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# Revegetation Plan For Areas of the Fitzner/Eberhardt Arid Lands Ecology Reserve Affected by Decommissioning of Buildings and Infrastructure and Debris Clean-up Actions

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January 2011



**Pacific Northwest**  
NATIONAL LABORATORY

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Pacific Northwest National Laboratory  
Richland, Washington 99352



## Summary

The U.S. Department of Energy (DOE), Richland Operations Office is working to remove a number of facilities on the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE), which is part of the Hanford Reach National Monument. Decommissioning and removal of buildings and debris on ALE will leave bare soils and excavated areas that need to be revegetated to prevent erosion and weed invasion. Four main areas within ALE are affected by these activities (DOE 2009; DOE/EA-1660F): 1) facilities along the ridgeline of Rattlesnake Mountain, 2) the former Nike missile base and ALE headquarters (HQ) laboratory buildings, 3) the aquatic research laboratory at Rattlesnake Springs area, and 4) a number of small sites across ALE where various types of debris remain from previous uses. This revegetation plan addresses the revegetation and restoration of those land areas disturbed by decommissioning and removal of buildings, facilities and associated infrastructure or debris removal.

The primary objective of the revegetation efforts on ALE is to establish native vegetation at each of the sites that will enhance and accelerate the recovery of the native plant community that naturally persists at that location. Revegetation is intended to meet the direction specified by the Environmental Assessment (DOE 2009; DOE/EA-1660F) and by Stipulation C.7 of the Memorandum of Agreement (MOA) for the *Rattlesnake Mountain Combined Community Communication Facility and Infrastructure Cleanup on the Fitzner/Eberhardt Arid Lands Ecology Reserve, Hanford Site, Richland Washington* (DOE 2009; Appendix B).

Pacific Northwest National Laboratory (PNNL) under contract with CH2M Hill Plateau Remediation Company (CHPRC) and in consultation with the tribes and U.S. Department of Energy-Richland Operations Office (DOE-RL) developed a site-specific strategy for each of the revegetation units identified within this document. The strategy and implementation approach for each revegetation unit identifies an appropriate native species mix and outlines the necessary site preparation activities and specific methods for seeding and planting at each area. Revegetation work is scheduled to commence during the first quarter of FY 2011 to minimize the amount of time that sites are unvegetated and more susceptible to invasion by non-native weedy annual species.



## Acronyms and Abbreviations

ALE	The Fitzner/Eberhardt Arid Lands Ecology Reserve
BFI	BFI Native Seeds LLC
CHPRC	CH2M Hill Plateau Remediation Company
CTUIR	Confederated Tribes of Umatilla Indian Reservation
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy-Richland Operations Office
EA	Environmental Assessment
FHA	Federal Highway Administration
ft	feet
ha	hectare(s)
HQ	headquarters
in.	inch
km	kilometer(s)
m	meter(s)
mi	mile(s)
MOA	Memorandum of Agreement
USFWS	U.S. Fish and Wildlife Service





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# 1.0 Introduction

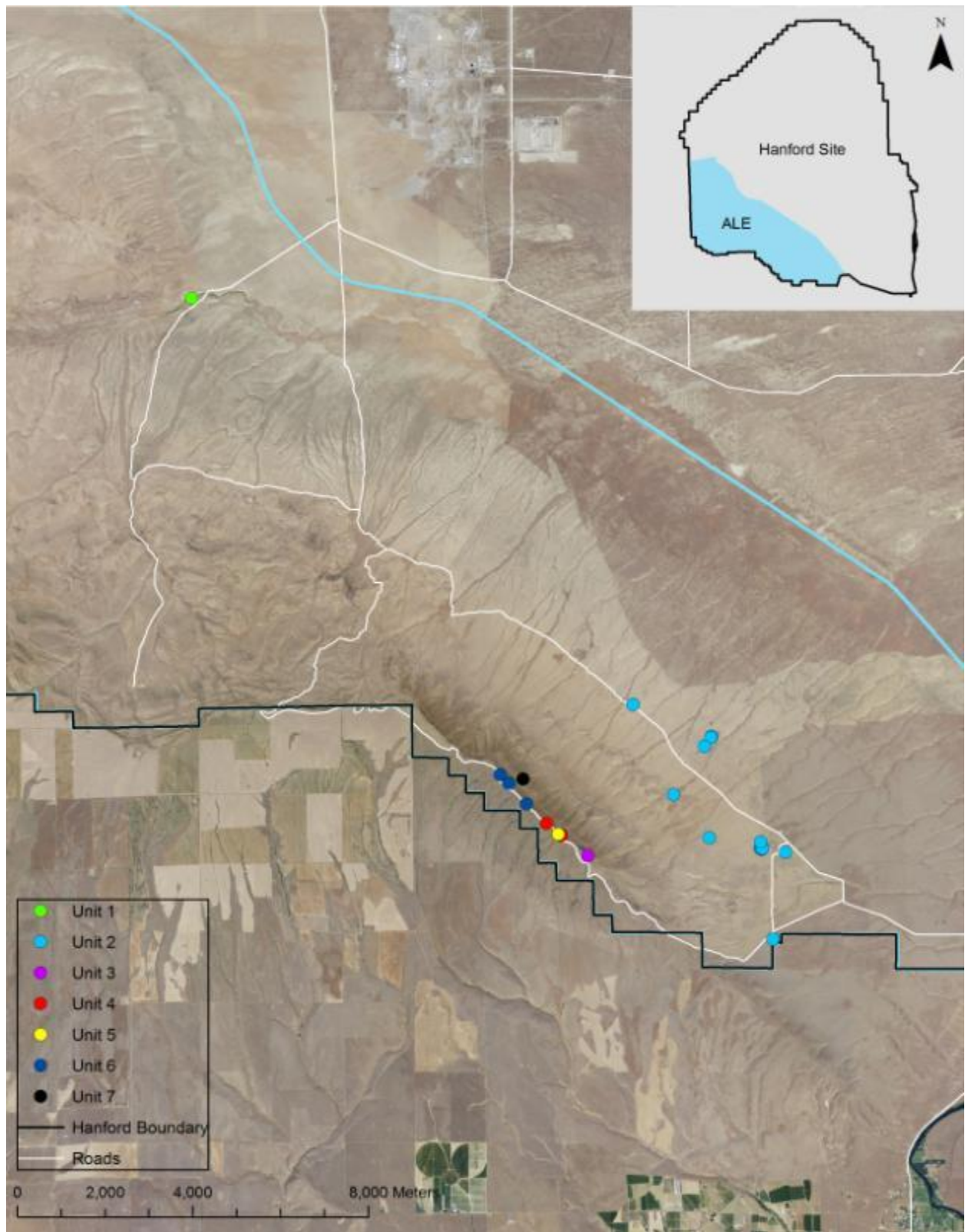
The U.S. Department of Energy (DOE), Richland Operations Office is working to remove a number of facilities on the Fitzner/Eberhardt Arid Lands Ecology Reserve (ALE). The ALE reserve is part of the Hanford Reach National Monument, which is managed by U.S. Fish and Wildlife Service (USFWS). Facilities remaining include those necessary for DOE and USFWS operations, and those facilities and communications equipment used by local governments and other organizations. Existing communications capabilities are being consolidated into a single facility on the ridgeline, consisting of an equipment building and two towers to support multiple antennas and radio repeaters. In addition, DOE will remove miscellaneous debris in various locations across ALE and repair the ALE boundary fence as necessary. Four main areas within ALE are affected by these activities (DOE 2009; DOE/EA-1660F): 1) facilities along the ridgeline of Rattlesnake Mountain, 2) the former Nike missile base and ALE headquarters (HQ) laboratory buildings, 3) the aquatic research laboratory at Rattlesnake Springs area, and 4) a number of small sites across ALE where various types of debris remain from previous uses. This revegetation plan addresses the revegetation and restoration of those land areas disturbed by decommissioning and removal of buildings, facilities and associated infrastructure or debris removal.

Revegetation of these locations was specified by the Environmental Assessment (DOE 2009; DOE/EA-1660F) and by Stipulation C.7 of the Memorandum of Agreement (MOA) for the *Rattlesnake Mountain Combined Community Communication Facility and Infrastructure Cleanup on the Fitzner/Eberhardt Arid Lands Ecology Reserve, Hanford Site, Richland Washington* (DOE 2009; Appendix B). These documents specify development of site-specific plans for implementing recontouring and revegetation of disturbed sites with native plant species. The site-specific guidance contained in this document is provided to support that objective.

Section 2 of this plan provides descriptions of the individual sites and locations, and classes the locations by their habitat types and revegetation requirements. In addition, this section outlines detailed guidance for implementing revegetation actions on each of the identified units, and describes the roles and responsibilities of parties and cooperators involved in conducting revegetation actions. Section 3 summarizes the plant materials needed for the revegetation actions. Section 4 describes the follow-on monitoring activities and management actions that are necessary to assess the success of the revegetation efforts and determine the need for any follow-on actions.

## 2.0 Revegetation Strategies and Implementation Guidance

Developing appropriate revegetation strategies and planning how to implement revegetation actions requires detailed information regarding the location, ecological and physical characteristics and site-specific limitations of each area to be revegetated. Each of the areas that require revegetation and restoration attention on the Arid Lands Ecology reserve were evaluated based on the type of habitat or plant association for that location, the amount and type of ground disturbing activities, the areal extent of the disturbance, and the soils and substrate. Using this information, areas were grouped according to habitat and site requirements into separate revegetation units (Figure 2.1, Table 2.1). Revegetation units are areas within the project site that have similar physical and or ecological characteristics where similar strategies and treatments will be applied.



