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Rocky Flats Site, Colorado, Revegetation Plan

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Abbreviations

COU	Central Operable Unit
DOE	U.S. Department of Energy
GIS	geographic information system
IA	Industrial Area
LM	Legacy Management
POU	Peripheral Operable Unit
USFWS	U.S. Fish and Wildlife Service

1.0 Introduction

The Rocky Flats Site, Colorado (Rocky Flats), is under the jurisdiction of the U.S. Department of Energy (DOE) Office of Legacy Management (LM). Long-term surveillance and maintenance activities at Rocky Flats are conducted under the Legacy Management Support contract. Vegetation management is conducted as part of the surveillance and maintenance activities at Rocky Flats, which include activities conducted pursuant to the Rocky Flats Legacy Management Agreement. That agreement established the regulatory framework to implement the final response action selected and approved in the Rocky Flats Corrective Action Decision/Record of Decision under the Comprehensive Environmental Response, Compensation, and Liability Act; the Resource Conservation and Recovery Act; and the Colorado Hazardous Waste Act to ensure that the response action remains protective of human health and the environment.

The Rocky Flats site closure activities included the removal of existing buildings and structures within the former Industrial Area (IA) of the site. As the buildings and other facilities and structures were removed across the site, revegetation of the areas was conducted to stabilize the soil, minimize erosion, and promote the establishment of native plant communities. Since 2007, most of the former buffer zone has been transferred to the U.S. Fish and Wildlife Service (USFWS) to become the Rocky Flats National Wildlife Refuge. The DOE-retained area is known as the Central Operable Unit (COU; the area where the IA was generally located), and the wildlife refuge areas are part of the Peripheral Operable Unit (POU) (Figure 1).

1.1 Goals and Objectives

The following goals and objectives are provided for revegetation efforts at the site:

Goal 1. Provide a vegetative cover in disturbed and degraded areas to stabilize the soil and minimize erosion.

Goal 2. Wherever possible, avoid or minimize the loss of native habitat where it is still present.

Goal 3. Develop sustainable native plant communities that provide habitat for native wildlife species that occur at the site.

Goal 4. If warranted, remove areas of planted, exotic plant species that were used for landscaping purposes.

Goal 5. Control noxious weeds in revegetation areas using an appropriate Integrated Weed Management Program strategy outlined in the *Rocky Flats Site, Colorado, Vegetation Management Plan* (DOE 2017a).

As defined for this plan, “revegetation” means reseeding the dominant native plant species for a given plant community type. Revegetation differs from restoration, which is defined as the reestablishment of the predisturbance native plant communities and all the associated natural processes and functions. Although initially the common native plant species are being seeded, other grasses, forbs, or shrubs found on the native prairie at the site could be seeded and planted at a future time, if desired, to provide greater diversity to the revegetation locations.

