

# HIGH ALTITUDE REVEGETATION EXPERIMENTS ON THE BEARTOOTH PLATEAU, PARK COUNTY, MONTANA AND PARK COUNTY, WYOMING<sup>1</sup>

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**Abstract.** The Federal Highway Administration Central Federal Lands Highway Division (FHWA) is conducting a comprehensive study to identify techniques that maximize the opportunities for successful revegetation along high altitude portions of U.S. Highway 212, the Beartooth Highway. A portion of the Beartooth Highway that travels through alpine and subalpine areas is proposed for reconstruction by the FHWA. FHWA has conducted revegetation experiments in the form of test plots and seed increase experiments since 1999 to identify the most successful revegetation techniques for revegetating alpine areas.

Over a 4-year period, ERO designed and oversaw construction of four revegetation experiments along the Beartooth Highway to investigate the most effective revegetation techniques for subalpine and alpine disturbances. Variables tested include topsoil placement, organic amendments, surface mulches, slope aspect and steepness, seeding rate, and seed source (locally collected or commercial sources).

The results from this study will assist highway departments, mining, oil and gas, and utility companies, and other land management agencies in revegetating high altitude disturbances to meet requirements of various state, local, and federal permits. The study makes conclusions about the effectiveness of several revegetation items, such as seeding rate, type of organic amendment, fertilizer reapplication, and topsoil placement.

**Additional Key Words:** alpine revegetation, native plant restoration, highway revegetation, soil amendments, seeding rates, topsoil.

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## **Introduction**

The FHWA proposes to reconstruct portions of U.S. Highway 212, the Beartooth Highway, in Park County, Wyoming. The Beartooth Highway is a scenic highway that traverses subalpine and alpine areas on the Beartooth Plateau. In anticipation of the proposed reconstruction, FHWA and ERO began a series of revegetation tests in 1999, to determine the most appropriate revegetation techniques for alpine portions of the Beartooth Highway. ERO conducted an extensive literature review, which was summarized in the proceedings of the 15th annual High Altitude Revegetation Workshop (Payson 2002). During the design of the revegetation test plots, ERO consulted with several people knowledgeable in the reclamation of sensitive natural areas, including Ray Brown, formerly with the Rocky Mountain Research Station, Dale Wick and Joyce Lapp of Glacier National Park, Eleanor Williams Clark of Yellowstone National Park, Mark Majerus of the USDA Bridger Plant Materials Center, Steve Parr of the USDA Meeker Plant Materials Center, and suppliers of plant materials seed, soil amendments and surface mulches. The revegetation tests examine seed mix densities, seed sources, topsoil salvaging, organic amendments, surface mulches, and the planting of nursery stock.

This paper provides a brief overview of studies that FHWA has conducted since 1999, and provides a brief summary of monitoring results, successes, and lessons learned.

## **Study Location and Design**

Revegetation test plots were placed in three locations along the Beartooth Highway: the Montana Borrow Area, the Gardner Headwall, and the West Summit (Fig. 1). The Montana Borrow Area is at an elevation of about 3230 m (10,600 ft.), the Gardner Headwall elevation is about 3240 m (10,630 ft.), and the elevation of the West Summit is about 3050 m (10,000 ft.).

## **Findings**

### **Montana Borrow Area**

**Vegetation Cover Analyses.** Vegetation cover on the 1999 Montana Borrow Area test plots ranged from 48% to 62% in 2004 monitoring (Table 5). There was little difference in vegetation cover at the Montana Borrow Area between 2003 and 2004, although cover generally decreased since 2002 on plots on which amendments were reapplied. On plots where amendments were not reapplied, cover has increased since 2002, with some exceptions (ERO 2003, 2004).

The ANOVAs conducted on the 1999 Montana Borrow Area test plots showed that plots treated with topsoil had higher cover (mean cover ranging from 54% to 62%) than plots not treated with topsoil (mean cover ranging from 45% to 52%; Table 5). The effect of organic amendments on vegetation cover was apparent, but was not as noticeable as the effect of topsoil. Seeding rate did not apparently influence vegetation cover.

