GRAVE CREEK DEMONSTRATION PHASE RIPARIAN REVEGETATION PLAN

DECEMBER, 2008

PREPARED FOR:

KOOTENAI RIVER NETWORK
P.O. BOX 491
LIBBY, MT 59923

PREPARED BY:

GEUM ENVIRONMENTAL CONSULTING, INC.
307 STATE STREET, P.O. BOX 1956
HAMILTON, MT 59840

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Section 1 Introduction

1.1 Project Identification

This document describes a riparian revegetation plan for the Demonstration Phase reach (Demo reach) of the Grave Creek restoration project, located in Lincoln County, near Eureka, Montana (Township 35 North, Range 26 West, Section 12; Latitude 48.81331 Longitude -114.89867). Grave Creek is a tributary to the Tobacco River, which flows into the Kootenai River (at Lake Koocanusa) west of Eureka, Montana. Figure 1 shows the location of the project area within the Grave Creek watershed, and the project location relative to major towns and other watercourses.

This plan includes implementing various riparian and floodplain restoration and enhancement strategies in the Demo reach. This project continues restoration efforts begun on this reach of Grave Creek in 2001 and supplemented in 2006. The project history and value of this natural resource is detailed in the following section. In general, past restoration efforts within the project reach included re-alignment of 8,200 feet of channel in three separate phases: Demonstration Phase (1,000 feet); Phase One (4,200 feet); and Phase Two (3,000 feet). While some revegetation work has been implemented as part of these phases, this riparian and floodplain restoration plan describes additional revegetation treatments for the Demonstration Phase (Figure 2).

The primary problem this plan addresses is the need for native riparian and floodplain vegetation recovery to improve floodplain function, decrease noxious weed infestations and reduce the risk of sediment inputs from an eroding slope adjacent to the left bank within the Demo reach.

This project will contribute to meeting Use Support Objectives, Allocation Strategies and Restoration Objectives described in the final Grave Creek TMDL (DEQ 2005), including:

- 63% reduction in bank erosion rates in lower Grave Creek; and
- Improve large woody debris recruitment potential through protection of riparian areas on all lands.