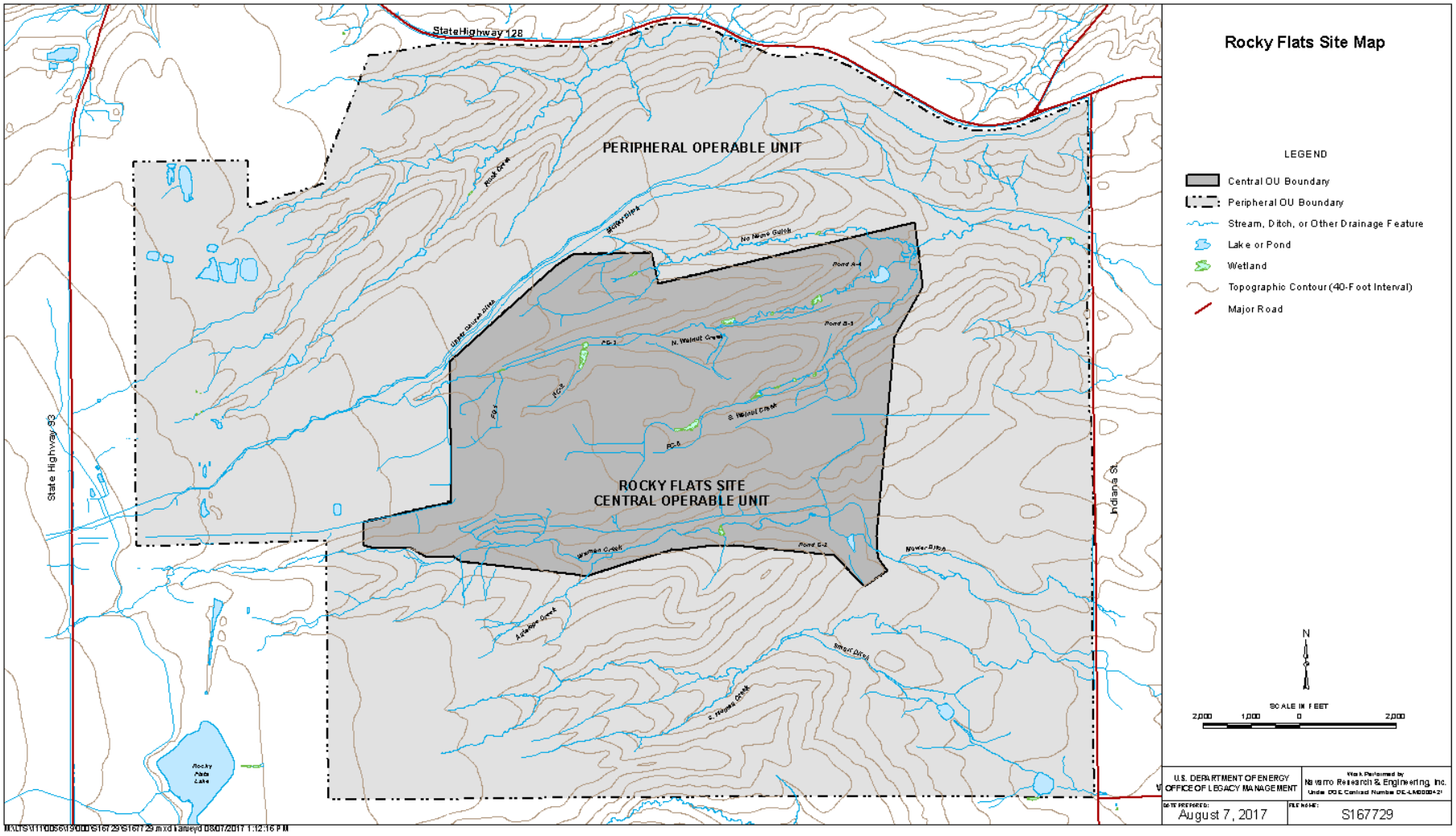

Figure 1. Rocky Flats Site Map

1.2 Site Description and History

At an elevation of approximately 6000 feet, the site (both COU and POU areas) contains a unique ecotonal mixture of mountain and prairie plant species resulting from the topography of the area and its proximity to the mountain front. The POU, the area surrounding the former IA, is one of the largest remaining undeveloped tracts of its kind along the Colorado Piedmont. The Colorado Natural Heritage Program has identified a number of plant communities present at the site as increasingly rare and unique. These communities include the xeric tallgrass prairie, tall upland shrubland, wetlands, and Great Plains riparian woodland communities. Small inclusions of a number of other increasingly rare plant communities are also found on the site.

The upper flat surfaces at the site (pediment tops) are composed of Rocky Flats alluvium. The soil types on this surface are classified as Flatirons very cobbly sandy loam and Nederland very cobbly sandy loam (SCS 1980). The vegetation on this surface is predominantly xeric tallgrass prairie on the western portions of the site and gradually changes to a needle-and-thread grass community as the alluvium thins to the east. Based on evidence from the current vegetation map, soil types, and historical aerial photographs, much of the COU was probably xeric tallgrass prairie prior to the construction of the IA. Common species on the xeric tallgrass prairie include *Andropogon gerardii*, *Andropogon scoparius*, *Muhlenbergia montana*, *Stipa comata*, *Bouteloua gracilis*, *Bouteloua curtipendula*, *Carex heliophila*, *Poa compressa*, and a variety of other graminoid and forb species. The dominance of these species varies from location to location.

The hillsides at the site are dominated by the mesic mixed grassland community. Soils on the hillslopes are classified as Denver-Kutch-Midway clay loams (SCS 1980). Common species on the mesic mixed grasslands include *Bouteloua gracilis*, *Bouteloua curtipendula*, *Agropyron smithii*, *Stipa viridula*, *Poa pratensis*, *Poa compressa*, *Bromus japonicus*, and other forbs and graminoids. The hillside areas in the COU were largely composed of this community prior to disturbance.

Riparian areas at the site are typically characterized by *Populus deltoides*, *Salix exigua*, *Amorpha fruticosa*, *Symphoricarpos occidentalis*, *Rosa arkansana*, and various wetland herbaceous plants such as *Carex nebrascensis*, *Juncus balticus*, and *Spartina pectinata*. The soils on the floodplains and stream terraces at the site are classified as Haverson loams (SCS 1980). Within the COU, historical aerial photographs show that two small tributaries to Walnut Creek drained the former IA and would have contained some wetland and riparian vegetation. These tributaries, however, were modified and the channels moved for construction of some of the buildings at the site.

Prior to purchase by the U.S. government, most of the land where the site occurs was rangeland that had been heavily overgrazed (Clark et al. 1980). Historical aerial photographs show little riparian woodland or shrubland vegetation along the streams at the site, likely attributable to overgrazing in the riparian corridors. After the land was purchased by the U.S. government, grazing was stopped and the native plant communities were allowed to return with little or no management. The vegetation maps that were produced of the site in 1996 (K-H 1997) and 2014 (DOE 2016) bear little resemblance to the 1980 map (data collected in 1973–1974 time frame).

2.0 Revegetation Planning

2.1 Revegetation Planning Assumptions

This revegetation plan is intended as guidance. It may be modified, altered, or departed from as specific locations warrant or as particular needs arise. This plan is specifically developed for use in the COU; however, because it is based on the native plant communities in both the COU and POU, it could guide work done by USFWS in the wildlife refuge if desired. This plan applies to revegetation locations in the COU, excluding those areas covered specifically by regulatory agreements that may have other requirements. Preble's meadow jumping mouse (Preble's mouse) habitat and wetland mitigation revegetation are not specifically addressed in this document. While the guidance in this plan may be used for these mitigation areas (and often has been in the past), the Preble's mouse and wetland mitigation areas may have more specific requirements that are outlined in the documents that govern the mitigation. This plan also does not address revegetation of soil covers on landfills (e.g., Present Landfill, Original Landfill), which may have specific requirements for vegetation based on the purpose of the covers.

Disturbance and mitigation of Preble's mouse habitat are typically addressed in USFWS consultation documents such as biological evaluations, biological assessments, and biological opinions for specific projects. Disturbance of jurisdictional wetland areas would require a 404 permit or use of a nationwide permit that may have additional specifications requirements for the wetlands reconstruction or mitigation. However, because the basis of this plan is the native plant communities found at the site, the native seed mixes provided in this plan would work (and have been shown to work) very well for any of the aforementioned situations.

