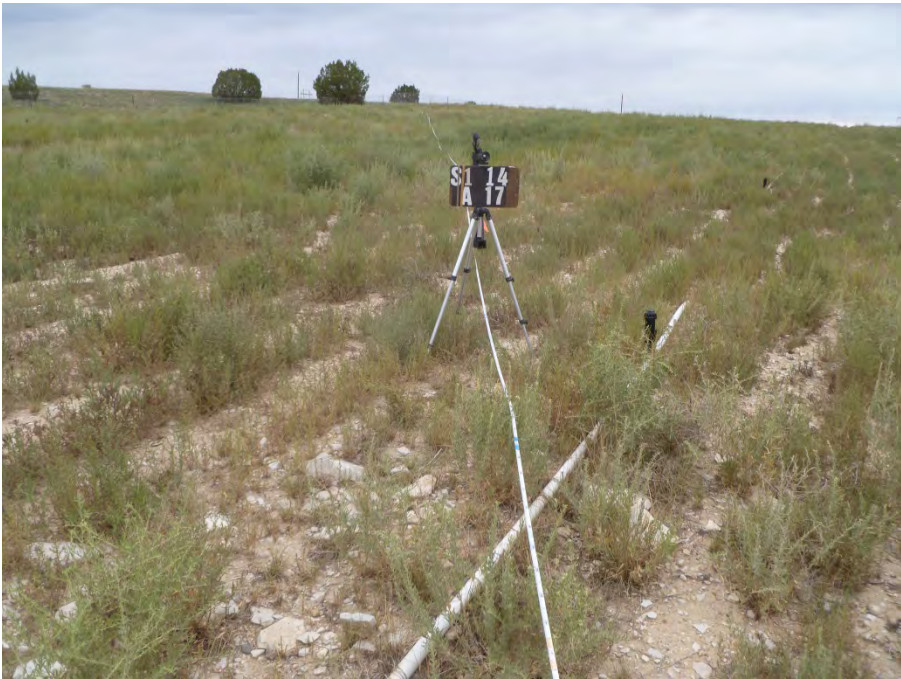
Photograph 14. S1 on Penrose, Manvel and Minnequa series, Sample 14 - 2014



Photograph 15. S1 on Penrose, Manvel and Minnequa series, Sample 15 - 2014



Photograph 16. S1 on Penrose, Manvel and Minnequa series, Sample 16 – 2014



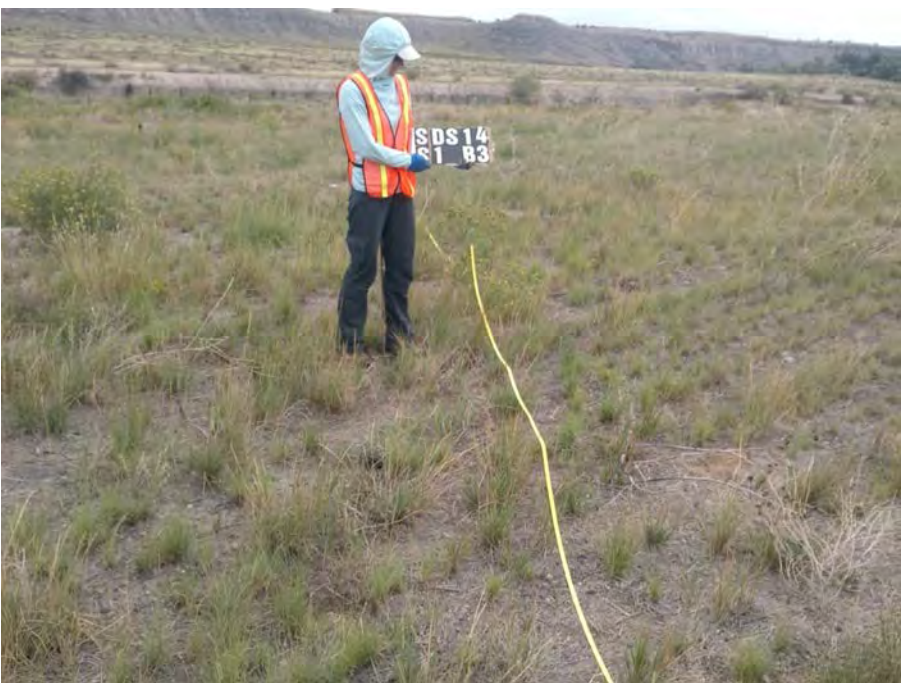
Photograph 17. S1 on Penrose, Manvel and Minnequa series, Sample 17 - 2014