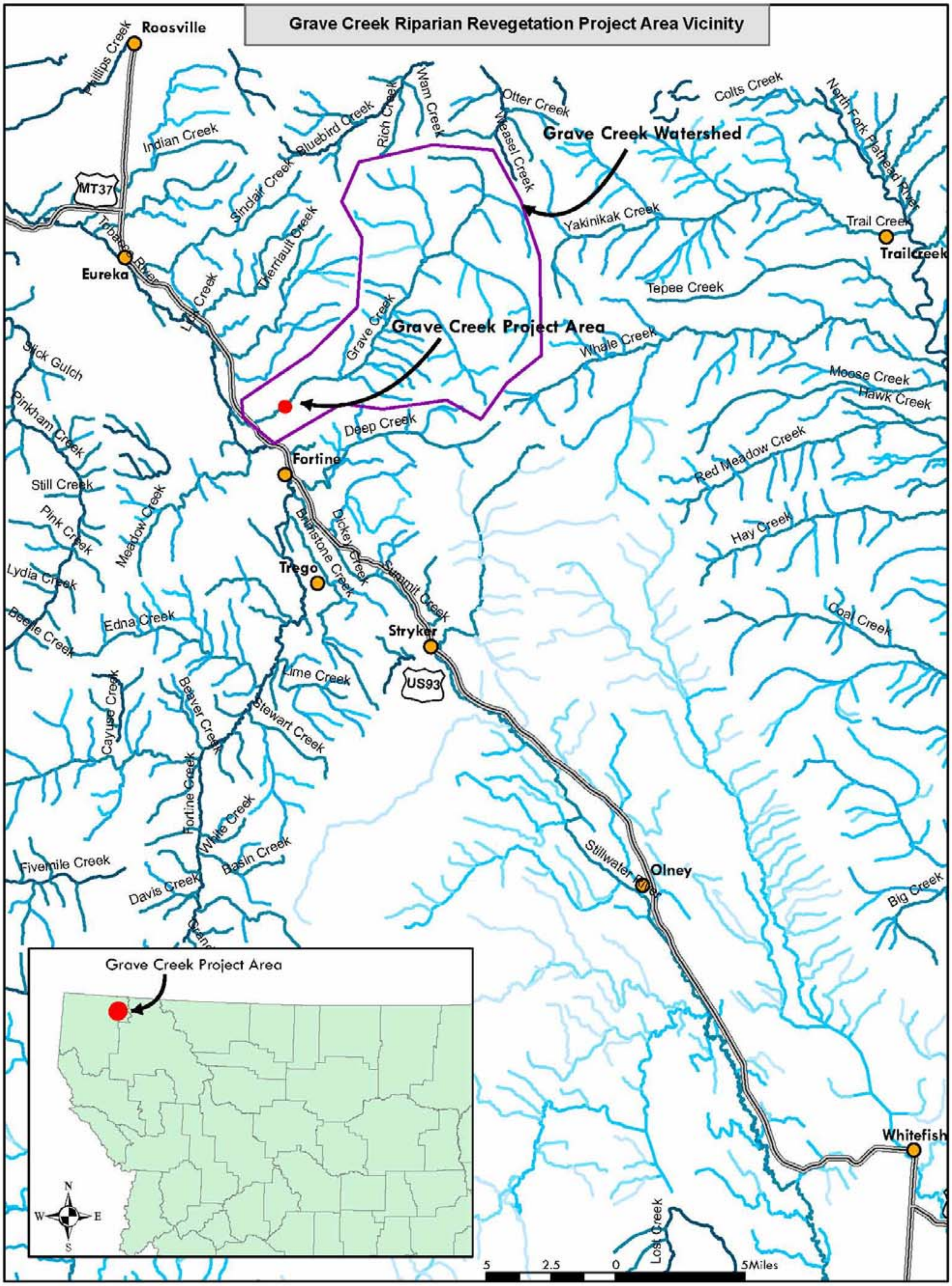

Figure 1. Location of the project area in relation to the Grave Creek watershed, the larger Tobacco River watershed and western Montana (inset)**.**