2.2 Revegetation Best Management Practices

2.2.1 Seed Mixes

Appendix A of this plan contains various seed mix specifications. Different seed mixes are provided depending on the topographic location and hydrologic conditions at the revegetation location. The following seed mixes are used for revegetation at the site:

- Flat areas seed mix—for use on the pediment tops at the site
- Hillside slope areas seed mix—for use on the hillslope areas at the site
- Riparian or drainage bottom areas seed mix—for use along the riparian areas and drainage bottoms at the site (depending on the hydrology at a location, this may be combined with the wetland areas seed mix)
- Wetland areas seed mix—for use in wetland areas at the site
- Temporary seeding seed mix 1—for use as temporary cover
- Temporary seeding seed mix 2—for use as temporary cover

These seed mixes may be modified for specific projects as warranted. All revegetation projects at the site must involve the Rocky Flats ecologist, who will coordinate with project management to provide project-specific revegetation specifications (e.g., seedbed preparation, soil amendments) to go into the Statement of Work. This approach is required because of the complexity of the

landscapes and regulatory and compliance issues in Preble's mouse habitat and wetland areas at the site. The Rocky Flats ecologist or designee must also be contacted for all erosion control requirements at the site prior to project initiation. The *Erosion Control Plan for Rocky Flats Property, Central Operable Unit* (DOE 2017b) will be used to address erosion control issues for revegetation projects.

2.2.2 Prohibited Species

The plant species listed below are prohibited for use at the site because (1) they are non-native species, and (2) they are aggressive and outcompete many of the native species.

- Annual rye grass *Secale cereale*
- Bulbous bluegrass *Poa bulbosa*
- Crested wheatgrass *Agropyron desertorum* or *Agropyron cristatum*
- Intermediate wheatgrass *Agropyron intermedium*
- Johnsongrass *Sorghum halepense*
- Orchardgrass *Dactylis glomerata*
- Quackgrass *Agropyron repens*
- Sheep fescue *Festuca ovina*
- Smooth brome *Bromus inermis*
- Timothy *Phleum pratense*
- Wild proso millet *Panicum milaceum*

The use of a sterile hybrid of wheat known as ReGreen is allowed under certain conditions at the site; however, prior approval from the Rocky Flats ecologist is required.

The use of any non-native species at the site is only allowed with prior approval by the Rocky Flats ecologist and will only be considered under very special conditions. No species found on the Colorado State noxious weed list or the Jefferson County noxious weed list are allowed to be planted at the site.

2.2.3 Soil Characterization

Soil characterization of several revegetation locations representative of general IA conditions was conducted during the summer of 2003. The soil sampling plan and results are presented in Appendix B. No nitrogen amendments were applied to any of the initial revegetation areas because scientific evidence indicated that the addition of nitrogen would foster weed growth at the expense of desired species. The use of soil amendments is discussed further below. If needed, additional location-specific soil characterization for revegetation factors may be conducted.

2.2.4 Seedbed Preparation

On the basis of experience since site closure in 2005, addressing two critical issues has been shown to greatly improve revegetation success at the Rocky Flats, soil compaction and soil amendments. These are discussed below.

2.2.4.1 Soil Compaction

Reducing soil compaction has been a critical component leading to the successful establishment of a stand of vegetation. Where parking lots, roads, and building were present for decades, soil compaction was very problematic. Ripping 12–18 inches or more, combined with discing, has greatly enhanced the successful establishment of the vegetation. No standardized "recipe" is provided here, but each project-specific revegetation plan should include specifications for reducing the soil compaction at specific locations.

2.2.4.2 Soil Amendments

At many revegetation locations after site closure, little organic material was present in the "soils." As a result, many of these locations failed to establish a good stand of vegetation after the initial seeding. The addition of compost, the use of slow-release, low-nitrogen fertilizers such as Biosol or Sustane, and adding mycorrhizal inoculant has dramatically improved the establishment of vegetation at these locations. Compost is typically spread on the ground at a rate of 50 cubic yards/acre, and then the area is ripped. Then if Biosol, Sustane, or mycorrhizal inoculant are used, they are spread at the manufacturers recommended rate and disced to mix all of these in the upper 3–6 inches of the seedbed. If Biosol, Sustane, or mycorrhizal inoculant are not used along with the compost, the area is disced after ripping to create a suitable seedbed.

2.2.5 Seeding

Seeding has been done successfully by either broadcasting or drill seeding, with the former the more commonly used method due to the rocky nature of the soil. If the seed is broadcast, then it must be harrowed to improve soil–seed contact and much of it buried so that it does not get blown away or eaten by small mammals or insects.

2.2.6 Erosion Controls

Erosion controls are discussed in greater detail in the *Erosion Control Plan for Rocky Flats Property, Central Operable Unit*. However, a few lessons learned are worth mentioning here. Crimped straw does not work at Rocky Flats due to the high winds and rocky soils. Coconut erosion control mats works better than straw erosion mats because they can last for 3 or 4 years, and it often takes 3–5 years to get a good stand of vegetation established because of the limited precipitation the site receives. Flexterra, a flexible growth media type of hydromulch, works very well to cover large areas and protect newly seeded areas at the site. It has performed best on flat areas and shallow slopes. Steeper slopes are better protected with the coconut matting. Woodstraw has also been used with good success to protect interseeded areas where adding matting would be impractical and on new revegetation locations where wind speeds on the ground will not be extreme. Straw wattles, wattles filled with compost, and GeoRidges have also been used with good success for sediment control.

3.0 Revegetation Management

Monitoring and management of the revegetation areas may be required for several years until the vegetation has been reestablished. The following considerations can be adapted and changed as necessary to achieve the desired goals and success criteria for the revegetation areas.

3.1 Revegetation Management

Management of the revegetation areas is critical to final success. Management measures may include weed control, reseeding areas as necessary, thinning vegetation through fire or other mechanical means, relocating or eliminating undesirable wildlife species, incorporating erosion control measures, and controlling or limiting anthropogenic activities within revegetated areas. The *Rocky Flats Site, Colorado, Vegetation Management Plan* outlines the integrated weed management program for the site and addresses potential tools that may be used to help establish desired vegetation while controlling noxious weeds. Noxious weeds will be evaluated on a species-specific basis, and weed control will be employed as necessary using appropriate integrated weed management strategies to achieve the success criteria listed below.