Plots on which amendments were reapplied had similar vegetation cover to plots on which amendments were not reapplied. In 2001 and 2002, the portions of plots on which amendments were reapplied had higher vegetation cover (ERO 2002, 2003), but in 2003, vegetation cover was not notably higher on plots on which amendments were reapplied (ERO 2004). Amendment reapplication has not taken place since 2001. The effects of amendment reapplication apparently did not last more than 1 year following the last reapplication of fertilizer. In 2001 and 2002,

cover on the Control plots where-fertilizer was reapplied (C-R) plots was quite high (66% in 2002). In 2003, however, C-R cover decreased to about 43%, and in 2004 mean cover on C-R plots increased to 48% (ERO 2002, 2003). In contrast, on control plots where fertilizer was not reapplied, vegetation cover was 45% in 2002 and 52% in 2003 (ERO 2003). This may indicate that an overabundance of nitrate caused high vegetation cover, which could not be sustained once reapplication of the additional nitrate source was discontinued. It appears that control plots where fertilizer was reapplied did not establish a nitrogen cycle. Also, in most cases, the northern half of the plot, on which amendments were reapplied, had lower mean vegetation cover than the southern half of the plot, on which amendments were not reapplied. This may indicate that an overabundance of nitrate caused high vegetation cover, which could not be sustained once the nitrate source was removed. This reinforces the need for topsoil in revegetating alpine disturbances.

Species Richness. There was no apparent treatment effect on species richness. This may be due to the limited number of species capable of colonizing the plots or because of the high variability within treatments.

#### 2000 West Summit Slope Test Plots

Vegetation Cover Analyses. At the 2000 West Summit Slope revegetation test plots, vegetation cover was higher on plots treated with Kiwi Power™ or BioSol Mix™ than on control plots, which had no organic amendments (Table 7). At very high elevations, organic amendments likely add nutrients that are important to vegetation establishment.

In the 2000 West Summit Slope Plots, plots seeded with the Beartooth-collected mix had higher cover than plots treated with the commercial mix. The effect of seed source could not be determined conclusively because the tests were not repeated, but both seed sources show a range of cover percentages, and seed from both sources apparently is establishing. The seeding rate used on the 2000 Gardner Headwall and 2000 West Summit Slope plots was lower than both seeding rates used on the 1999 Montana Borrow Area revegetation test plots. Vegetation cover on the 2000 Gardner Headwall and 2000 West Summit Slope plots (Tables 6 and 7) is lower than at the 1999 Montana Borrow Area (Table 5). This could be related to the seeding rate, the higher elevation of the Gardner Headwall and West Summit, or other factors.

Vegetation cover was higher on 1:2 slopes than on 1:3 slopes. The higher vegetation cover on 1:2 slopes is possibly related to site-specific factors because these plots were not replicated.

Slope aspect was examined at the 2000 West Summit Slope and 2000 Gardner Headwall Plots. South-facing slopes had the highest vegetation cover, east-facing slopes had moderate cover, and north-facing slopes had the lowest vegetation cover. It is interesting to note that in previous years of monitoring, east-facing slopes had higher cover than south-facing slopes. North-facing slopes probably present the biggest challenge to revegetation in alpine areas because they are exposed to the sun for shorter durations than east-or south-facing slopes. East-facing slopes may be more protected from the wind than south facing slopes on the Beartooth Plateau because the wind generally blows from the west or southwest on the Beartooth Plateau, and east-facing slopes are protected from wind. South-facing slopes, however, are likely warmer and receive more direct sunlight.

Species Richness. Species richness was higher on plots treated with sod transplants than on seeded plots. In addition, plots treated with BFM or WC had higher species richness than plots treated with ECBs.

## Conclusions

The most notable conclusion of these revegetation test plots is the importance of topsoil salvaging in alpine areas. In these studies, topsoil application appeared to be the most important variable in establishing cover on the revegetation test plots. Few commercially grown species are suitable for alpine revegetation use; therefore, seedbank and propagules in topsoil may add diversity to reclaimed alpine disturbances. The seedbank and propagules present in topsoil may be valuable in adding diversity to reclaimed alpine disturbances.