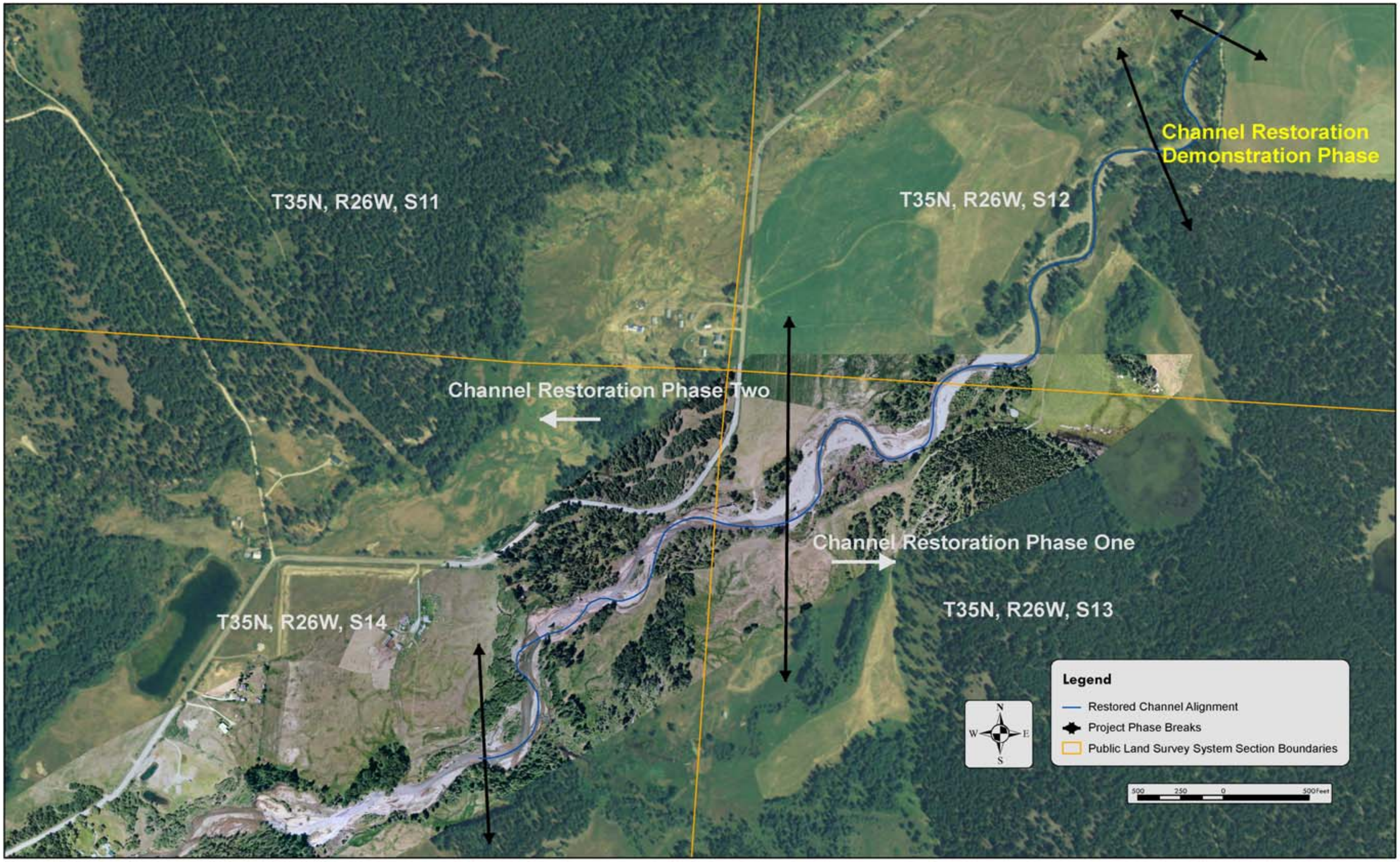

Figure 2. Overview of Grave Creek restoration project area**.** This riparian revegetation plan includes the channel restoration Demonstration Phase (highlighted in yellow).

1.2 Project History

This project is the continuation of restoration efforts begun in this reach of Grave Creek in 2001. In 1996, a watershed analysis was completed to support development of a Total Maximum Daily Load (TMDL) for the watershed. This analysis identified Grave Creek as having fish habitat limitations linked to excess sediment loading (DEQ 2005). Habitat limitations in the lower reaches of Grave Creek were linked to a lack of pools and low levels of large woody debris. Additional problems in lower reaches of the watershed included: an overly widened channel; eroding banks linked to past channelization and past and recent land management practices; and a reduction in function of the riparian corridor due to historical management practices (DEQ 2005).

Grave Creek supports an important bull trout fishery and provides habitat for several other native fish, including westslope cutthroat trout. Grave Creek and its associated tributaries have been identified as the most important bull trout spawning tributary for the portion of the Upper Kootenai River watershed located in the United States (as reported in the 2007 RFP for revegetation planning work prepared by Kootenai River Network (KRN)). Historical data suggest that runs of mountain whitefish, bull trout, and westslope cutthroat trout from the Kootenai River have declined since the mid 1940s due to past management practices in the watershed (DEQ 2005).

Since completion of the watershed assessment, a number of agencies and other organizations including: Montana Fish, Wildlife and Parks, U.S. Fish Wildlife Service through the Partners for Fish and Wildlife Program, the Lincoln Conservation District, and the Natural Resources Conservation Service and private landowners; have been working together to implement restoration and land management changes within the watershed.

The project reach, including the Demo reach, was identified by partners as a high priority for reducing sediment sources and restoring habitat for fish. Restoration activities focused on restoring proper form and function of the river channel through reconstruction of a large gravel to small cobble, meandering, riffle-pool stream type. A variety of design methods were used including an analog or referenced based approach, hydraulic modeling, and application of regional curves and regime equations. Specific restoration actions included: channel reconstruction; installation of fish habitat features; grade control and bank stabilization structures; and improving hydrologic connectivity with the adjacent floodplain, historical wetland side channels and meander oxbows. Converting the channel from an unstable, braided system to a single thread channel resulted in large areas of bare, alluvial surfaces which require rapid development of riparian vegetation to promote floodplain and channel stability. Grade control and bank structures typically limit short-term channel movement and provide time for riparian vegetation communities to develop.