Initial success in all revegetation efforts is not a guarantee of long-term viability. Many factors can influence the success of revegetation. Some of these factors include variable climate (precipitation amounts, timing of precipitation events, temperatures), seedbed preparation, seed viability, soil fertility, undesirable species competition for resources, and herbivory. Even if all these factors are favorable and conditions are conducive for revegetation success, a planting may fail. Therefore, revegetation projects should have appropriate monitoring and management to increase the chances that initial revegetation efforts will succeed.

Time is a critical factor for establishing a native revegetation planting, and it will take several years for the revegetation areas to begin to resemble the native prairies found on the undisturbed portions of the site. It is normal for any revegetation effort to go through an initial stage of annual weeds followed by the establishment and dominance of the desired perennial species. Depending on the weed species, however, weed control is not always immediately warranted. Species such as *Kochia scoparia*, *Salsola iberica*, *Helianthus annuus*, *Erodium cicutarium*, and various annual mustard species are often common at the site during the first 2 or 3 years of a revegetation effort. These species are adapted to the early successional environmental conditions and often will not substantially reduce the growth and development of the desired perennial species. The species can actually protect the developing perennial vegetation by creating shade, providing a buffer from the wind, and creating favorable moisture conditions. In addition, they provide additional organic matter to the topsoil. After the first 2 or 3 years of establishment, control of the annual species may be desirable. However, control of noxious weeds should be conducted as regulated and as needed, using appropriate control methods.

Native plants often take longer to germinate and establish than non-native species. For the first year or two, many native species spend most of their energy developing a substantial root system before sending up much aboveground growth. Therefore, reseeding is not always an immediate recommendation if some establishment is taking place. Reseeding is recommended only after it is determined that the desired perennial vegetation is not progressing adequately toward the revegetation goals and success criteria. Two potential scenarios may trigger reseeding efforts: (1) bare areas greater than 500 square feet exist over the course of a single growing season, and

(2) after four growing seasons, quantitative data show that the total vegetation cover is less than 70% of the success criteria.

Access to the revegetation areas may be restricted to provide the greatest opportunity for success of the revegetation effort. Human access may be restricted through the use of temporary fencing, signage, and education, as needed. Restricting access from wildlife such as elk or deer may require more substantial or permanent fencing.

3.2 Industrial Area Revegetation Success Criteria

Success criteria and monitoring are an important component of a revegetation project. Revegetation success is typically judged according to criteria for species richness, species composition, and total ground cover. These criteria are important indicators of site conditions and stability, and they can be adjusted as desired to achieve the objectives. Also, conditions at some locations may never reach specified success criteria simply because the physical, environmental, and climatic factors at a location are not conducive for substantial vegetative growth. Situations such as this currently exist at some locations on the native prairie at the site. These success criteria are provided as initial guidance; however, common sense combined with scientific data must be applied to final evaluations to determine whether further management actions are required. The success criteria also depend on the goals or requirements for the establishment of a good stand of vegetation at a specific location.

Quantitative Grassland Success Criteria

- The revegetation site will have a minimum of 30% relative foliar cover of live desired species (seeded or nonseeded native species). Relative cover is defined as the percentage of cover of a given species divided by the total amount of vegetation cover present.

  Example: Species A has 20% absolute cover, and total vegetation cover (all individual species cover values summed) is 80%.
  Relative cover = (20/80) × 100 = 25%.

- The revegetation site will have a minimum of 70% total ground cover that comprises litter cover, current year live vegetation, basal cover, and rock cover.
- A minimum of 50% of the seeded native species will be present at the revegetation site.
- No single species will contribute more than 45% of the relative foliar cover (except in areas where dominance by a single species is appropriate for long-term wildlife and habitat management objectives).

3.3 Revegetation Monitoring Methodology

Revegetation monitoring will consist of a twofold approach that uses both qualitative and semiquantitative methods. Qualitative monitoring will be conducted through the use of permanent photo points and field notes. Photo points will be visited annually unless a less-frequent schedule is determined to be appropriate based on professional judgement. Additional photographs may be taken at other times if necessary. Both landscape and quadrat photographs may be used as appropriate. Field notes will be taken to note the status of the revegetation and any management needs. Appendix C shows an example of a "Qualitative Revegetation Evaluation Form" that may be used to assess the revegetation locations. Qualitative evaluations

may be used to evaluate the revegetation success and determine if additional management actions are needed at these locations.

Semiquantitative monitoring will consist of weed mapping and quadrat sampling. Weed mapping in the revegetation areas will be conducted as part of the sitewide weed-mapping efforts to provide information for integrated weed management. Weed species to be mapped will be selected annually and mapped when most visible. Mapping data will be entered and stored in the site geographical information system (GIS).

Quadrats will be used to determine species richness and estimate vegetation, litter, and rock cover. A 0.5-square-meter rectangular quadrat will be used for semiquantitative revegetation monitoring. Species richness will be determined by listing all species found rooted within or overhanging the quadrat. Foliar cover by species will be estimated visually using the Daubenmire cover class system (Table 1). The midpoint of each cover class will be used for analysis. Estimates of total foliar and basal vegetation cover, litter cover, and rock cover will also be estimated for the entire quadrat. To assist in the estimates of cover, the edges of the quadrat may be painted using the Daubenmire method to aid in the estimation of 5%, 25%, 50%, and 75% cover increments (Bonham 1989).

Table 1. Daubenmire Cover Class System

Cover Class	Range of Cover (%)	Class Midpoints (%)
1	0−5	2.5
2	5−25	15
3	25−50	37.5
4	50−75	62.5
5	75−95	85
6	95−100	97.5

(From Global Rangelands 2017)

Revegetation areas will be divided into monitoring areas or units according to a variety of factors that may include slope, aspect, historical location information, project-specific information, seedbed preparation, erosion control type, or landmark features. Random quadrat locations will be generated for each monitoring area. Random locations will be generated using a GIS. Quadrat locations will be located in the field using a global positioning system unit. Data will be analyzed and summarized for each year to evaluate revegetation success and change.