Where topsoil salvaging was possible, the application of some sort of organic amendment apparently is effective. An organic amendment such as composted organic material, while it may be a source of soil organic carbon, and may help to reduce soil bulk density, is costly to haul. BioSol Mix<sup>™</sup> and Kiwi Power<sup>™</sup>, two organic amendments that do not provide organic carbon to the soil and that likely do not help to increase bulk density, also were effective at extremely high elevations where topsoil was not applied to the test plots.

Observations made during previous research conducted by Ray Brown seemed to indicate that seeding effectiveness did not decrease with increasing seeding rate (Brown 1999). When very high seeding rates were tested on the 1999 Montana Borrow Area plots, it appeared that very high seeding rates did not result in higher cover or greater species richness. High seeding rates apparently are more effective than low or very low seeding rates at high elevations.

In general, some of the revegetation techniques, such as transplanting sod or planting of nursery-grown transplants, were valuable means to increase the number of species that established in disturbances, although these techniques did not appear to be cost effective for large areas or instead of seeding and topsoil salvaging for the Beartooth studies.

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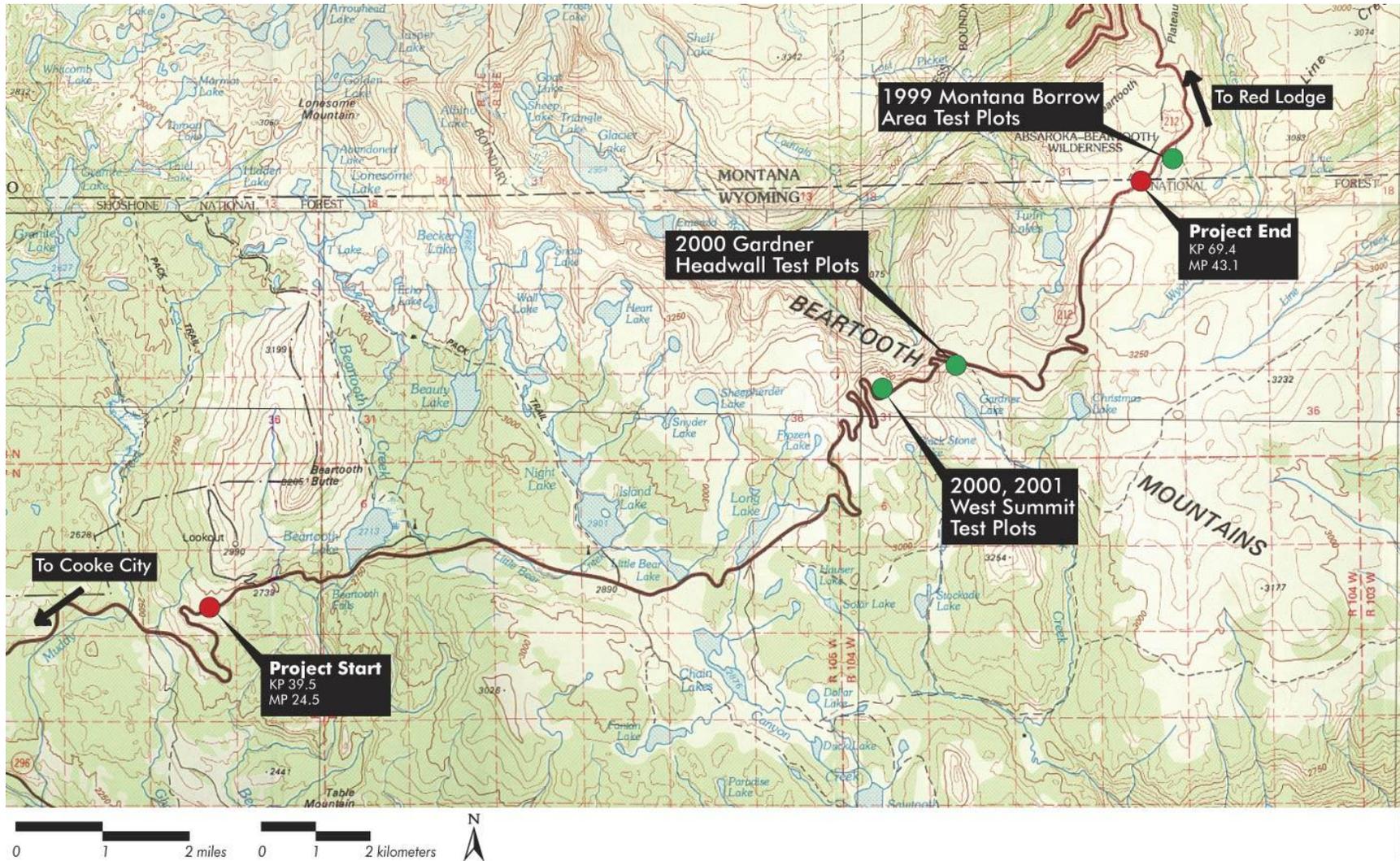
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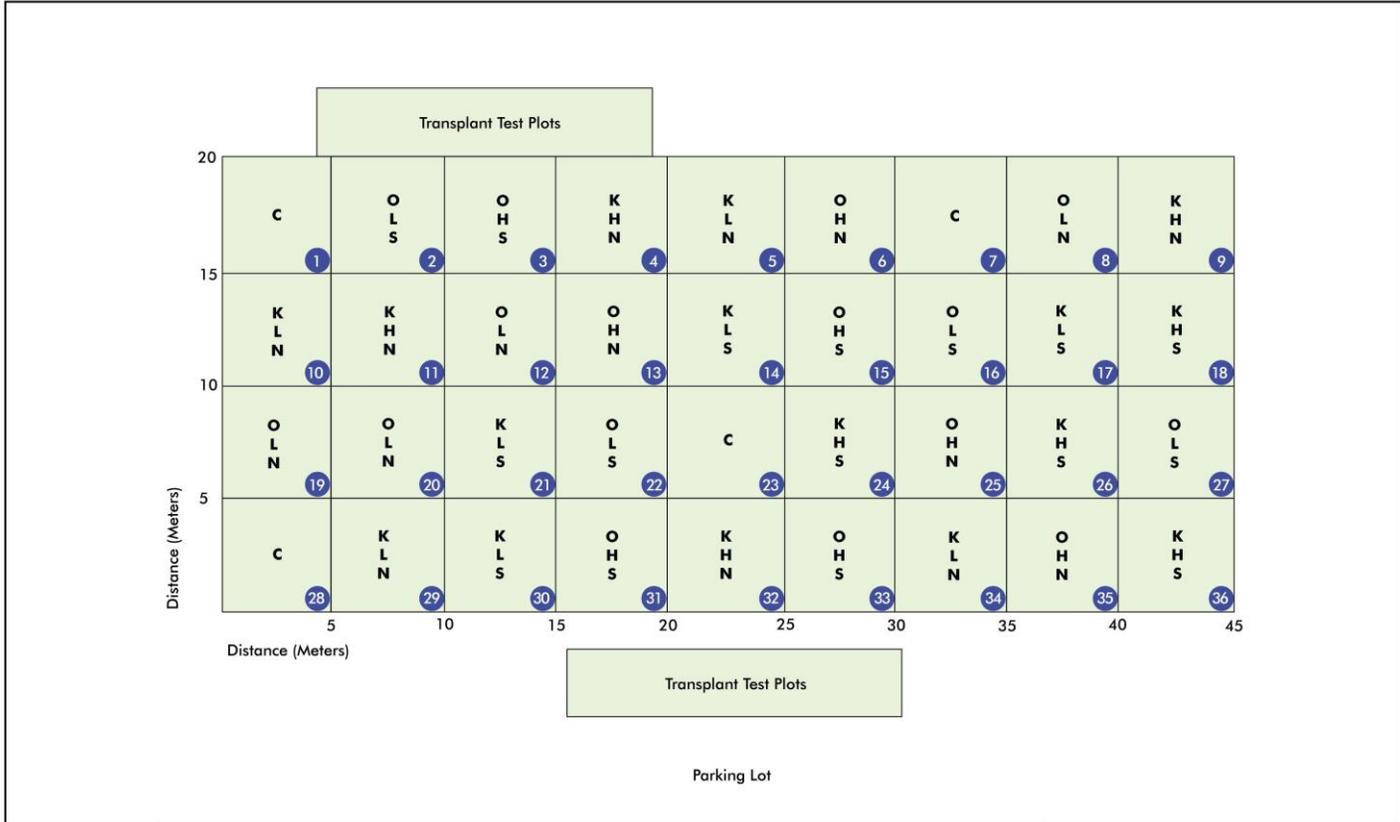
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**Figures**