Initial revegetation of the project reach, including the Demo reach, was accomplished using: whole sod and shrub transplants, containerized root stock, sprigs and dormant pole plantings, broadcast seeding, and organic compost application. Initial efforts to promote revegetation of the reach resulted in limited success due to several site constraints. These constraints included: browse pressure from livestock and wild ungulates; erodible outer banks being subject to annual scour; limited moisture holding capacity of exposed cobble substrates; and lack of microsites to support plant establishment on smooth, flat constructed floodplain surfaces. These constraints are described further in Section 2. To address these constraints, supplemental riparian revegetation activities were implemented within project reaches in 2005, 2006, and 2008. Revegetation in 2005 and 2006 included: stream bank bioengineering techniques, such as vegetated soil lifts; planting a small number of containerized shrubs; and enhancement of constructed floodplain areas to promote natural floodplain processes such as sediment storage, erosion control, and plant community succession. Floodplain enhancement techniques included construction of floodplain swales, planting of containerized shrubs in select swale features, and placement of large woody debris on floodplain surfaces. Revegetation completed in 2008 included streambank and floodplain bioengineering, maintenance of previously installed containerized plants, point bar revegetation, floodplain grading, weed control and the installation of an electric wildlife fence around the Demonstration Phase and Phase One portions of the Grave Creek project area. The 2008 treatments and the constraints they addressed are described in two documents, *Grave Creek Riparian Revegetation and Monitoring Plan* (2008 Revegetation Plan, Geum Environmental Consulting 2008a) and *Grave Creek Riparian Revegetation As-built and Monitoring Report* (Geum Environmental Consulting 2008b).

While these efforts have contributed to restoring stream and floodplain function, additional constraints and revegetation needs have been identified for the Demo reach of this project. This document describes those additional revegetation strategies that will address the remaining site constraints. Implementing these strategies will promote recovery of desired riparian plant communities, and will protect the significant investment in channel and floodplain restoration that has been made to date.

1.3 Project Purpose and Objectives

The purpose of this project is to restore the riparian and floodplain environment along Grave Creek within the Demo reach. The project will result in conditions that will support the establishment of diverse plant communities capable of sustaining floodplain ecological processes. These ecological processes include: plant community succession, sediment storage, flood water retention, and long-term channel stability. Implementing this project will assist project partners in preserving valuable natural resources in Grave Creek including threatened and sensitive fish species, wildlife, and water quality.

To achieve the project purpose and the desired future condition, the following specific objectives were developed:

1. Promote riparian vegetation community development and succession by enhancing microtopography and creating more diverse niches where plants can become established.
2. Reduce sediment inputs from the eroding slope through the use of bioengineering, planting, and seeding treatments that will promote long-term stability through vegetation establishment.

3. Limit the spread of noxious weeds through the development and implementation of a project wide weed control program and establishment of native vegetation.

The remaining sections of this document include the following information:

- **Section 2** describes the existing conditions, desired future conditions and limiting factors to achieving the desired future condition.
- **Section 3** describes the preferred alternative for achieving project objectives and other alternatives considered, including a No Action alternative.
- **Section 4** describes how the preferred alternative for achieving project objectives will be implemented.
- **Section 5** provides a timeline for implementing the preferred alternative.
- **Section 6** provides supplemental technical documentation on the project.

Section 2 Existing and Desired Future Condition

2.1 Existing Condition

The Demo reach was assessed during August 2008 and previously during site visits and implementation efforts in 2005, 2006, and 2007. Assessments focused on: characterizing existing plant communities and the natural processes contributing to the development of those plant communities; observing how the reach is responding to past restoration and revegetation efforts; and determining the existing limiting factors to achieving the desired future condition for the project reach. This section describes the current conditions of the riparian and floodplain environment within the project reach including: the reach's potential natural community; observations of riparian and floodplain revegetation processes; and the primary constraints and limitations to achieving revegetation objectives.

The concept of a potential natural community (adapted from Daubenmire 1968) refers to the plant community that will develop on a site over time as a result of (1) natural disturbance processes that occur over relatively long periods; (2) the particular combination of climate, landform, substrate, latitude, and hydrogeomorphic conditions; and (3) biological processes such as seed dispersal, soil biology, and influence from animals and birds. The potential natural community represents a range of plant communities that occur as a spatial mosaic and represent a variety of successional states corresponding with random disturbance events and complex microtopographic and moisture gradients on a site. Developing revegetation strategies based on the potential natural community of a site increases success of establishing dynamic plant communities that can be sustained long-term.