Monitoring will be conducted annually at revegetation locations until success criteria have been achieved or until determined to be unnecessary. After locations have met success criteria, they will be incorporated into a rotation in which they will continue to be monitored every few years. The primary purpose of the continued monitoring is to demonstrate that the success criteria continue to be met and that there is sufficient vegetation cover to stabilize the soil and help prevent erosion. The data will also document successional plant community change over time and whether additional management actions are necessary.

The success criteria and monitoring described here do not necessarily apply to revegetation where other regulatory drivers take precedence (e.g., Preble's mouse habitat, wetlands). Though

the monitoring described here may be used for these types of locations, the regulatory requirements may have their own monitoring protocols and success criteria.

4.0 References

Bonham, C.D., 1989. *Measurements for Terrestrial Vegetation*, John Wiley & Sons, New York.

Clark, S.V., P.J. Webber, V. Komarkova, and W.A. Weber, 1980. *Map of Mixed Prairie Grassland Vegetation, Rocky Flats, Colorado*, Occasional Paper No. 35, Institute of Arctic and Alpine Research. University of Colorado, Boulder, Colorado.

DOE (U.S. Department of Energy), 2016. *Annual Report of Site Surveillance and Maintenance Activities at the Rocky Flats Site, Calendar Year 2015*, LMS/RFS/S13696, Office of Legacy Management, April.

DOE (U.S. Department of Energy), 2017a. *Rocky Flats Site, Colorado, Vegetation Management Plan*, LMS/RFS/S04512, Office of Legacy Management, August.

DOE (U.S. Department of Energy) 2017b. *Erosion Control Plan for Rocky Flats Property, Central Operable Unit,* LMS/RFS/S03416, Office of Legacy Management, September.

Global Rangelands, 2017. Daubenmire Cover Class Method. https://globalrangelands.org/inventorymonitoring/daubenmire, accessed August 21, 2017.

K-H (Kaiser-Hill Company LLC), 1997. *Site Vegetation Report: Terrestrial Vegetation Survey (1993–1995) for the Rocky Flats Environmental Technology Site*, prepared by Kaiser-Hill Company LLC for the U.S. Department of Energy, Rocky Flats Field Office, Golden, Colorado, June.

SCS (Soil Conservation Service), 1980. *Soil Survey of Golden Area, Colorado*, U.S. Department of Agriculture.

Appendix A

Revegetation Seed Mixes

(NOTE: Revegetation specifications will be provided
in the Statement of Work for each project
because of location-specific requirements.)

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Flat Areas Seed Mix 1 (Areas on Pediment Tops* with Slopes Less Than 10%)
(Based on 50 seeds/sq. ft.)

Date: 08/17

Scientific Name	Common Name	Variety	% of Seed Mix	# Seeds Needed	# Seeds/Lb.	# Seeds/Sq. Ft.	Lbs./Acre (PLS)
Graminoids							
Agropyron smithii	Western wheatgrass	Arriba	20	435600	120000	10.0	3.63
Agropyron trachycaulum	Slender wheatgrass	San Luis	10	217800	120000	5.0	1.82
Andropogon gerardii	Big bluestem	Bonilla	10	217800	130000	5.0	1.68
Andropogon scoparius	Little bluestem	Aldous	8	174240	225000	4.0	0.77
Bouteloua curtipendula	Side-oats grama	Vaughn	15	326700	190000	7.5	1.72
Bouteloua gracilis	Blue grama	Hachita	15	326700	710000	7.5	0.46
Buchloe dactyloides	Buffalo grass	Texoka	5	108900	45000	2.5	2.42
Koleria pyrimidata	June grass		3	65340	2315400	1.5	0.03
Sorghastrum nutans	Indian grass	Cheyenne	2	43560	120000	1.0	0.36
Sporobolus cryptandra	Sand dropseed		7	152460	5298000	3.5	0.03
Stipa viridula	Green needlegrass	Lodorm	5	108900	115000	2.5	0.95
	Total		100	2178000		50.0	13.86
	Sq. ft/acre		43560				
	Seeds/sq. ft.		50				
	Seeds needed/acre		2178000				

(1) This pounds per acre assumes drill-seeding is used. If the seed is to be broadcast, the application rates are to be doubled.

(2) PLS = pure live seed. Be sure to specify this to the seed dealer when ordering.

(3) The seed is to be certified weed-free.

* Note: The pediment tops are the upper flat surfaces at Rocky Flats.

Hillside Seed Mix
(Based on 50 seeds/sq. ft.)

Date: 08/17

Species	Common Name	Variety	% of Seed Mix	# Seeds Needed	# Seeds/Lb.	# Seeds/Sq. Ft.	Lbs./Acre (PLS)
Graminoids							
Agropyron dasystachyum	Thickspike wheatgrass	Critana	5	108900	150000	2.5	0.73
Agropyron smithii	Western wheatgrass	Arriba	23	500940	120000	11.5	4.17
Agropyron trachycaulum	Slender wheatgrass	San Luis	15	326700	120000	7.5	2.72
Bouteloua curtipendula	Side-oats grama	Vaughn	13	283140	190000	6.5	1.49
Bouteloua gracilis	Blue grama	Hachita	24	522720	710000	12.0	0.74
Buchloe dactyloides	Buffalo grass	Texoka	10	217800	45000	5.0	4.84
Stipa viridula	Green needle grass	Lodorm	10	217800	180000	5.0	1.21
	Total		100	2178000		50.0	15.90
	sq. ft./acre		43560				
	Seeds/sq. ft.		50				
	Seeds needed/acre		2178000				

(1) This pounds per acre assumes drill-seeding is used. If the seed is to be broadcast, the application rates are to be doubled.

(2) PLS = pure live seed. Be sure to specify this to the seed dealer when ordering.

(3) The seed is to be certified weed-free.

Note: For use on hillslope areas at Rocky Flats.