**ERO**  
 ERO Resources Corp.  
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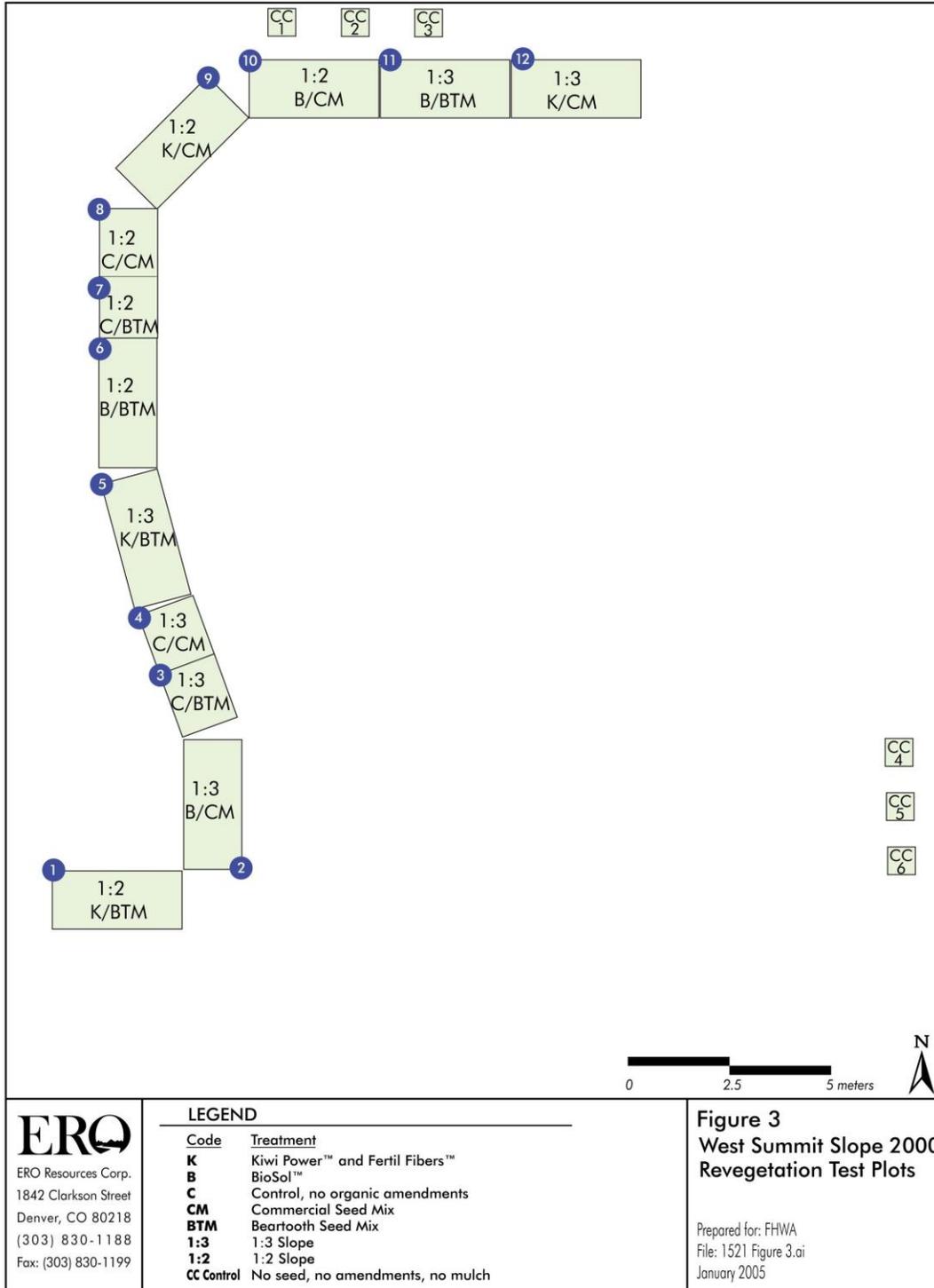
**LEGEND**