**Figure 2.1.** Locations of the Revegetation Units on the ALE Reserve

**Table 2.1.** Listing of Areas to Be Revegetated by Habitat Type and Approximate Size

Site	Location	Habitat Type	Revegetation Unit	Estimated Size (acres)
646 – Aquatic Research Laboratory	East of Rattlesnake Springs	Black greasewood ( <i>Sarcobatus vermiculatus</i> )/Saltgrass ( <i>Distichlis stricta</i> )	Unit 1	0.5
6652-G, H, I, J, L and M, and parking areas;	ALE HQ	Big sagebrush ( <i>Artemisia tridentata</i> )/Bluebunch wheatgrass ( <i>Pseudoroegneria spicata</i> )	Unit 2	8.7
8 miscellaneous debris sites	8 sites; 1000 to 1600 ft elevation	Big sagebrush /Bluebunch wheatgrass	Unit 2	~ 1.0
Hodges Well Pump House and Roadway (6630)	South of ALE HQ	Big sagebrush ( <i>Artemisia tridentata</i> )/Bluebunch wheatgrass ( <i>Pseudoroegneria spicata</i> )	Unit 2	0.42
Radio telescope site (6631) and road	Rattlesnake ridge	Big sagebrush/bluebunch wheatgrass-Idaho fescue ( <i>Festuca idahoensis</i> ) and Thyme buckwheat ( <i>Eriogonum thymoides</i> )/bluebunch wheatgrass	Unit 3- Transitional	0.35
6652-C building and parking area, including 6652-D and 6632	Top of ridge	Thyme buckwheat/Bluebunch wheatgrass and Big sagebrush/Bluebunch wheatgrass-Idaho fescue	Unit 4- Transitional	
623A	Top of ridge	Thyme buckwheat/Bluebunch wheatgrass and Big sagebrush/Bluebunch wheatgrass-Idaho fescue	Unit 4- Transitional	0.35
6652-C Shed, Telescope Dome, and Berm Areas	Top of ridge	Thyme buckwheat /Bluebunch wheatgrass and Eastside Canyon Shrublands	Unit 5- Transitional	0.9
Power line Roadway— New underground power service	Along Rattlesnake ridge	Thyme buckwheat/Bluebunch wheatgrass and Big sagebrush/Bluebunch wheatgrass-Idaho fescue	Unit 4- Transitional	0.2
Combined Community Communications Facility	Along Rattlesnake Ridge	Thyme buckwheat/Bluebunch wheatgrass and Big sagebrush/Bluebunch wheatgrass-Idaho fescue	Unit 4- Transitional	0.34
Crown Castle (6635)	Along Rattlesnake Ridge	Thyme buckwheat/Bluebunch wheatgrass and Big sagebrush/Bluebunch wheatgrass-Idaho fescue	Unit 6- Transitional	0.1
6636 and 6637 Communication Towers and Access Roads	Along Rattlesnake Ridge	Thyme buckwheat/Bluebunch wheatgrass and Big sagebrush/Bluebunch wheatgrass-Idaho fescue	Unit 6- Transitional	0.6
6652T—Pumphouse	Below Ridgeline	Eastside Canyon Shrublands-Riparian	Unit 7	0.1

The strategies and implementation steps for each of the revegetation units depend on the initial site conditions and the desired future conditions. The main objective of revegetation on the ALE sites is to develop a robust and functional native plant community at each revegetation unit that is appropriate for the soil and local climate. Revegetation strategies at these sites are intended to accelerate the recovery of the habitat and restore ecosystem function to enable recovery of the natural vegetation without the need for further treatment; however, the success of these efforts and determination of the need for further treatment will be evaluated through monitoring. The species mix identified for each unit consists of locally-derived native plants and seeds designed to provide a range of vegetation structure and diversity

that will facilitate continuing natural recovery of the habitat and provide resistance to invasion by weedy exotic species. Section 2.1 outlines the general approach to implementing revegetation strategies. Section 2.2 presents the site considerations, specific objectives, and strategies for each revegetation unit.

## 2.1 Implementation Approach

In general, three types of ground surface conditions exist at the ALE revegetation units that will require different site preparation, seeding and planting strategies:

- heavily disturbed sites where ground surfaces consist of bare soils with relatively little rock or cobble at the completion of project decommissioning activities
- heavily disturbed sites where the resulting ground surface consists of mixed cobble, rocks and soils with very limited amounts of soil or fine materials in the rock substrate
- sites where much of the ground surface has not been disturbed or excavated, but may be compacted or rocky, such as unimproved two-track access routes or parking areas.

Revegetation units that are located at the upper elevations of ALE (above 2600 ft MSL), will also be subject to extreme weather events—that is, high winds, cooler temperatures, and earlier and more snow. These conditions must be considered in planning implementation at these sites. Seeding and planting schedules (see Section 3) are designed to avoid harsh winter conditions, and seeding strategies are designed to ameliorate the effects of high winds. Revegetation units at the lower elevations of ALE generally will have a more consistent soil substrate with fewer rocks and rubble and weather is expected to be more moderate during the planting and establishment phase.

In order to meet the demands of current project schedules and funding availability, we recommend a two-pronged approach of seeding grasses and forbs as well as transplanting shrubs and forbs at a number of the revegetation units. This type of approach is also likely to accelerate the recovery of the natural vegetation. The mix of seeds and transplants are identified for each unit where this approach is prescribed. Planting strategies for transplanting forbs and shrubs are anticipated to be similar for silt-loam and sandy-loam soil conditions. Where substrates consist of cobbles and compacted soils, strategies for transplanting may be modified. Transplanting into sites with primarily rocky substrate will be limited. The timing of transplanting will be dependent on weather (see section 3).

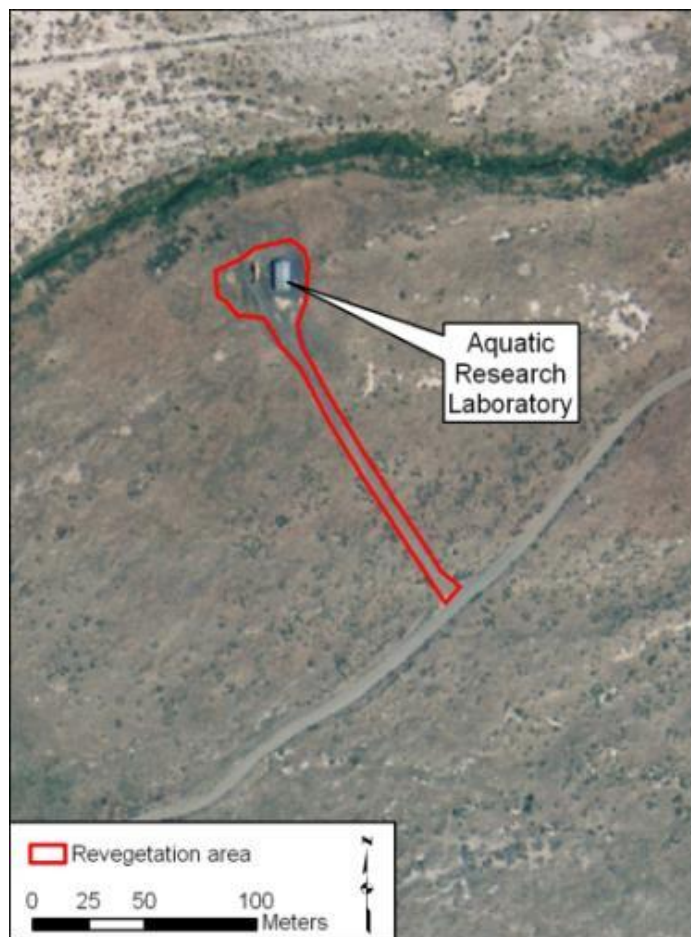
For several of the revegetation units where soils consist primarily of silt loams, of grasses will be drill seeded and forb seeds will be broadcasted to provide islands of diversity within the larger revegetation footprint. On smaller revegetation units and those with rocky substrate, seeding will generally be conducted as a three-step process: 1) broadcast seeding; 2) watering, to achieve 1/10<sup>th</sup> in. across the planting area; and 3) a mulch application held in place by either crimping or a tackifier. Seed will not be added to the hydromulch; rather it will be applied in the order specified here. Depending on the size of the site and topography, broadcasting seeds may be accomplished either by hand sowing, broadcasting using specially equipped all-terrain vehicles, or using hydroseeding equipment. For revegetation units located below 2600 ft elevation, a native grass straw cover will be applied in step 3, followed by crimping to hold the straw in place. When seeding the revegetation units at the upper elevation on ALE, the hydroseeding process may be modified. The process will use water to move seeds into the substrate and into safe sites. Then, a plant-based guar gum tackifier will be applied to stabilize the surface over the winter months and prevent seeds from being blown away from the revegetation site.

## 2.2 Site Descriptions and Revegetation Strategies

Within this section, we briefly describe the location and current conditions at each site, describe the desired future conditions and revegetation objectives for each revegetation unit, and outline the treatment strategies to address site-specific conditions. Equipment limitations are identified and recommendations are made to maximize revegetation success and limit further disturbance of the revegetation footprint for each revegetation unit. The desired seed and plant mix is also outlined for each unit. The approximate extent of each area was delineated in the field using global positioning systems to map revegetation site boundaries.

### 2.2.1 Revegetation Unit 1—646 Aquatic Research Laboratory Area

The area associated with the 646 building is approximately 0.5 acres and is located adjacent to Rattlesnake Springs along the gravel road entering ALE from Gate 118. The site of the building includes a short entrance road from the main access road (Figure 2.2) and together these areas comprise Unit 1. Current soil conditions consist of graveled and bare surfaces underlain by compacted soils. The primary objectives for revegetation unit 1 are to develop sufficient grass and shrub cover to protect the site from wind and water erosion, provide resistance to weed invasion, provide a representative level of species diversity, and enhance the recovery of the unit to a black greasewood/saltgrass community.



**Figure 2.2.** Unit 1: Aquatic Research Laboratory

The general habitat around the site is best characterized as falling within a black greasewood/saltgrass vegetation association. Saltgrass grows within the existing site footprint. Soils are silty to sandy at the site and are highly alkaline. Weedy species are prevalent in the area as a result of previous disturbance and land-use, and cheatgrass (*Bromus tectorum*) is common. The desired future conditions for this site would be to return it to a black greasewood/saltgrass association consistent with the surrounding habitat; however, establishing either of these species from seed at this area may be problematic for differing reasons. Black greasewood is a phreatophyte, that is, its taproot must reach the groundwater for survival. It is unlikely that seedlings, either from seed or from transplanting, would be able to grow sufficiently during the first growing season to make root contact with the groundwater, which is believed to be approximately 20 ft below the surface in the subject area. Saltgrass could be established from seed, but very few seed sources are available for this species, and no sources have been found within the Columbia Basin. Seed for saltgrass could be collected from the surrounding area for inclusion in the seed mix or for growing plugs to transplant. It may also be feasible to collect some rhizomes of this species and spread the existing salt grass plants growing on the unit across the revegetation area.

Where the depth of gravel exceeds 1 in., it should be removed and/or lightly scraped or bladed from the surface; where gravels are thin (<1 in.) they may be left in place or lightly tilled to provide a rock mulch for retention of moisture and seeds. Compacted soils should be lightly tilled using equipment such as a rock ripper or subsoiler (or possibly a disk harrow) to loosen/roughen the surface and shatter compacted areas to a depth of at least 6 in.