Drainage Bottom Seed Mix
(Based on 50 seeds/sq. ft.)

Date: 08/17

Wet Areas Along Edge of Streambank or Pond Edge							
Scientific Name	**Common Name**	**Wetland Designation**	**% of Seed Mix**	**# Seeds Needed**	**# Seeds/Lb.**	**# Seeds/Sq. Ft.**	**Lbs./Acre (PLS)**
Graminoids							
Agrostis scabra	Hair grass	FAC	20	435600	5000000	10.0	0.09
Carex nebrascensis	Nebraska sedge	OBL	25	544500	534000	12.5	1.02
Eleocharis palustris	Longstem spike rush	OBL	10	217800	1240000	5.0	0.18
Juncus balticus	Baltic rush	OBL	25	544500	500000	12.5	1.09
Scirpus americanus	Three-square	OBL	15	326700	600000	7.5	0.54
Shrubs							
Amorpha fruticosa	Wild indigo	OBL	5	108900	77000	2.5	1.41
	Total		100	2178000		50.0	4.33

Dryer Areas away from Edge of Streambank or Pond Edge							
Scientific Name	**Common Name**	**Variety**	**% of Seed Mix**	**# Seeds Needed**	**# Seeds/Lb.**	**# Seeds/Sq. Ft.**	**Lbs./Acre (PLS)**
Graminoids							
Agropyron smithii	Western wheatgrass	Arriba	15	326700	120000	7.5	2.72
Agropyron trachycaulum	Slender wheatgrass	San Luis	20	435600	120000	10.0	3.63
Andropogon gerardii	Big bluestem	Bonilla	15	326700	130000	7.5	2.51
Bouteloua gracilis	Blue grama	Hachita	10	217800	710000	5.0	0.3
Elymus canadensis	Canada wildrye	-	20	435600	115000	10.0	3.79
Panicum virgatum	Switchgrass	Nebraska 28	20	435600	390000	10.0	1.12
	Total		100	2178000		50.0	14.08
	Sq. ft/acre		43560				
	Seeds/sq. ft.		50				
	Seeds needed/acre		2178000				

(1) This pounds per acre assumes drill-seeding is used. If the seed is to be broadcast, the application rates are to be doubled.

(2) PLS = pure live seed. Be sure to specify this to the seed dealer when ordering.

(3) The seed is to be certified weed-free.

Wetland Seed Mix
(Based on 50 seeds/sq. ft.)

Date: 08/17

Scientific Name	Common Name	Wetland Designation	% of Seed Mix	# Seeds Needed	# Seeds/Lb.	# Seeds/Sq. Ft.	Lbs./Acre (PLS)
Graminoids							
Agrostis scabra	Hair grass	FAC	10	217800	5000000	5.0	0.04
Carex nebrascensis	Nebraska sedge	OBL	5	108900	534000	2.5	0.20
Eleocharis palustris	Longstem spike rush	OBL	15	326700	1240000	7.5	0.26
Juncus balticus	Arctic rush	FACW	10	217800	8000000	5.0	0.03
Juncus torreyi	Torrey's rush	FACW	15	326700	12300000	7.5	0.03
Scirpus acutus	Hard-stem bulrush	OBL	7	152460	405000	3.5	0.38
Scirpus americana	Three-square	OBL	5	108900	600000	2.5	0.18
Scirpus validus	Soft-stem bulrush	OBL	13	283140	550000	6.5	0.51
Spartina pectinata	Prairie cordgrass	FACW	20	435600	197000	10.0	2.21
	Total		100	2178000	28826000	50	3.85
	Sq. ft./acre		43560				
	Seeds/sq. ft.		50				
	Seeds needed/acre		2178000				

(1) PLS = pure live seed. Be sure to specify this to the seed dealer when ordering.

(2) The seed is to be certified weed-free.

Temporary Seeding Seed Mix 1
(Based on 50 seeds/sq. ft.)

Date: 08/17

Species	Common Name	Variety	% of Seed Mix	# Seeds Needed	# Seeds/Lb.	# Seeds/Sq. Ft.	Lbs./Acre (PLS)
Agropyron smithii	Western wheatgrass	Arriba	25	544500	120000	12.5	4.5
Agropyron trachycaulum	Slender wheatgrass	San Luis	40	871200	120000	20.0	7.3
Bouteloua curtipendula	Side-oats grama	Vaughn	35	762300	190000	17.5	4.0
	Total		100	2178000		50.0	15.8
	Sq. ft/acre		43560				
	Seeds/sq. ft.		50				
	Seeds needed/acre		2178000				

(1) This pounds per acre assumes drill-seeding is used. If the seed is to be broadcast, the application rates are to be doubled.

(2) PLS = pure live seed. Be sure to specify this to the seed dealer when ordering.

(3) The seed is to be certified weed-free.

Temporary Seeding Seed Mix 2
(Based on 50 seeds/sq. ft.)

Date: 08/17

Species	Common Name	Variety	% of Seed Mix	# Seeds Needed	# Seeds/Lb.	# Seeds/Sq. Ft.	Lbs./Acre (PLS)
Agropyron trachycaulum	Slender wheatgrass	San Luis	90	1960200	120000	45.0	16.3
Tricitum aestivum x Elytrigia elongata	ReGreen		10	217800	11000	5.0	19.8
	Total		100	2178000		50.0	36.1
	Sq. ft/acre		43560				
	Seeds/sq. ft.		50				
	Seeds needed/acre		2178000				

(1) This pounds per acre assumes drill-seeding is used. If the seed is to be broadcast, the application rates are to be doubled.

(2) PLS = pure live seed. Be sure to specify this to the seed dealer when ordering.

(3) The seed is to be certified weed-free.