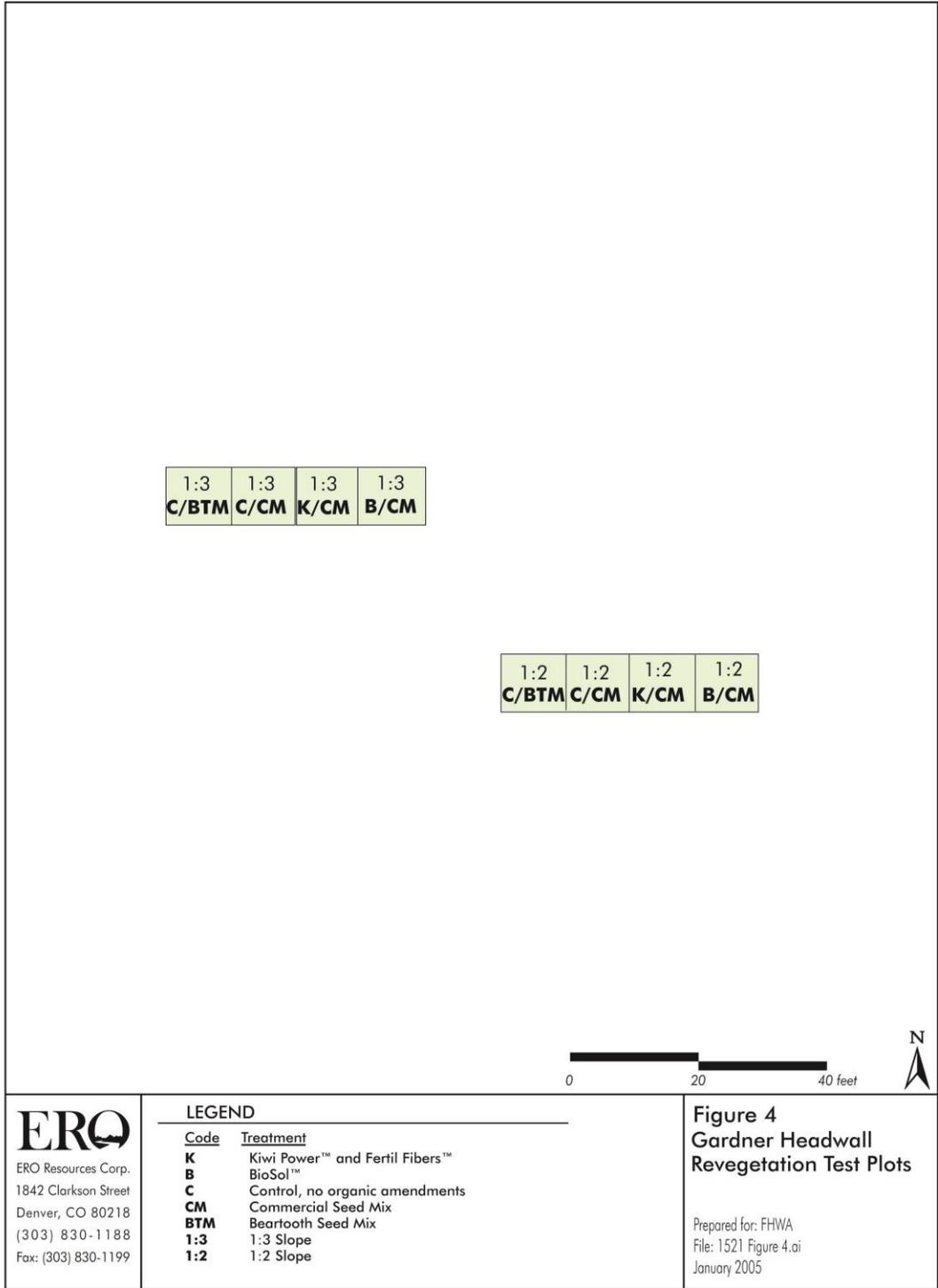
Code	Treatment
O	Organic amendment plus fertilizer
K	Kiwi Power™ + Fertil-Fibers™
L	Lower density seeding rate
H	Higher density seeding rate
S	Topsoil salvaged
N	No topsoil salvaged
C	Control: Fertilizer and lower density seeding rate