The desired future conditions for Unit 1 are to develop a stand of native species that will blend with the surrounding vegetation and provide a native base for successional establishment of black greasewood and saltgrass. These two species will likely move into the revegetated area and become established over time if weeds are controlled and if the revegetation effort is successful. Sandberg’s bluegrass is a common component of the surrounding habitat and is included in the revegetation seed mix. Other recommended species that represent seral stages or transition species for this association are presented in Table 2.2. The amounts and rates of application for forb seeds used in revegetation are dependent on seed availability.

**Table 2.2.** Revegetation Unit 1: Suggested Species for Seed Mix and Transplant Stock

Planting Mix	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg’s bluegrass	small bunchgrass	seeding	20
Crouching milkvetch	forb	seeding and transplant	see Table 3.1
Carey’s balsamroot	forb	seeding	(a)
Slender hawksbeard	forb	seeding	(a)
Hoary aster	forb	seeding	(a)
Hoary falseyarrow	forb	seeding	(a)
Monro’s globemallow	forb	seeding	(a)
Yarrow	forb	seeding	(a)
Big sagebrush	shrub	seeding and transplant	see Table 3.1
Spiny hopsage	shrub	transplant	see Table 3.1

(a) Seeding rate dependent on seed availability  
 PLS = pure live seed



## 2.2.2 Revegetation Unit 2—6652-G, H, I, J, M, and L, Hodges Well and Access Road, and Miscellaneous Debris Locations

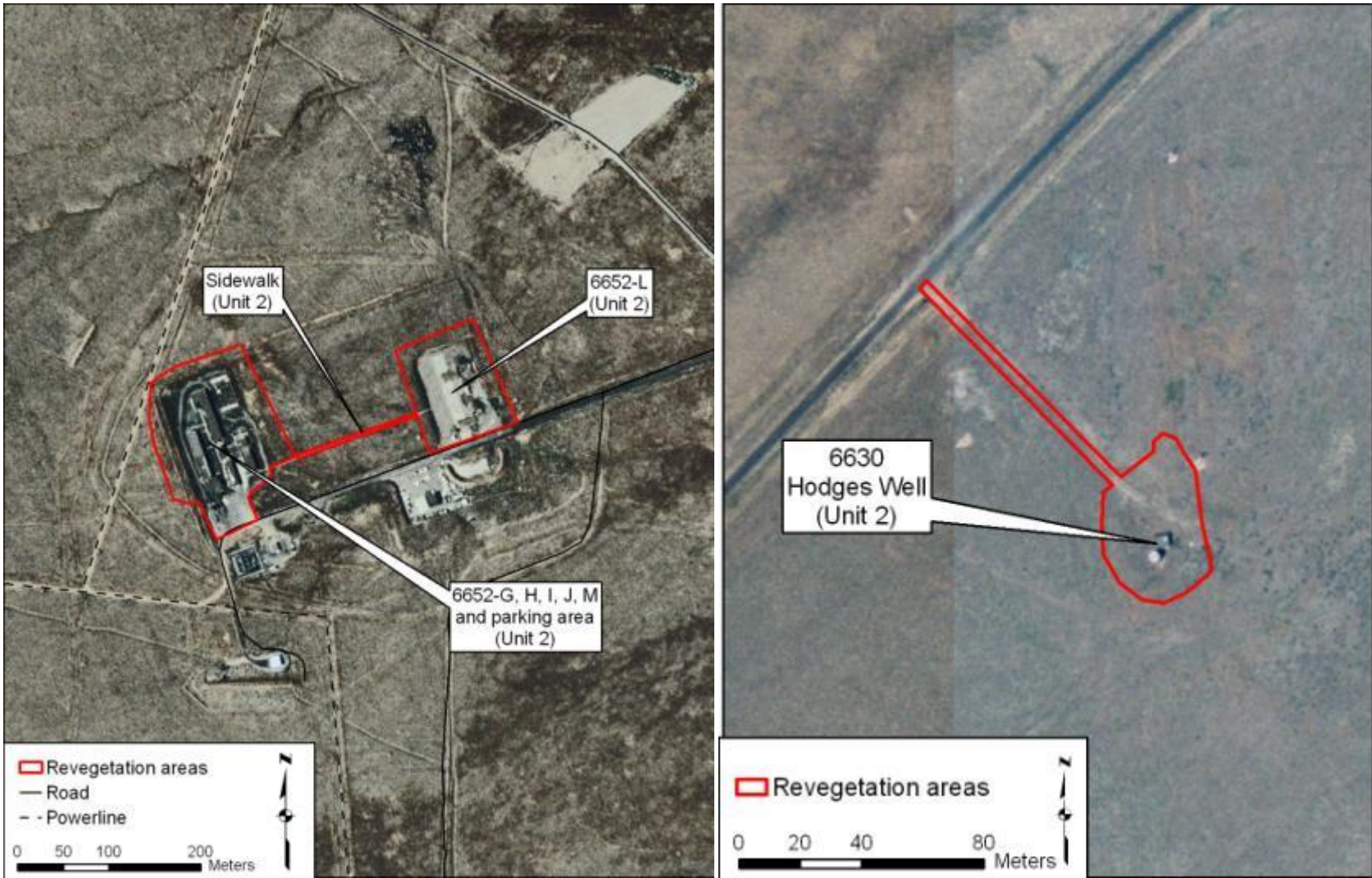
Unit two consists of two larger footprint areas approximately 2 km apart and 8 miscellaneous debris locations: the ALE headquarters buildings (6652-G, H, I, J, K, L, and M and surrounding facilities) as well as 6630 building (the Hodges well building, storage and access route); cisterns associated with the gas wells above the 1200 ft road; cisterns located off the Gate 111 road, concrete debris, and a concrete structure used for research. Together the individual sites comprise approximately 9.7 acres that will require revegetation. These sites are located at approximately 1000 to 1600-ft elevation in silt loam soils (Figure 2.1 and Figure 2.3 and Figure 2.4). The primary objectives for revegetation unit 2 are to develop sufficient bunchgrass grass and shrub cover to protect the site from wind and water erosion, provide resistance to weed invasion, provide a representative level of species diversity, and enhance the recovery of the unit to a big sagebrush/bluebunch wheatgrass community. The seed mix and planting methods are similar for these areas and the ground conditions are expected to be similar.

The 6652-L facility is currently in use as part of a National Science Foundation research project and will not be decommissioned until November 2011; revegetation of that area and location is planned to be conducted during fall and winter of 2011 to 2012. The area that will be disturbed by removal and decommissioning of the 6652-L facility is estimated to be approximately 2.9 acres. During decommissioning the underground facility will be filled with grout and above-ground portions will be removed. Then, the surface will be contoured using soil from the adjacent area between 6652-L and the 6652-H and I footprint, which lies at slightly higher elevation. Soils would be graded from approximately 100 ft back from the edge of the existing pavement and gravels associated with the 6652-L facility. The area to the west of 6652-L has been previously revegetated using a crested wheatgrass (*Agropyron cristatum*) mix. The entire disturbance footprint will be revegetated using the methods and seed mix identified for revegetation of unit 2 during FY 2011.

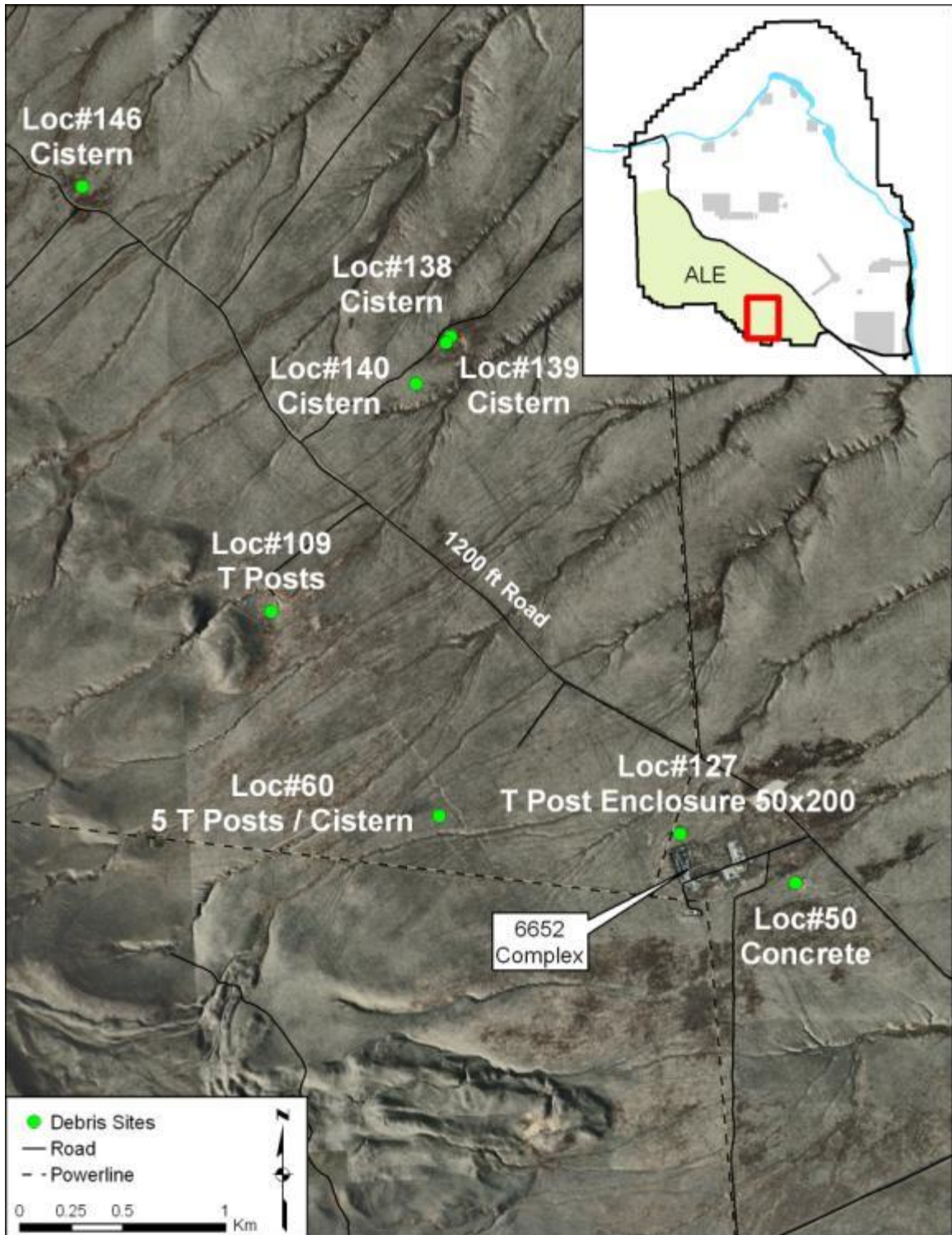
The sites designated as revegetation unit 2 fall within the big sagebrush/bluebunch wheatgrass habitat type. Thus, the desired future conditions for the sites in revegetation unit 2 are to establish species that will support development and recovery of a big sagebrush/bluebunch wheatgrass plant community. Establishing a robust stand of bluebunch wheatgrass and Sandberg's bluegrass is a critical step in restoring community function and developing a weed-resistant vegetation cover. The shrub and forb species listed in Table 2.3 are included to provide diversity and vegetation structure, which should accelerate recovery of the plant community.