Appendix B

IA Revegetation Areas
Soil Characterization Data
from Summer 2003

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Industrial Area Revegetation Plan Soil Sampling

Problem

After remediation activities have been completed in the Industrial Area (IA) for various projects, revegetation of the locations is necessary to prevent soil erosion and to return the areas to a more native state. The seedbed into which seeding will take place consists of the material left after the remediation portion of the project is completed. Soil characterization sampling is being done to characterize soil conditions at revegetation locations to determine whether soil amendments will need to be added for optimal plant growth. For the best revegetation success it is important to know if any soil parameters are outside the range required for optimal plant growth.

Identification of Decisions

The characterization sampling and analysis question to be evaluated is:

1. Do the selected soil parameters at the revegetation locations fall within the range specified for optimal plant growth and revegetation success (Savage and Savage 2003)?

Inputs to the Decisions

Information needed to evaluate the confirmation sampling and analysis question are as follows:

1. List of soil parameters to measure and the range of optimal values for each parameter. See Table 1 below.

Table 1. Soil Parameters To Be Measured

pH
Electrical Conductivity (EC; mmhos/cm)
Sodium Adsorption Ratio (SAR)
Saturation (%)
Boron (ppm)
Selenium (ppm)
Textural Class
Coarse Fragments
Nitrogen (NO3)
< 1% organic matter
1-2% organic matter
>2% organic matter
Phosphorus
Potassium

ppm = parts per million

2. Soil sampling locations.

3. Sampling results.

Study Boundaries

Samples will be collected from each of three broad categories identified for different seed mixes in the IA: flat areas, hillside slope areas, and drainage bottom areas. Figure 1 shows the general locations where soil samples will be taken initially. As additional areas are prepared for revegetation, additional samples may be collected.

For the flat area category (representing the pediment top in the IA), the solar ponds and the building footprints for T893A, T893B, and 125 have been selected for initial sampling. A total of three composite samples will be taken from these areas—one from the solar ponds, one from the T893A and T893B buildings, and one from Building 125. For the hillside area category, three samples will be taken—one from the north-facing hillside where Buildings 993 and 987 were located, one from the old Perimeter Intrusion Detection Assessment System (PIDAS) area west of the waste-water treatment plan that was regraded as part of the solar pond project, and one from a small disturbance along the north access road where a fence corner was removed. Table 2 summarizes the locations and number of samples to be taken. As additional hillside areas in the IA are prepared for revegetation, additional sampling will be conducted. For the drainage bottom categories, no samples will be taken currently since no areas in this category have been disturbed. Sampling for these areas will be conducted when these areas become ready for revegetation.

Table 2. Soil Sampling Locations and Number of Samples

Location	# of Samples	# Subsamples for Compositing
Solar Ponds	1	15
T893A and T893B	1	10
Building 125	1	10
Fence corner	1	4
Old PIDAS	1	10
Buildings 993 and 987 area	1	10
Total # Samples	6	

The soil samples will be collected and shipped to an off-site soil laboratory for analysis. A composite sample of the top 18 inches of plant growth medium from representative locations within the revegetation parcels will be collected for each sample. Specific locations for representative subsamples within the revegetation parcels will be subjectively selected and flagged in the field by site ecologists. Randomization of subsamples is not required so that the apparent visual variability can be taken into account. Samples will be taken from areas recently revegetated. The subsamples from each location will be composited into one sample for each area to be sent to the laboratory for analysis. Site procedures and policies will be followed for the collection and shipping of samples. Soil volumes collected will be consistent with the amounts needed to conduct the laboratory analyses. Table 1 lists the soil parameters that are to be measured.

Results will be provided in hardcopy and electronic form to the K-H Ecology Group.

Decision Rules

The sampling and analysis decision rules that describe how the data will be evaluated are listed below.

1. Laboratory results for each composite sample will be compared to the range of suggested optimal values the CDMG column in Table 1 from Savage and Savage (2003). If any of the values for the parameters measured fall outside the optimal values listed in Table 1 evaluation of potential corrective actions will be taken.

Tolerable Limits on Decision Errors

The composite sampling method will provide a good overall measure of the soil conditions present at the revegetation locations. No statistical analysis is required or necessary for these data. A simple descriptive comparison of laboratory results to the values in Table 1 will be sufficient for the level of accuracy and scope required.

Optimization of Plan Design

Optimization of this sampling design does not need to meet rigorous statistical analysis. It is a simple descriptive comparison of laboratory results to the values in Table 1 in Savage and Savage (2003) will be sufficient for the level of accuracy and scope required.

References

Savage and Savage, 2003. *Rocky Flats Environmental Technology Site Industrial Area Revegetation Plan,* Final Draft, Prepared by Savage and Savage, Inc., Louisville, Colorado, for Kaiser-Hill Company, LLC., January.