**Figure 2**  
 1999 Montana Borrow Area  
 Revegetation Test Plots

Prepared for: FHWA  
 File: 1521 Figure 2.ai  
 January 2005





1:3	1:3	1:3	1:3
<b>C/BTM</b>	<b>C/CM</b>	<b>K/CM</b>	<b>B/CM</b>

1:2	1:2	1:2	1:2
<b>C/BTM</b>	<b>C/CM</b>	<b>K/CM</b>	<b>B/CM</b>

0 20 40 feet

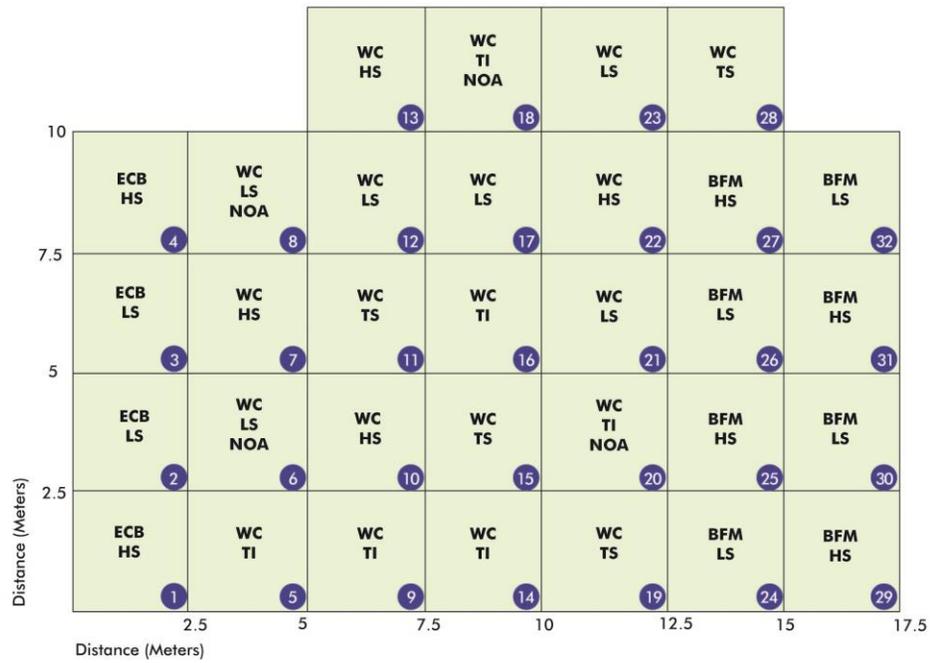


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LEGEND	
Code	Treatment
<b>K</b>	Kiwi Power™ and Fertil Fibers™
<b>B</b>	BioSol™
<b>C</b>	Control, no organic amendments
<b>CM</b>	Commercial Seed Mix
<b>BTM</b>	Beartooth Seed Mix
<b>1:3</b>	1:3 Slope
<b>1:2</b>	1:2 Slope

**Figure 4**  
**Gardner Headwall**  
**Revegetation Test Plots**

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 File: 1521 Figure 4.ai  
 January 2005



Parking Lot



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**LEGEND**

Code	Treatment
<b>WC</b>	Wood Chips
<b>BFM</b>	Bonded fiber matrix
<b>ECB</b>	Erosion control blanket
<b>LS</b>	Lower density seeding rate
<b>HS</b>	Moderate density seeding rate
<b>TI</b>	Transplants placed immediately following excavation
<b>TS</b>	Transplants placed 1 month following excavation
<b>NOA</b>	No organic amendment



**Figure 5**  
**West Summit Flat**  
**2001 Revegetation Test Plots**

Prepared for: FHWA  
File: 1521 Figure 5.ai  
January 2005