At the largest scale, Grave Creek's potential natural community within the project reach is the *Picea*/*Cornus sericea (*spruce/red-osier dogwood) habitat type (Hansen et al. 1995). It appears that this habitat type is capable of occupying all areas of the floodplain up to the stream bank. Because Grave Creek is a dynamic system with significant sediment transport and deposition, this habitat type will usually result from the following progression:

1. *Populus trichocarpa*/recent alluvial bar (Black cottonwood/recent alluvial bar) community will develop first, colonizing depositional areas resulting from flood events.
2. Over time, the black cottonwood/recent alluvial bar community will trap sediment, allowing first willows and then other later successional shrubs to develop, ultimately resulting in the black cottonwood/red-osier dogwood community type.
3. Once either overhead or lateral shade has developed due to cottonwoods rapidly growing, spruce seedlings will become established and longer-lived spruce will ultimately replace the cottonwood communities.

In addition to the above succession scenario, spruce appears to directly colonize alluvial bars along Grave Creek.

The speed at which this progression occurs is highly dependent on annual run-off timing and magnitude and the scour and deposition that occur as a result.

Within the spruce/red-osier dogwood habitat type, patches of minor, transitional community types may become established, such as:

- The *Salix exigua* (sandbar willow) community type (Hansen et al. 1995), which can form dense stands that may include other shrub species like *Salix drummondiana* (Drummond's willow), *Alnus incana* (mountain alder) and red-osier dogwood. These plant communities are likely to occur on new depositional areas along the channel or in open, low depression areas with coarse substrate within the forested overstory; or
- The mountain alder community type (Hansen et al. 1995), which may form in swales where groundwater is consistently close to the soil surface.

Examples of vegetation community types and successional stages occurring within the Demo reach at Grave Creek are shown in Figures 3, 4 and 5 below.

Figure 3. Example of Spruce/red-osier dogwood habitat type encroaching on a point bar within the Demo reach. Young spruce are growing under the cover of mature cottonwood trees (photo background).

Figure 4. Example of black cottonwood/recent alluvial bar community type colonizing a point bar within the Demo reach.

Figure 5. Example of black cottonwood/red-osier dogwood community type within the Demo reach.

In general, existing riparian plant communities throughout the project reach lack young age classes. Young stands of both cottonwoods and willows are rare within the channel migration zone. One reason for this is likely due to the pre-restoration channel conditions of the reach, which consisted of a braided channel. Cottonwoods and willows likely germinated on exposed floodplain gravels, but gravels were likely re-distributed before seedlings could establish. Another reason for this is the long history of grazing and current levels of wildlife browse occurring in the reach.

Intense levels of browse are also limiting understory shrub development in forested areas. Black cottonwood stands are common along outer meander bends, but consist almost entirely of even-aged mature stands with heavily browsed woody understory vegetation

(Figure 6). Woody understory vegetation consists of species such as red-osier dogwood, alder, *Symphoricarpos* spp (snowberry), *Rosa woodsii* (Wood's rose) and *Rubus idaeus* (red raspberry); but they are heavily browsed and grasses and forbs remain as the dominant component.

Browse is limiting plant community development throughout the project reach. During the December site visit, browse was observed on all unprotected shrubs and trees, with the exception of spruce, along the entire length of the Demo reach (Figure 7). Browse pressure is likely affecting the survival of both naturally recruited and planted seedlings and saplings, and may also limit the amount of available seed.

The level of browse intensity within the project reach, including the Demo reach, is intense, with intense defined as browse resulting in a complete annual stem segment being killed (Keigley and Frisina 1998). Most shrubs within the project reach exhibit an arrested-type architecture indicative of intense browsing. Herbivory is uniform throughout the project reach, and all individuals within the young age class exhibit this arrested-type architecture. The existing stands of cottonwoods and willows are likely remnants of an early period of light-to-moderate browse and are often the parents of the short, heavily browsed plants.

Figure 6. Black cottonwood plant community illustrating the dominance of older age class cottonwoods and a lack of understory woody vegetation within the Demo reach.

Some portions of the Demo reach lack mature woody vegetation along the banks (Figure 8). This is primarily due to past land uses that resulted in the removal of riparian vegetation communities. This is also due to the short time since channel restoration was completed. Restoring the channel from braided to single thread resulted in large areas of newly constructed surfaces, which require a long period of time for desired, mature vegetation to develop. Another possible cause for the lack of woody vegetation along the stream banks, primarily the left bank, is the construction of flat, uniform floodplain surfaces during initial channel reconstruction. Flat, uniform surfaces lack the complexity and niches required to support the establishment of desired woody vegetation.

Figure 7. Photograph showing suppressed cottonwood seedling growth due to browse.