Potential constraints and limitations for these sites include compaction of soils beneath the area where the ALE Headquarters buildings were removed, where the mobile offices are staged, and in the parking areas. When decommissioning is completed, thick (>1 in. depth) gravels will need to be removed. Compacted soils will need to be shattered and the soil surface roughened by ripping or disking to promote soil-to-seed contact and allow root elongation. Several of the revegetation sites in unit 2 are highly compacted and will require mechanical manipulation of the soil surface for seedbed preparation to improve seed-to-soil contact and allow root elongation. This should be accomplished using a subsoiler or rock ripper to roughen the surface and till the soil to a depth of at least 6 in.

Depending on the size and condition of the substrate, some of the areas within revegetation unit 2 will be drill-seeded to plant the grass species. Seeding of the species listed in Table 2.3 should be conducted in the late fall/ early winter time frame. Because the amount of forb seed available to include in the seeding mix is small in comparison to the amount of grass seed, the forbs may be hand broadcasted



**Figure 2.3.** Revegetation Unit 2: 6652-G, H, I, J, K, L, and M and Surrounding Facilities



**Figure 2.4.** Miscellaneous Debris Sites That Will Require Revegetation

rather than drilled with the grass seed. Shrubs and forbs grown in the greenhouse will be transplanted to the sites after late fall/early winter seeding. Seeding rates for forb species are dependent on the amount available.

**Table 2.3.** Revegetation Unit 2: Suggested Species for Seed Mix and Transplant Stock

Planting Mix	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg's bluegrass	small bunchgrass	seeding	10
Bluebunch wheatgrass	large bunchgrass	seeding	10
Lupine sp.	forb	seeding	as available
Carey's balsamroot	forb	seeding	as available
Piper's daisy	forb	seeding and transplant	transplant rates see Table 3.2
Yarrow	forb	seeding	as available
Crouching milkvetch	forb	seeding and transplant	see Table 3.1
Slender hawkbeard	forb	seeding	as available
Bigseed lomatium	forb	seeding and transplant	see Table 3.1
Hoary aster	forb	seeding	as available
Hoary falseyarrow	forb	seeding	as available
Big sagebrush	shrub	seeding	as available

PLS = ?

### 2.2.3 Revegetation Unit 3: 6631 Radio-Telescope Site and Access

The area where the radio telescope and pad were removed is located approximately 200 m to the north of the paved road traveling to the top of Rattlesnake ridge (Figure 2.5). It consists of an access road approximately 450 ft long and a roughly circular area where the radio telescope and concrete pad were located. The site supports a transitional plant community that includes elements of lithosol communities (i.e., thyme buckwheat or roundhead buckwheat (*Eriogonum sphaerocephalum*)/bluebunch wheatgrass that establish on shallow rocky/stony soils) grading into a bunchgrass and shrub community containing bluebunch wheatgrass, Idaho fescue, big sagebrush, green and gray rabbitbrush and three-tip sagebrush (*Artemisia tripartita*).

Most of the site is relatively flat with a 2 to 3-ft sloped edge where the area leveled for the facility intersects the hillside and surrounding undisturbed landscape (Figure 2.6). Disturbance of the side slope and grading to re-contour and reduce the slope angle would not only disturb a significant additional land area that currently supports undisturbed native vegetation, it would also remove the native vegetation that has reestablished on the slope. We recommend that the sideslopes be left undisturbed and that contouring and revegetation activities be limited to the footprint for the building, parking area, and roadway.

The desired future conditions for revegetation unit 3 involve development of a big sagebrush-three-tip sagebrush/bunchgrass community. Because the site lies within an area of transition between lithosol communities and deeper soil communities, the proposed species mix includes species from both types of plant associations (Table 2.4). Establishment of a robust stand of native bunchgrass is an important component of the revegetation strategy. Shrubs that are appropriate for rockier soils will be transplanted into the rocky portions of the revegetation area to provide additional vegetation structure and diversity.



**Figure 2.5.** Relative Location and Extent of Revegetation Unit 3



**Figure 2.6.** Unit 3 Area to be Revegetated and Side Slope at the Radio-telescope (6631)

The substrate of unit 3 is made up of thin compacted soils with some rocky/gravel surfaces. Seeding on these sites will follow the three-step process using an all-terrain vehicle or hand-broadcasting equipment. Ripping of the level soil/gravel surfaces will be necessary prior to seeding; we recommend the side slopes not be disturbed or re-contoured. Species, seeding, and transplant rates are described in Table 2.4. We also recommend a one-time hand broadcast of big sagebrush and gray rabbitbrush seed. Seeds will be collected in mid to late November from small adjacent shrub stands and hand scattered within the unit.

**Table 2.4.** Revegetation Unit 3: Suggested Species for Seed Mix and Transplant Stock

Planting Mix	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg's bluegrass	small bunchgrass	seeding	10
Bluebunch wheatgrass	large bunchgrass	seeding	5
Idaho fescue	medium bunchgrass	seeding	5
Big sagebrush	shrub	seeding with adjacent source	as available
Purple sage	shrub	transplant	see Table 3.1
Three-tip sage	shrub	transplant	see Table 3.1
Gray rabbitbrush	shrub	seeding with adjacent source	as available
Rock buckwheat	forb	seeding and transplant	see Table 3.1
Thyme buckwheat	forb	seeding and transplant	see Table 3.1

PLS=pure live seed

## 2.2.4 Revegetation Unit 4: 6652-C Building Area, Associated Structures, and New Underground Powerline

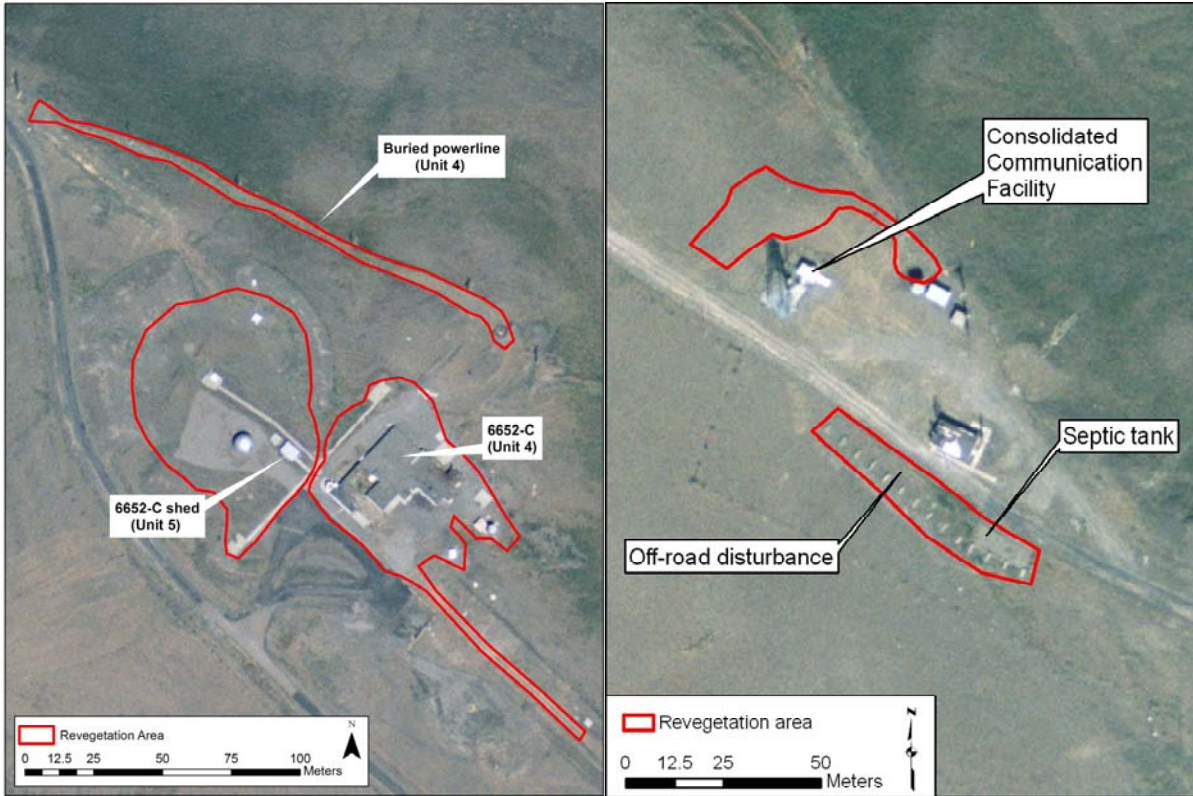
Revegetation unit 4 includes 5 sites that occur at the uppermost elevations along Rattlesnake ridge where the native plant community consists primarily of a thyme buckwheat/bluebunch wheatgrass-Sandberg's bluegrass association that transitions to a big sagebrush/bluebunch wheatgrass—Idaho fescue association where pockets of deeper soils occur. The total estimated acreage for the revegetation unit is approximately 1.8 acres consisting of the areas disturbed/excavated around 6652-C building, new underground power service along the existing power line roadway, 623A facility and roadway, areas bordering the new Combined Community Communications facility, and the area disturbed across the roadway from T-520 associated with a septic system and concrete anchor blocks.

The desired future conditions for areas in revegetation unit 4 involve revegetating to develop a plant community typical of ridge-top lithosols or lithosol-transition zones, such as those described in the preceding paragraph. This is likely to be a challenging and slow revegetation process. Soils are primarily shallow stony silt loams. An important first step in the recovery process will be the establishment of bluebunch wheatgrass and Sandberg's bluegrass as a basis for the community. Rocky substrates adjacent to the decommissioned facilities that were disturbed more than 50 years ago have slowly recovered some native vegetation including: Sandberg's bluegrass, white scorpionweed (*Phacelia hastata*), Gray's biscuitroot (*Lomatium grayi*), common yarrow (*Achillea millefolium*), and scattered bluebunch wheatgrass. Other common shrubs in the area include purple sage (*Salvia dorii*) and green and gray rabbitbrush. Three-tip sagebrush occurs on some of the steeper north-facing slopes. In rocky areas, or areas where the topography or buildings cause moisture to accumulate, scattered individuals of wax currant (*Ribes cereum*) have established, and some forbs and graminoids generally associated with wet meadow habitats or seeps and springs occur in limited pockets.