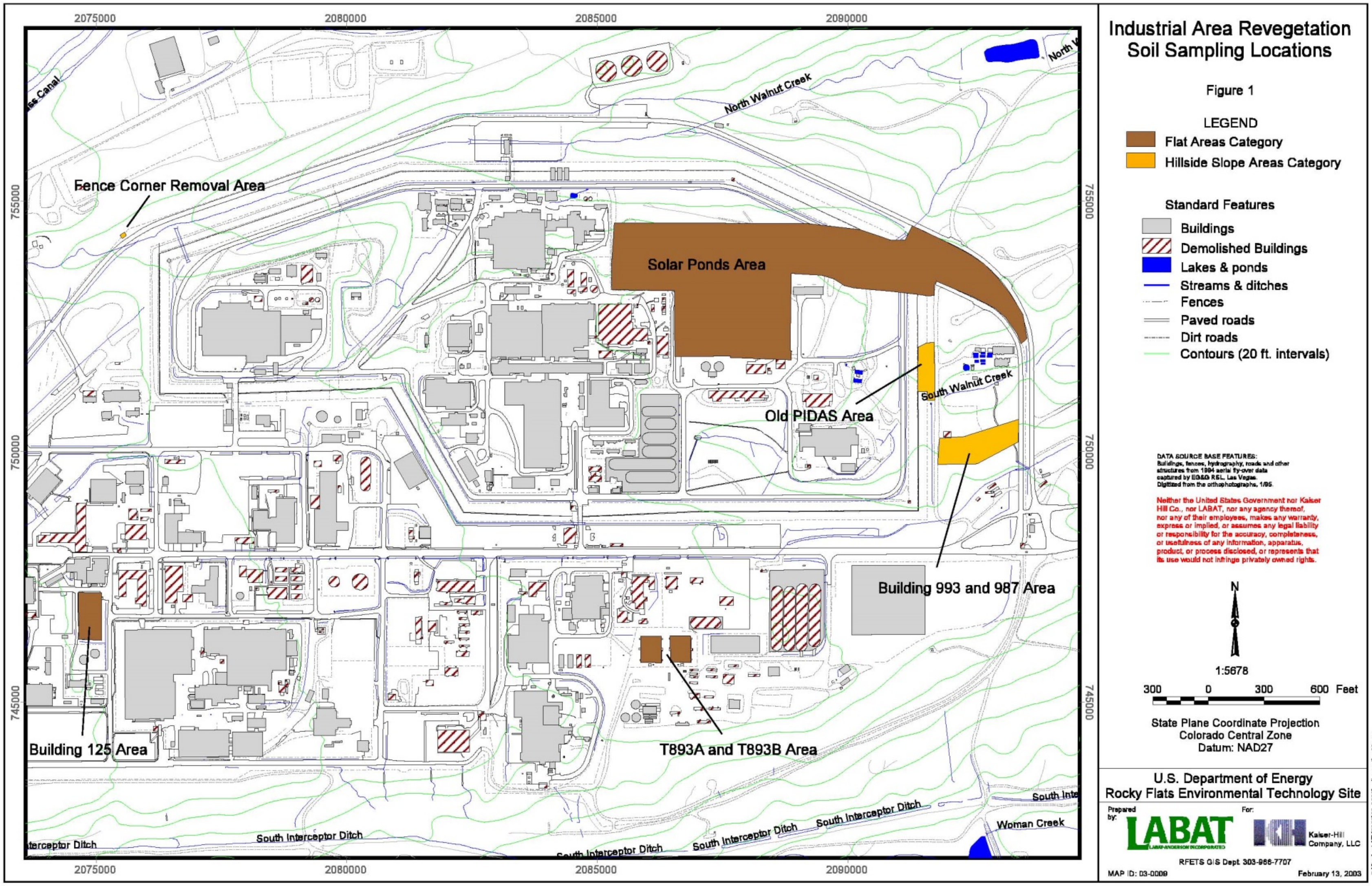
Industrial Area Revegetation
Soil Sampling Locations
Figure 1
LEGEND
Flat Areas Category
Hillside Slope Areas Category
Standard Features
Buildings
Demolished Buildings
Lakes & ponds
Streams & ditches
Fences
Paved roads
Dirt roads
Contours (20 ft. intervals)
Fence Corner Removal Area
Solar Ponds Area
Old PIDAS Area
Building 993 and 987 Area
Building 125 Area
T893A and T893B Area
North Walnut Creek
South Walnut Creek
South Interceptor Ditch
Woman Creek
2075000
2080000
2085000
2090000
755000
750000
745000
1:5678
300 0 300 600 Feet
State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27
U.S. Department of Energy
Rocky Flats Environmental Technology Site
Prepared by:
LABAT
For:
Kaiser-Hill Company, LLC
RFETS GIS Dept. 303-966-7707
MAP ID: 03-0009
February 13, 2003

Table B-3. Rocky Flats Industrial Area Revegetation Soil Sampling Summary

	Mesic		Xeric		CDMG*
Soil Variable	**Mean**	**SD**	**Mean**	**SD**	
Nitrogen (ppm)	4.27	2.72	5.93	4.06	<6 ppm
% Organic matter	1.66	0.43	1.39	0.45	1–2
Phosphorus (ppm)	4.67	2.31	4.33	2.31	<3 ppm
Potassium (exchan; ppm)	170.00	60.00	126.67	15.28	<60 ppm
pH	7.43	0.29	8.23	1.01	<5.5, >8.8
Electrical conductivity (mmho/cm)	0.58	0.13	1.55	0.96	>8.0
SAR	1.17	0.72	1.50	1.11	>10
% Saturation	38.77	1.35	32.73	8.24	<25, >80
Boron (ppm)	0.07	0.02	0.25	0.28	>5 ppm (pH >8.0)
Selenium (ppm)	0.00	0.00	0.00	0.00	>2.0 (pH >8.0)
Soil texture	Loam		Loam, sandy loam		clay, silt-clay, sand

n = 3 for each habtype

* CDMG = Colorado Division of Minerals and Geology unpublished guidance document (Savage and Savage 2003)

SD = standard deviation

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Appendix C

Qualitative Revegetation Evaluation Form

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Qualitative Revegetation Evaluation Form Form #_____

Date_____
Observer(s)_____
Location ID_____

Photographs taken today? Y N

Are seeded plant species present? Y N

Which seeded species are present? How abundant are the seeded species? Estimate overall cover of each seeded species using the following cover class system (1 = <5%; 2 = 6–25%; 3 = 26–50%; 4 = 51–75%; 5 = >75%). Comments on their condition.

Any evidence of nutrient or water deficiencies? If so, describe. _____

Are noxious weeds present? Y N

If yes, what species of noxious weeds are present? How abundant are the noxious weed species? Estimate overall cover of each noxious species using the following cover class system (1 = <5%; 2 = 6–25%; 3 = 26–50%; 4 = 51–75%; 5 = >75%).

Are other weedy species present? Y N

If so, what species and how abundant are they? Estimate overall cover of each weedy species using the following cover class system (1 = <5%; 2 = 6–25%; 3 = 26–50%; 4 = 51–75%; 5 = >75%).

Total Vegetation Cover (Estimate to nearest percent) _____