Figure 8. Photograph of existing conditions within the Demo reach, where banks lack mature riparian vegetation. During initial channel construction in 2001, concerns of possible avulsions or headcutting resulted in the construction of floodplain surfaces that are uniform and at elevations that are less frequently accessed by high flows.

Vegetation along the right bank floodplain of the Demo reach consists of a native shrub understory and native canopy. The understory consists predominantly of Wood's rose with minor components of red-osier dogwood, snowberry, and *Amelanchier alnifolia* (western serviceberry). The herbaceous layer is a mix of native and weedy forbs and pasture grasses. Mature black cottonwood is present throughout the canopy.

Near the downstream end of the Demo Reach, a point bar that was reconstructed in 2006 is exhibiting conditions that support the recruitment and establishment of woody vegetation. Woody debris and organic matter are scattered throughout this surface which has led to an accumulation of varying substrates, seed, and plant propagules, while also providing microsites where seed can germinate and grow (Figures 9 and 10). Red-osier dogwood and black cottonwood seedlings are present on this point bar feature. Weedy species, such as *Linaria* spp. (toadflax), *Centaurea* spp. (knapweed species), and *Leucanthemum vulgare* (oxeye daisy) are also present.

Within the Demo reach, the left bank floodplain surface lacks depositional surfaces that are low enough to be frequently accessed during high flows. For this reason, this surface appears to support a monoculture of weeds with small inclusions of grass species and islands of Englemann spruce (Figure 8). Other floodplain surfaces further away from the channel that were left undisturbed during initial channel reconstruction support a mature cottonwood overstory and *Aralia nudicaulis* (wild sarsaparilla) understory with scattered Engelmann spruce saplings and poles. The lack of establishment of native woody vegetation on the constructed left bank floodplain surface within the Demo reach is due to a variety of factors, including; heavy browse pressure, uniform topography resulting in insufficient microsites, and a lack of connectivity with the channel due to localized channel incision through the reach. These limiting factors are discussed in more detail in Section 2.1.1 below.

Figure 9. Photograph shows flood deposited woody debris accumulating on a point bar surface in the Demo reach. Inset photo shows native species are colonizing around the woody debris.

Figure 10. Photograph of point bar illustrating flood deposited coarse woody debris and organic matter accumulation around large woody debris. Colonization of woody species is occurring in the sediments and organic matter deposited around the woody debris.

The left bank at the downstream end of the Demo reach is adjacent to a high, steep eroding slope. A bankfull bench and woody debris jams were installed along this bank during initial channel restoration activities. A significant flood event that occurred during 2005 resulted in erosion between the debris jams. In response to this erosion, vegetated soil lifts and a bankfull bench were constructed along this bank in 2006 to establish woody vegetation and limit scour and erosion of the slope toe (Figure 11). Monitoring of these treatments in August 2008 indicated that willow survival in the soil lift is high and seeded species such as *Achillea millefolium* (common yarrow) and *Trifolium* spp. (clover) are colonizing the bankfull bench, although total percent cover is relatively low on the bench (Figure 12). Colonization of the bankull bench is limited by the predominantly large sized cobble substrate (Figures 13 and 14).

Observations of the eroding slope made during August 2008 indicate that although there is evidence of rilling and erosion (Figure 13), the risk of major sediment inputs to the stream is not severe because the constructed bankfull bench separates the slope from most flows. The slope is being colonized by a mix of native and non-native early successional species. Species colonizing the toe and lower portions of the slope include: *Bromus inermis* (smooth brome), *Phleum pratense* (common timothy), *Agrostis stolonifera* (redtop), *Elymus trachycaulus* (slender wheatgrass), *Festuca* spp. (fescue), *Agropyron riparium* (streambank wheatgrass), *Dactylis glomerata* (orchardgrass), *Poa pratensis* (Kentucky bluegrass), Wood's rose, red raspberry, snowberry, and other *Bromus* spp. (brome species) (Figure 14). Species colonizing the upper portions of the slope include common yarrow, *Aster* spp. (aster), *Galium* spp. (bedstraw), *Fragaria virginiana* (strawberry), *Taraxacum officinale* (common dandelion), *Cynoglossum officinale* (houndstongue), Kentucky bluegrass, common timothy, and *Medicago lupulina* (black medic). Shrub species are present only on the lower portions of the slope. The steepest portions of the upper slope do not support any vegetation because of frequent erosion. It appears that most of the slope erosion is caused by the slope toe being frequently undercut, causing portions of the slope to adjust as it seeks the angle of repose. Any treatment that stabilizes the toe will likely allow the slope to support perennial vegetation within five to ten years.