Parking areas adjacent to the paved road to the top of the ridge where 6652-C has been removed will be left intact to provide adequate space for vehicle parking and turn-around points for visitors to the site. The footprint of the 6652-C buildings and surrounding associated structures discussed in this section does not include the adjacent area where large rock berms rise 10 to 12 ft above the ground surface (Figure 2.7). That area is dealt with as a separate revegetation unit (Unit 5 in Table 2.1). Ground surface conditions at the completion of building decommissioning at the 6652-C site are expected to consist of a mix of stony silt loam soils with larger cobbles and rubble (



Figure 2.8) and the site of the building footprint will be re-contoured to provide a relatively consistent slope between the parking areas and the northeast face of the ridgeline.



**Figure 2.7.** Revegetation Units 4 and 5: Unit 4 (6652-C Buildings, Associated Infrastructure and the Consolidated Communication Facility) and Unit 5 (6652-C Shed and Observatory Area)

In addition to the area associated with the buildings, a new underground power line to service the Combined Community Communications Facility was installed along the existing power line road just below the crest of the ridge. Backfill of this area apparently included rock/rip-rap as well as soils. The area has since been invaded by exotic annual weeds (cheatgrass and tumble mustard, *Sisymbrium altissimum*) and will require weed control after fall rains occur to eradicate the weeds, before planting this winter (Figure 2.9). Workers will attempt to remove these weeds before and during the revegetation process. If monitoring results indicate that manual removal of weeds is not successful, the one-time application of a contact herbicide using a wipe-on method or other hand application method may be employed to achieve weed control before seeded plants germinate.





**Figure 2.8.** Unit 4: Area to be Revegetated where 6652-C Buildings were Removed



**Figure 2.9.** Unit 4: Linear Area Associated with Removal of Overhead Powerline and New Underground Power Service

An alternative may be to treat the area with glyphosate using a wipe technique in the spring after cheatgrass begins growth, but before native seedlings reach a 4-in. height. This approach would potentially kill the cheatgrass without allowing herbicide to come in contact with newly planted native vegetation. This area lies on a relatively steep slope and is not accessible using standard equipment. It may require the use of all-terrain vehicles, or hand sprayers and hand broadcast equipment to treat and seed the area with native species.

Further along the ridgeline, unit 4 also includes the areas disturbed by the construction of the Combined Community Communication facility. This portion of the unit also is surrounded primarily by lithosol communities (thyme buckwheat/bluebunch wheatgrass) and the substrate conditions after construction consist of stony loam soils with rocks and rubble.

The substrates typical of revegetation unit 4 are thin rocky lithosols. With the exception of the power line, seeding on these sites will follow the three-step process using a small four-wheeler or hand-broadcasting equipment. The power line roadway has been allowed to develop a weedy cover after installation of the underground power service. Herbicide treatment will be required in early October or November before any seeding to reduce annual weeds that will germinate and grow as soon as fall rainfall amounts total 0.5 to 1 in. Because the slope is too steep and the surface is covered in rubble, this site will likely require hand application methods using backpack equipment. Seeding will be accomplished by hand-broadcasting due to the steepness of the slope in this area. All other seeding in unit 4 will follow the three-step process using a small four-wheeler and hand-broadcasting equipment. Shrub and forb transplants will be installed at a later date. Species, seeding, and transplant rates are described in Table 2.5.

**Table 2.5.** Revegetation Unit 4: Suggested Species for Seed Mix and Transplant Stock

Planting Mix <sup>(a)</sup>	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg's bluegrass	small bunchgrass	seeding	10
Bluebunch wheatgrass	large bunchgrass	seeding	5
Idaho fescue	medium bunchgrass	seeding	5
Thyme buckwheat	forb	seeding and transplant	see Table 3.1
Rock buckwheat	forb	seeding and transplant	see Table 3.1
Rosy balsamroot	forb	seeding and transplant	see Table 3.1
Modoc hawksbeard	forb	seeding	as available
Wooly-pod milkvetch	forb	seeding and transplant	see Table 3.1
Bigseed lomatium	forb	seeding and transplant	see Table 3.1
Wax currant	shrub	transplant	see Table 3.1
Chokecherry	shrub	transplant	see Table 3.1
Purple sage	shrub	transplant	see Table 3.1
Three-tip sage	shrub	transplant	see Table 3.1

(a) Powerline planting method will include hand broadcasting only  
 PLS = pure live seed

### 2.2.5 Revegetation Unit 5: 6652 Dome, 6652-C Shed, and Areas Adjacent to Observatory

This revegetation unit includes the excavated and bladed areas lying within the rock berms that were adjacent to the observatory at the top of the ridge (Figure 2.7). Figure 2.10 illustrates that the substrate in these areas is primarily rock and cobble with a minimal amount of fine silts. Revegetation of this area will present a number of technical challenges. Existing basalt cobble berms that were historically emplaced to protect the military installation at this location have been colonized by native plants to varying degrees depending on berm placement, aspect, and orientation to prevailing wind directions. Rock from two of the existing berms will be used as backfill for cisterns located upslope from the 1200-ft road, and to re-contour and fill areas within revegetation unit 5.



**Figure 2.10.** Substrate Conditions for Unit 5

The largest challenge to revegetating these surfaces is the lack of a soil substrate to provide germination sites for seeds and to retain moisture for plant growth. Adding soil to this area is problematic—no ready source of silt loam soil is available within the Arid Lands Ecology Reserve without further disturbance of native plant communities. Soil will accrete in this area over long time periods through wind erosion and wind transport of fines. Cobble and rubble substrate could potentially benefit from treatments to add organic material to the seeding mixture; however, addition of extra organic materials also poses a risk of increasing establishment of exotic annual plants.

The substrates typical of the area surrounding the heavily disturbed revegetation unit 5 are thin rocky lithosols that support thyme buckwheat or rock buckwheat/bunchgrass plant communities. These communities represent the desired future conditions for this area. The current objectives for revegetating unit 5 include re-contouring the surface of the area to fill in depressions caused by excavation and demolition and to smooth the transition from the adjacent berms where material has been removed (cobble and rocks from berms close to the parking area will be used for backfill at this site and at the cisterns located at site 109; see Figure 2.10) to the center of the revegetation unit. Berms that have naturally revegetated over the past 50 years and that were not disturbed by the excavation and decommissioning of the observatory and associated buildings/sidewalks will not be re-contoured at this time.

Because surface roughness of the revegetation unit is expected to be extreme, it may be necessary to use smaller equipment to work safely on the site. Seeding on these sites will follow the three-step process using a small four-wheeler or hand-broadcasting equipment if large equipment cannot be used. Shrub and forb transplants will be installed at a later date. Species, seeding, and transplant rates are described in Table 2.6.

**Table 2.6.** Revegetation Unit 5: Suggested Species for Seed Mix and Transplant Stock

Planting Mix	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg's bluegrass	small bunchgrass	seeding	10
Bluebunch wheatgrass	large bunchgrass	seeding	10
Thyme buckwheat	forb	seeding and transplant	see Table 3.1
Rock buckwheat	forb	seeding and transplant	see Table 3.1
Rosy balsamroot	forb	seeding and transplant	see Table 3.1
Modoc hawksbeard	forb	seeding	as available
Wooly-pod milkvetch	forb	seeding and transplant	see Table 3.1
Bigseed lomatium	forb	seeding and transplant	see Table 3.1
Wax currant	shrub	transplant	see Table 3.1
Chokecherry	shrub	transplant	see Table 3.1
Purple sage	shrub	transplant	see Table 3.1
Three-tip sage	shrub	transplant	see Table 3.1

PLS = pure live seed

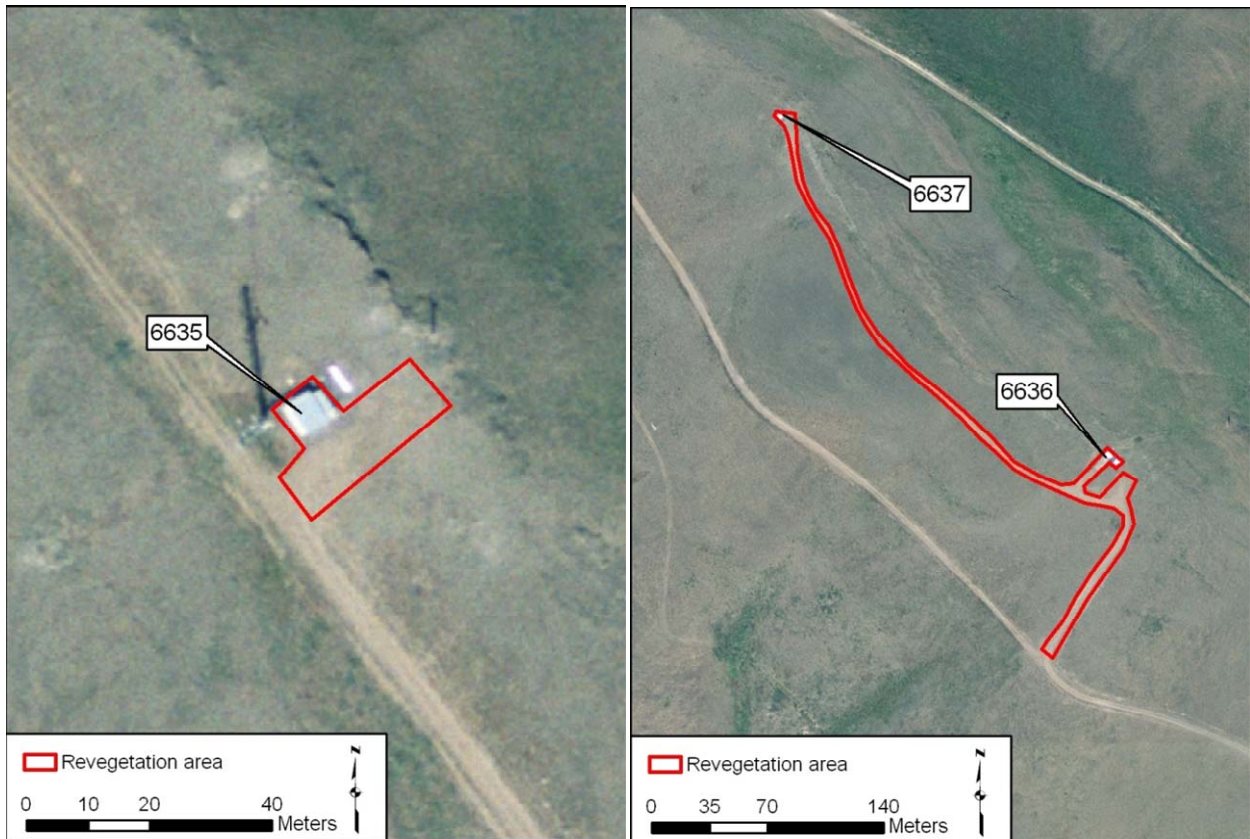
## 2.2.6 Revegetation Unit 6: Communication Towers, Facilities, and Access Routes for 6635, 6636, and 6637

Revegetation Unit 6 consists of three small facilities supporting radio tower/communication towers and the unimproved two-track road that provides access and parking at these facilities along Rattlesnake ridge. Figure 2.11 and Figure 2.12 illustrate the locations character of these facilities along the ridgeline.