Photograph 18. S1 on Limon and Heldt series, Sample 1 - 2014



Photograph 19. S1 on Limon and Heldt series, Sample 2 - 2014



Photograph 20. S1 on Limon and Heldt series, Sample 3 - 2014



Photograph 21. S1 on Limon and Heldt series, Sample 4 - 2014



Photograph 22. S1 on Limon and Heldt series, Sample 5 - 2014



Photograph 23. S1 on Limon and Heldt series, Sample 6 - 2014



Photograph 24. S1 on Limon and Heldt series, Sample 7 - 2014



Photograph 25. S1 on Limon and Heldt series, Sample 8 - 2014



Photograph 26. S1 on Limon and Heldt series, Sample 9 - 2014



Photograph 27. S1 on Limon and Heldt series, Sample 10 - 2014



Photograph 28. S1 Midway-Shale complex; Shingle series, Sample 1 - 2014



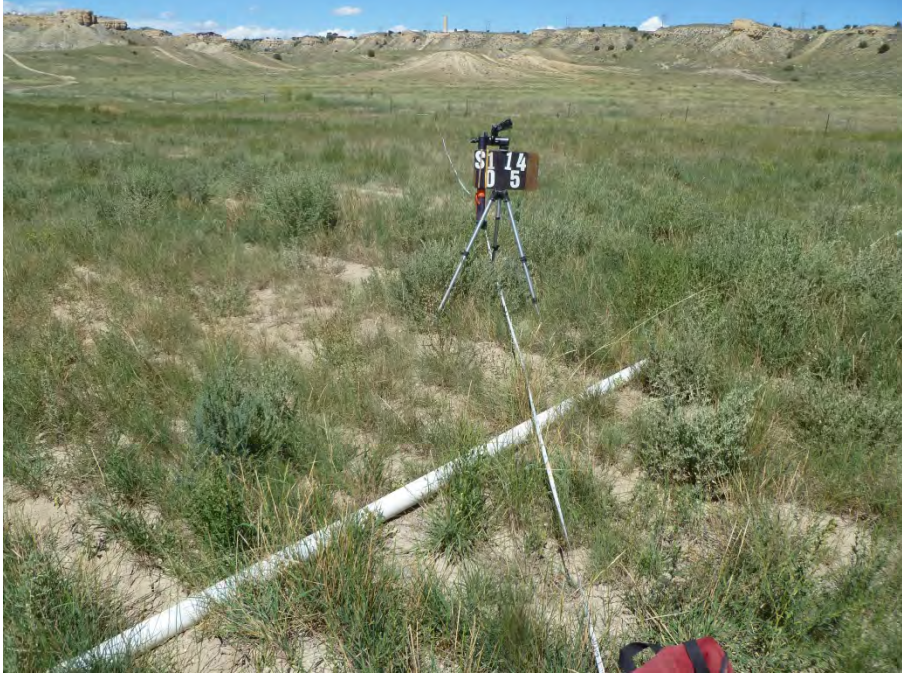
Photograph 29. S1 on Midway-Shale complex; Shingle series, Sample 2 - 2014



Photograph 30. S1 on Midway-Shale complex; Shingle series, Sample 3 - 2014



Photograph 31. S1 on Midway-Shale complex; Shingle series, Sample 4 - 2014



Photograph 32. S1 on Midway-Shale complex; Shingle series, Sample 5 - 2014



Photograph 33. S1 on Midway-Shale complex; Shingle series, Sample 6 - 2014



Photograph 34. S1 on Midway-Shale complex; Shingle series, Sample 7- 2014



Photograph 35. S1 on Midway-Shale complex; Shingle series, Sample 8 - 2014



Photograph 36. S1 on Midway-Shale complex; Shingle series, Sample 9 - 2014



Photograph 37. S1 on Midway-Shale complex; Shingle series, Sample 10 - 2014

Appendix D: Established Vegetation Sampling Protocols

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 3

Post-Revegetation Sampling

This Technical Memo describes the design and methodology CNHP will use to sample and quantitatively assess post-disturbance revegetation success. For the practicality of achieving an unbiased evaluation, the approach is based on random sampling and the use of resulting means to compare results to previously established performance standards. By the nature of plant growth in response to varying conditions along the length of the revegetated area, and by the nature of random sampling, variability in levels of plant abundance are to be expected both on the ground and in sample results. The use of 50 meter-long transects tends to encompass variability though a certain amount of variability can be expected at scales larger than this.

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 the relative cover by those plants in the pre-construction sample data will not be counted toward establishment of proof of successful revegetation (see below).

Maximum allowable relative cover by Introduced Annual and Biennial Species:

A. Soils Shallow over Shale and Limestone (Penrose, Manvel and Minnequa series; Tables 4, 7, and Samples 5, 7 and 8 of Table 8): **22.2 percent**

B. Soils on Clay-rich, Salt-affected Alluvial Material (Limon and Heldt series; Tables 1, 5, and 11): **2.6 percent**

C. Soils Deep on Early Pleistocene Alluvium (Stoneham and Cascajo series; Tables 10 and 15): **3.9 percent**

D. Soils on Weathered Shale (with active erosional removal) (Midway – Shale complex; Shingle series; Tables 9 and 13): **1.3 percent**

E. Soils on Deeply Weathered Shale (without active erosional removal) (Razor series; Table 14): **3.6 percent**

F. Soils on Recent Alluvium of Moderate Texture and Salt Content (Haverson series and Ustic Torrifluvents; Table 6 and 16): **16.7 percent**

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.

In areas with total Soil Group length less than 0.1 mile, three (3) to five (5) samples will be made. Professional judgment will be used in these small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

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. If 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.

Professional judgment will be used in small sample areas (e.g. Soil Groups B and F in S3) to determine the location and number of samples collected.

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 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 (\bar{x}) is indistinguishable from 90 percent of the pre-existing cover, stated as $H_0: \bar{x} = Q$. 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.