The desired future conditions for revegetation unit 6 are recovery to a thyme buckwheat/bluebunch wheatgrass plant community typical of the lithosolic soils of the ridgetop. Portions of the access roads and of the facility footprint at each individual location harbor remnant native grasses and forbs.

Substrate conditions after building and concrete pad removal are completed will likely be similar to substrate conditions for Unit 4; however, the surface of the access routes varies from compacted stony loams in the tracks to bare rock surfaces. The disturbance footprint for removing facilities at these units is very small and does not require significant excavation and soil disturbance except to remove concrete pads and foundations. Several of the buildings in this revegetation unit are on skids and will be removed using a forklift, which will cause minimal disturbance. Access routes harbor significant amounts of native vegetation that may recover naturally, but compacted sections of road may require some surface roughening treatment to allow plant establishment.

The substrates typical of revegetation unit 6 are thin rocky lithosols. Each section of compacted road should be assessed on a case-by-case basis to avoid unnecessary impacts to existing native vegetation by surface roughening. To avoid further disturbance to intact native plant communities and to avoid other important resources, seeding on these sites will follow the three-step process using a small four-wheeler and/or hand-broadcasting equipment only. Shrub and forb transplants will be installed at a later date. Species, seeding, and transplant rates are described in Table 2.7.



**Figure 2.11.** Revegetation Unit 6: Communication Facilities 6635, 6636, 6637 and Access Route



**Figure 2.12.** Example of Road and Parking/Access to Communication Facilities in Unit 6

**Table 2.7.** Revegetation Unit 6: Suggested Species for Seed Mix and Transplant Stock

Planting Mix	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg's bluegrass	small bunchgrass	seeding	10
Bluebunch wheatgrass	large bunchgrass	seeding	5
Idaho fescue	medium bunchgrass	seeding	5
Thyme buckwheat	forb	seeding and transplant	see Table 3.1
Rock buckwheat	forb	seeding and transplant	see Table 3.1
Rosy balsamroot	forb	seeding and transplant	see Table 3.1
Modoc hawkbeard	forb	seeding	as available
Wooly-pod milkvetch	forb	seeding and transplant	see Table 3.1
Bigseed lomatium	forb	seeding and transplant	see Table 3.1
Purple sage	shrub	transplant	see Table 3.1
Three-tip sage	shrub	transplant	see Table 3.1

PLS=pure live seed

### 2.2.7 Revegetation Unit 7: 6652T Pumphouse and Debris

Revegetation Unit 7 is located on the north-facing slope of Rattlesnake ridge at an elevation of approximately 3000 ft (Figure 2.13). Soil at the site is a stony silt loam and the general area surrounding the site supports vegetation typical of seeps and springs occurring on hills within the shrub-steppe areas of the Columbia Plateau ecoregion, which can be characterized as Eastside Canyon Shrublands. This habitat can develop near talus slopes, at the heads of dry drainages, and toe slopes in moist shrub-steppe and steppe zones. At this site, the most common tall shrub is chokecherry (*Prunus virginiana*), which often occurs with medium tall shrubs such as common snowberry (*Symphoricarpos albus*), rose (*Rosa woodsii*), smooth sumac (*Rhus glabra*), blue elderberry (*Sambucus cerulea*) and currants (*Ribes* spp.).

The desired future conditions for revegetation unit 7 involve re-establishing native shrubs and grasses in the small areas disturbed by excavation of the building and parking area. The unit lies in a transitional zone between the big sagebrush-three-tip sagebrush/bunchgrass plant community and the Eastside Canyon Shrubland habitat that persists around the existing springs and seeps adjacent to the revegetation site. Establishing a robust cover of bunchgrasses including basin wildrye (*Leymus cinereus*) is an important objective of revegetation efforts at this site to develop a weed-resistant plant cover. Transplant of shrub species will be limited to the borders of the site that are adjacent to the existing seeps and springs. Shrubs such as chokecherry, blue elderberry and currants will re-establish from existing stands as well as from transplants where the substrate and moisture conditions are appropriate.

The site has a small footprint and the current ground conditions are a mix of stony silt loam and rocks (Figure 2.14). Weedy species such as cheatgrass and stinging nettle (*Urtica dioica*) are common in the surrounding area and herbicide treatment of cheatgrass is recommended to avoid invasion of the revegetated area. Small amounts of rocks and gravel materials may need to be removed or re-contoured before seeding or planting is initiated.



**Figure 2.13.** Revegetation Unit 7: 6652-T Pumphouse and Parking



**Figure 2.14.** Revegetation Unit 7: Substrate and Current Vegetation

Seeding on these sites will follow the three-step process using a small four-wheeler or hand-broadcasting equipment, with the exception that no additional water will be applied at the time of seeding. Straw will be added, but will not be crimped into the surface. Shrub transplants will be installed at a later date. Species, seeding, and transplant rates are described in Table 2.8.

**Table 2.8.** Revegetation Unit 7: Suggested Species for Seed Mix and Transplant Stock

Planting Mix	Lifeform	Planting Method	Rate (lbs PLS/acre)
Sandberg's bluegrass	small bunchgrass	seeding	10
Bluebunch wheatgrass	large bunchgrass	seeding	5
Basin wildrye	very large bunchgrass	seeding	5
Carey's balsamroot	forb	seeding	as available
Slender hawksbeard	forb	seeding	as available
Bigseed lomatium	forb	seeding	as available
Chokecherry	shrub	transplant	see Table 3.1
Wax Currant	shrub	transplant	see Table 3.1

PLS=pure live seed

## 2.3 Roles and Responsibilities

The protection and establishment of healthy communities of native plants is part of the scope of final cleanup and decommissioning at the ALE sites. A multi-disciplinary project team has been assembled to address revegetation objectives, including plant ecologists, restoration ecologists, project engineers and planners. Preliminary information on proposed plants for seeding was presented to the tribal cultural issues group in June 2010, and comments and suggestions received at that meeting have been incorporated or addressed in this plan. Table 2.9 indicates the responsible entities for planning and completing revegetation actions described in this document.

**Table 2.9.** Roles and Responsibilities of Parties Involved in Revegetation Actions on ALE after Final Decommissioning and Debris Cleanup

Responsible Entity or Cooperator	Activity Description
CHPRC	Demolition, Debris Removal and Initial Re-contouring
PNNL	Revegetation Planning, Seed Collection, Restoration Subcontracting and Oversight, Revegetation Monitoring
DOE-RL	Approval of Revegetation Planning and Support of Revegetation Actions
CTUIR	Growing Transplant Stock, Seed Collection/Seed Provider, Transplanting Forbs
USFWS	Revegetation Consultation and Monitoring
Tribal Nations	Revegetation Consultation and Monitoring



### **3.0 Plant Materials and Methods**

The primary objectives for revegetation of each unit are to develop sufficient grass and shrub cover to protect the sites from wind and water erosion, provide resistance to weed invasion, provide a representative level of species diversity, and thus, enhance or accelerate the recovery of each unit to the appropriate native plant community for that soil, elevation and climate. As described in Section 2, a two-pronged approach is recommended to accomplish revegetation objectives. The cumulative amount of seeds and plant materials needed are listed in Table 3.1 and Table 3.2. First a fall dormant seeding will be conducted between October 15 and December 15, 2010. Dates for seeding depend on the location and elevation. We assume that it may be necessary to seed revegetation units along the ridgeline earlier in the fall than revegetation units at lower elevations. For all revegetation units, the forbs and shrubs grown as transplant stock from seed or cuttings will be installed during the early part of February 2011 or as soon as the units can be safely accessed. Some forb seeds will require pre treatment to enhance or enable germination. Hard-coated seeds such as the milkvetch species, lupine, and globemallow will require scarification before seeding.

Local collections have been made for this project and limited inquiries to local vendors and discussions with restoration ecologists of the Confederated Tribes of the Umatilla Indian Reservation have identified locally-derived seed available for most of the species listed in this plan. This information is provided in Appendix A.

**Table 3.1.** Approximate Amount of Seeds Required for ALE Revegetation Actions

Species	Revegetation Unit							Total (13.2 ac)
	Unit 1 (0.5 ac)	Unit 2 (8.6 ac)	Unit 3 (0.35 ac)	Unit 4 (1.8 ac)	Unit 5 (1.1 ac)	Unit 6 (0.7 ac)	Unit 7 (0.1 ac)	
Grasses (lbs PLS/unit)								
Sandberg's bluegrass (several sources)	10	86	3.5	18	11	7	1	136.5
Bluebunch wheatgrass		86	1.8	9	11	7.5	0.5	115.8
Idaho fescue			1.8	9		1.5		12.3
Basin wildrye							0.5	0.5
Forbs (lbs PLS dependent on seed availability)								
Rock buckwheat			x	x	x	x		as available
Thyme buckwheat			x	x	x	x		as available
Crouching milkvetch	x	x						as available
Wooly-pod milkvetch			x	x	x	x		as available
Carey's balsamroot	x	x					x	as available
Rosy balsamroot			x	x	x	x		as available
Modoc hawksbeard			x	x	x	x		as available
Slender hawksbeard	x	x					x	as available
Bigseed lomatium		x	x	x	x	x	x	as available
Nineleaf biscuitroot			x	x				as available
Whiteleaf scorpionweed			x	x	x	x		as available
Lupine		x						as available
Piper's daisy		x						as available
Hoary aster	x	x						as available
Hoary falseyarrow	x	x						as available
Monro's globemallow	x	x						as available
Yarrow	x	x						as available
PLS=pure live seed								

**Table 3.2.** Number of Forbs and Shrubs to Be Grown for Transplant

Transplant Material	Revegetation Unit							Total No. Transplants
	Unit 1 (0.5 ac)	Unit 2 (8.6 ac)	Unit 3 (0.35 ac)	Unit 4 (1.8 ac)	Unit 5 (1.1 ac)	Unit 6 (0.7 ac)	Unit 7 (0.1 ac)	
<b>Forbs (plants/unit)</b>								
Rock buckwheat			50	75	75	50		250
Thyme buckwheat			50	75	75	50		250
Crouching milkvetch	50	150						200
Wooly-pod milkvetch			50	75	75	50		250
Rosy balsamroot			50	75	75	50		250
Bigseed lomatium		200	50	75	75	50		450
Piper's daisy		200						200
<b>Shrubs (plants/unit)</b>								
Wax Currant				75	50		25	150
Chokecherry				50	25		25	100
Purple sage			25	25	25	25		100
Big sagebrush	150							150
Three-tip sagebrush			25	25	25	25		100
Spiny hopsage	150							150

## 4.0 Monitoring and Management Strategy

Effective management of revegetation sites requires that administrative and physical protections be instituted, commensurate with the relative importance of the revegetated site as an ecological resource. Additionally, the condition of the site must be monitored to determine if the desired future conditions are likely to be met, and if not, corrective actions must be designed and implemented.

Monitoring and management activities are an important step to ensure that revegetation actions meet objectives and commitments. Even when all the best revegetation practices are applied and the revegetation plan is followed carefully, the resulting vegetation may not turn out as intended. Factors outside our control, such as unfavorable weather, disease, or unforeseen issues can affect the success of the revegetation efforts. Monitoring and observation of the site is needed to evaluate success of the revegetation effort and determine whether further actions are needed to correct, manage, or maintain the restored area. Monitoring allows managers and stakeholders to determine answers to the following questions and can be used to improve future revegetation efforts.

1. Has native vegetation become well-established on the revegetation site, or are corrective actions necessary?
2. Have revegetation objectives and commitments been met?
3. Do different revegetation treatments result in different plant responses?

Efforts to answer these questions begin during implementation of the revegetation project and continue after revegetation is complete. Monitoring and management of the revegetation site involves several steps:

- Revisit project objectives and desired future conditions
- Conduct site-specific monitoring strategies and protocol(s)
- Evaluate data and compare to criteria for successful revegetation (desired future conditions)
- Develop and apply any corrective measures necessary to achieve success
- Share lessons learned.

### 4.1 Monitoring Criteria and Objectives

Monitoring the relative abundance of plants that establish on each of the revegetation units provides the information needed to assess whether revegetation objectives are being met, or whether corrective actions will be necessary to achieve those objectives. Revegetation and restoration of native plant communities cannot be accomplished in a single growing season, but monitoring the early results of revegetation actions provides information on the growth and potential recovery of the site. The following section describes the recommended monitoring and evaluation protocols to evaluate the establishment of native species on each revegetation unit.

The primary objectives for each of the revegetation units during the first growing season after planting are to establish a vigorous stand of the appropriate native species that will protect the sites from wind and water erosion and provide some resistance to annual weed invasion. The revegetated site

should support a representative level of species diversity with shrubs, grasses, and forbs that will enhance and accelerate the recovery of the plant community. Monitoring of revegetation sites at Hanford is typically conducted for a period of 5 years post planting to assess the growth and establishment of native vegetation on the revegetation unit relative to the revegetation objectives and criteria. Table 4.1 outlines criteria to be used in assessing the initial overall condition of the revegetated area and evaluating whether corrective measures may be necessary. Results of monitoring during the first growing season after planting will be compared with the initial criteria listed in Table 4.1 to determine whether additional actions or corrective measure need to be implemented. If the revegetation unit or an individual site within a revegetation is judged as failing to meet criteria, a review and evaluation process will be implemented to design the best corrective measures to apply that will achieve the final targets for revegetation success.

#### **4.1.1 Monitoring Protocols and Measurements**

Four characteristics are of interest in monitoring revegetation success: the amount of bare ground, the abundance of species at the site (cover and density of native plants in comparison to cover and density of exotic plants), the species diversity or richness, and measurement of attributes that indicate the survival and growth of the planted species. Monitoring should generally be conducted during the season of maximum plant biomass/growth, for the largest number of species found on the revegetation unit. The timing of maximum plant growth/biomass will be between mid-May and the end of July depending on the elevation of the revegetation site.

Measurements of density and frequency, or biomass generally employ a quadrat as the sampling unit. For cover, however, the sampling unit can be a line, a point, or a quadrat depending on the vegetation type being measured. Density is measured by counting some entity (e.g., individuals, ramets, stems) within quadrats. The size and placement of the quadrats is based on the dispersion of the species of interest. In general, measurements of herbaceous species at Hanford have traditionally been conducted using quadrats ranging in size from 0.1 m<sup>2</sup> (1.08 square ft), to 0.5 m<sup>2</sup> (5.4 square ft), to 1 m<sup>2</sup> (10.8 square ft) depending on the size and distribution of the species of interest. In sandy and loam soils where bunchgrasses and forbs are less dense than on silt loam soils, the larger quadrat sizes are more likely to provide a representative sample using fewer quadrats.

Sampling quadrats (0.5 m<sup>2</sup>) for measurement of herbaceous plant abundance will be placed systematically across the revegetation unit (either along transects or grids equally spaced). The number of samples and sampling quadrat placement within the revegetation units will be determined using guidance found in Elzinga et al. (1998) and in the Federal Highway Administrations “Roadside Revegetation Guide” (FHA 2007). Both of these references provide detailed guidance for designing a monitoring strategy and protocols. Within each quadrat, the numbers of each native grass and forb species will be recorded to determine density, and the cover of bare ground and canopy cover of plant species will be visually estimated.

Sampling cover and density of shrub species will require larger sampling quadrats or plots to assess larger woody species. Density can easily be measured by counting the number of shrubs located in square or rectangular plots that encompass tens of square meters (i.e., such as a rectangular plot that measures 5 m by 20 m (16 ft by 66 ft) in width and length, respectively, or a 10-m by 10-m (33-ft by 33-ft) plot. Rectangular plots measuring 5 m x 20 m will be randomly located within the revegetation footprint at each site and all shrubs rooted within the plot will be counted and the height and widest diameters will be measured.

**Table 4.1.** Monitoring and Preliminary Evaluation Criteria for Each Revegetation Unit

Revegetation Unit	Desired Future Condition/Plant Community	Measured Component	First Season Growth Minimum Criteria (density of plants/measured area)	Final Target Criteria (density of plants/measured area)
Unit 1	Black greasewood/saltgrass	Native Shrubs	5 plants/100 m <sup>2</sup>	10 plants/100 m <sup>2</sup>
		Large Native Bunchgrasses	15 plants/m <sup>2</sup>	4 plants/ m <sup>2</sup>
		Sandberg's bluegrass		12 plants/m <sup>2</sup>
		Native Forbs	1 plant/ 2 m <sup>2</sup>	2 plant/ 2 m <sup>2</sup>
		Native Species Richness	4 species/100 m <sup>2</sup>	5 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 30% canopy cover
Unit 2	Big sagebrush/bluebunch wheatgrass	Native Shrubs	5 plants/100 m <sup>2</sup>	10 plants/100 m <sup>2</sup>
		Large Native Bunchgrasses	15 plants/m <sup>2</sup>	5 plants/m <sup>2</sup>
		Sandberg's bluegrass		15 plants/m <sup>2</sup>
		Native Forbs	1 plant/ m <sup>2</sup>	1 plant/ m <sup>2</sup>
		Native Species Richness	4 species/100 m <sup>2</sup>	6 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 30% canopy cover
Unit 3	Thyme buckwheat/bluebunch wheatgrass and Big sagebrush/bluebunch wheatgrass-Idaho fescue	Native Shrubs <sup>(a)</sup>	Large: 5 /100 m <sup>2</sup> Small: 2 / m <sup>2</sup>	Large: 10 /100 m <sup>2</sup> Small: 3 / m <sup>2</sup>
		Large Native Bunchgrasses	20 plants/m <sup>2</sup>	5 plants/m <sup>2</sup>
		Sandberg's bluegrass		20 plants/m <sup>2</sup>
		Native Forbs	2 plants/m <sup>2</sup>	3 plants/ m <sup>2</sup>
		Native Species Richness	4 species/100 m <sup>2</sup>	6 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 30% canopy cover
Unit 4	Thyme buckwheat/bluebunch wheatgrass and Big sagebrush/bluebunch wheatgrass-Idaho fescue	Native Shrubs <sup>(a)</sup>	Large: 5 /100 m <sup>2</sup> Small: 2 / m <sup>2</sup>	Large: 10 /100 m <sup>2</sup> Small: 3 / m <sup>2</sup>
		Large Native Bunchgrasses	12 plants/m <sup>2</sup>	4 plants/m <sup>2</sup>
		Sandberg's bluegrass		20 plants/m <sup>2</sup>
		Native Forbs	1 plants/m <sup>2</sup>	1 plant/ m <sup>2</sup>
		Native Species Richness	4 species/100 m <sup>2</sup>	6 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 25% canopy cover
Unit 5	Thyme buckwheat/bluebunch wheatgrass	Native Shrubs <sup>(a)</sup>	Large: 2 /100 m <sup>2</sup> Small: 1 / m <sup>2</sup>	Large: 5 /100 m <sup>2</sup> Small: 3 / m <sup>2</sup>
		Large Native Bunchgrasses		3 plants/m <sup>2</sup>
		Sandberg's bluegrass	5 plants/m <sup>2</sup>	10 plants/m <sup>2</sup>
		Native Forbs	1 plants/m <sup>2</sup>	3 plant/ m <sup>2</sup>
		Native Species Richness	4 species/100 m <sup>2</sup>	5 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 20% canopy cover

**Table 4.1. (contd)**

Revegetation Unit	Desired Future Condition/Plant Community	Measured Component	First Season Growth Minimum Criteria (density of plants/measured area)	Final Target Criteria (density of plants/measured area)
Unit 6	Thyme buckwheat/ bluebunch wheatgrass	Native Shrubs <sup>(a)</sup>	Large: 5 /100 m <sup>2</sup> Small: 2 / m <sup>2</sup>	Large: 10 /100 m <sup>2</sup> Small: 3 / m <sup>2</sup>
		Large Native Bunchgrasses	12 plants/ m <sup>2</sup>	4 plants/m <sup>2</sup>
		Sandberg's bluegrass		15 plants/m <sup>2</sup>
		Native Forbs	1 plants/m <sup>2</sup>	3 plant/ m <sup>2</sup>
		Native Species Richness	4 species/100 m <sup>2</sup>	6 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 20% canopy cover
Unit 7	Eastside Canyon Shrublands Transition	Native Shrubs	10 plants/100 m <sup>2</sup>	
		Large Native Bunchgrasses and Sandberg's bluegrass	8 plants/ m <sup>2</sup>	1 to 3 plants/ m <sup>2</sup> 10 plants/ m <sup>2</sup>
		Native Forbs	1 plants/m <sup>2</sup>	3 plants/m <sup>2</sup>
		Native Species Richness	5 species/100 m <sup>2</sup>	6 species/100 m <sup>2</sup>
		Exotic Species Cover	< 30% canopy cover	< 25% canopy cover

(a) Large shrubs include big sagebrush, green or gray rabbitbrush, purple sage, rock buckwheat, wax currant, golden currant, chokecherry, or blue elderberry; small shrubs include plants such as thyme buckwheat, narrowleaf goldenweed, and Hood's phlox.

Species richness is a primary measurement of diversity. It is simply the number of different species found in a particular sampling unit. The number of unique native species found in each 100 m<sup>2</sup> sampling plot will be recorded to quantify native species diversity.

Native species richness in relatively undisturbed shrub-steppe plant communities is usually greater than the initial monitoring criteria of 6 species/100 m<sup>2</sup>, especially in the plant communities occurring at higher elevations and on lithosols. However, it is likely that species richness will continue to increase after the first year of monitoring as passive restoration and colonization of the revegetation unit by ruderal species occurs. The initial monitoring criteria are intended to provide a metric that can be evaluated to determine whether further treatment and additional seeding/planting will be required after the first season of growth. The CTUIR are providing seed for a number of additional native forbs that will likely increase species richness over a number of years. The final target criteria in Table 4.1 will be further refined based on measurements of density and diversity in reference plant communities and described in more detail in the monitoring plan for each revegetation unit.

## 4.2 Site Management

The revegetation process does not end with the planting of the last seed or transplant. Revegetated sites must continue to be protected, monitored, and managed. Management of the revegetation site includes:

- Protecting the site from new disturbances, such as project construction or invasion by weeds

- Ensuring that adequate monitoring is conducted and that the results of the monitoring are available for review
- Using results of monitoring to guide management strategies and actions.

#### **4.2.1 Site Protection**

Once a revegetated site is established, administrative and physical site protection measures should be instituted as appropriate. Administrative protection includes providing site coordinates to be included in site land-use and development maps and GIS systems. Physical protection measures could include installing signs around the perimeter, or at major access points, but could also include installing physical barriers such as fences, gates, or items such as boulders to physically prevent vehicular entry.

#### **4.2.2 Monitoring, Reporting and Contingency Planning**

Revegetated sites intended to restore or enhance native communities should be monitored for a minimum of 5 years post planting using techniques as described in Section 4.1. The monitoring results will be compared with the predetermined criteria for the site. The criteria will normally be based on the desired future conditions for the site, and the measured values such as cover, density, and diversity will be compared with the predefined values to determine whether the plant community is developing along the desired trajectory or if corrective actions should be taken.

When the monitoring indicates that the desired conditions have not been met, or it is unlikely that the conditions will be met within the desired timeframe, corrective actions will be taken. Specific corrective actions will depend on the particular conditions or deficiencies encountered, but could include relatively simple actions such as transplanting additional shrubs or forbs, or inter-seeding with additional grass seed. More difficult corrective actions may be needed in some cases, such as removal of invasive species by physical or chemical means, or in a worst-case scenario, repeating much of the original revegetation action.



## 5.0 References

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## **Appendix A**

### **Available Plant Materials**



# Appendix A

## Available Plant Materials

**Table A.1.** Source Identified Seed Available from Commercial Sources and Local Collections. Local Collections were made by the Confederated Tribes of the Umatilla Indian Reservation (CTUIR) in Previous Years and by PNNL Staff in 2010 for Revegetation of the Arid Lands Ecology Reserve

Common Name	Scientific Name	Commercial Source Identified Seed Availability [Location, Other Information if Known, (Source)]	Local Collections Available [Source Location, Year (Source)]
<b>Shrubs</b>			
Big sagebrush	<i>Artemisia tridentata</i>		Hanford Site Collection (PNNL); Washington State University-Tri-Cities (CTUIR)
Three-tip sagebrush	<i>Artemisia tripartita</i>	none located	none located
Spiny hopsage	<i>Grayia spinosa</i>		Richland, near Duportail and Keene, (CTUIR); along SR240 near Horn Rapids Off Rd park (CTUIR)
Chokecherry	<i>Prunus virginiana</i>	none located	none located
Wax Currant	<i>Ribes cereum</i>		Pumphouse spring on Rattlesnake Mtn, 2006 (CTUIR)
Purple sage	<i>Salvia dorrii</i>		Top of Rattlesnake Mtn, 2006 (CTUIR)
<b>Grasses</b>			
Squirreltail	<i>Elymus elymoides</i>		ALE, 2006 (CTUIR); 1200-ft Rd. ALE, 2010 (PNNL)
Idaho fescue	<i>Festuca idahoensis</i>	Duffy Creek, Lithosol, 2600-3000' elev., (BFI); Wenatchee, (not lithosol, in transition zone to forest habitat), 1100' elev., (BFI)	none located
Basin wildrye	<i>Leymus cinereus</i>	Toppenish, *lower elevation source 750' elev.; Lincoln county (near Sprague) 2100' elev., (BFI)	Pumphouse spring on Rattlesnake Mtn 2006 (CTUIR)
Sandberg's bluegrass	<i>Poa secunda</i>	Duffy Creek, Lithosol, 2600-3000' elev., (BFI); Rattlesnake Slope, sandy loam, 750' elev., (BFI)	Red Mtn Road; amount available unknown (CTUIR); Rattlesnake Mtn Top, 2010 (PNNL) amount limited

**Table A.1.** (contd)

Common Name	Scientific Name	Commercial Source Identified Seed Availability [Location, Other Information if Known, (Source)]	Local Collections Available [Source Location, Year (Source)]
Bluebunch wheatgrass	<i>Pseudoroegneria spicata</i>	Duffy Creek (BFI), Rattlesnake Slope, loamy sand, 750' elev., (BFI)	ALE Bldgs.; amount available unknown (CTUIR)
<b>Forbs</b>			
Yarrow	<i>Achillea millefolium</i>	Yakima (BFI)	ALE 1200-ft Rd, 2006 (CTUIR), and 2010 (PNNL)
Rock onion	<i>Allium macrum</i>		Rattlesnake Mtn Top, 2010 (PNNL) very few
Buckwheat milkvetch	<i>Astragalus caricinus</i>		ALE, 1200-ft Rd, 2010 (PNNL)
Dr. Bill's locoweed	<i>Astragalus conjunctus</i>		Rattlesnake Mtn Top, 2010 (PNNL)
Woolly-pod milkvetch	<i>Astragalus purshii</i>		Top of Rattlesnake Mtn; 2006 (CTUIR); and 2010 (PNNL)
Crouching milkvetch	<i>Astragalus succumbens</i>		ALE, 2006 (CTUIR)
Carey's balsamroot	<i>Balsamorhiza careyana</i>	Horn Rapids, amount uncertain (BFI)	ALE, 2006 (CTUIR); ALE, 2010 (PNNL)
Rosy balsamroot	<i>Balsamorhiza rosea</i>		Rattlesnake Mtn, 2006 (CTUIR); Top of Mtn, 2010 (PNNL)
Sagebrush mariposa lily	<i>Calochortus macrocarpus</i>		ALE, 1200-ft Rd, 2010 (PNNL) small collection
Thompson's paintbrush	<i>Castilleja thompsonii</i>		Rattlesnake Mtn Top, 2010 (PNNL)
Hoary false yarrow	<i>Chaenactis douglasii</i>	Duffy Creek (about 3lb available) (BFI)	
Slender hawksbeard	<i>Crepis atriobarba</i>		ALE, 2006 (CTUIR), ALE, 2010 (PNNL)
Modoc hawksbeard	<i>Crepis modocensis</i>		Rattlesnake Mtn, 2006 (CTUIR), 2010 (PNNL)
Piper's daisy	<i>Erigeron piperianus</i>		Benson Ranch (900' elev.), 2006 (CTUIR); 1200-ft Rd ALE, 2010 (PNNL)
Rock buckwheat	<i>Eriogonum sphaerocephalum</i>	Beverly (near Wanapum Dam), don't know how much but they just harvested and seed is now drying (8/20/2010)	Rattlesnake Mtn, 2006 (CTUIR)
Thyme buckwheat	<i>Eriogonum thymoides</i>		Rattlesnake Mtn, 2006 (CTUIR); Top of Mtn, 2010 (PNNL)
Gray's biscuitroot	<i>Lomatium grayi</i>		ALE, 2010 (PNNL); Vernita Bridge, 2006 (CTUIR)
Bigseed lomatium	<i>Lomatium macrocarpum</i>	Columbia Basin sources all claimed	ALE, 2006 (CTUIR)

**Table A.1.** (contd)

Common Name	Scientific Name	Commercial Source Identified Seed Availability [Location, Other Information if Known, (Source)]	Local Collections Available [Source Location, Year (Source)]
Nineleaf biscuitroot	<i>Lomatium triternatum</i>	Idaho biotype (BFI)	Rattlesnake Mtn Top, 2006 (CTUIR)
Silky lupine	<i>Lupinus sericeus</i>		ALE 1200-ft Rd, 2006 (CTUIR), and 2010 (PNNL)
Lupine	<i>Lupinus</i> sp.		Rattlesnake Mtn Top, 2010 (PNNL);
Hoary aster	<i>Machaeranthera canescens</i>		Richland, 2005 and 2006 (CTUIR); 2010 (PNNL to collect)
Narrowleaf mock goldenweed	<i>Nestotus stenophyllus</i>		Rattlesnake Mtn Top, 2006 (CTUIR); 2010 (PNNL)
Whiteleaf scorpionweed	<i>Phacelia hastata</i>		Rattlesnake Mtn, 2006 (CTUIR)
Daggerpod	<i>Phoenicaulis cheiranthoides</i>		Rattlesnake Mtn Top, 2010 (PNNL)
Monro's globemallow	<i>Sphaeralcea munroana</i>		Red Mtn Rd, 2006 (CTUIR)
<b>Other</b>			
Native Grass Straw	<i>Festuca idahoensis</i>	<i>Festuca</i> native straw available (BFI)	





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