Figure 11. The downstream outer meander of the Demo reach is occupied by a steep slope, a bankfull bench, and two vegetated soil lifts.

Figure 12. Photograph shows the slope, bankfull bench, and vegetated soil lift in the Demo reach. Grasses and forbs (both seeded and naturally recruited) are colonizing the slope and bench, but bare soil areas are still present.

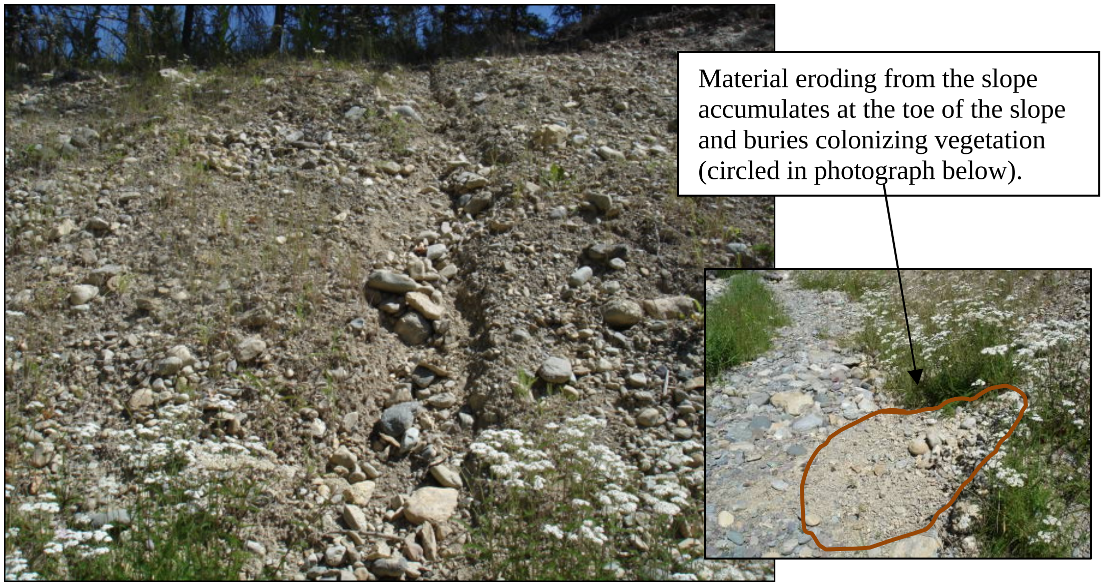

Figure 13. Photograph shows evidence of rilling and erosion on the upper portions of the steep slope within the Demo reach. Note the yarrow that has colonized the bottom of the slope. Inset photo shows the eroding material accumulating at the toe of the slope and covering a patch of yarrow.

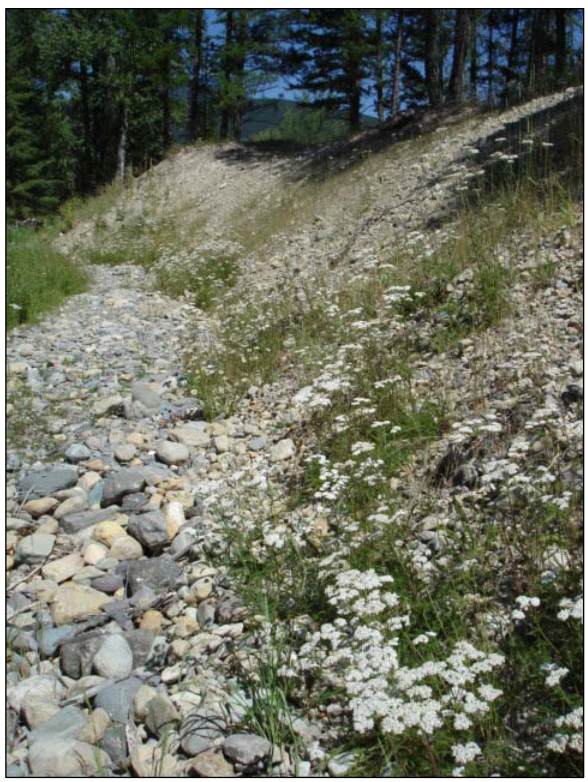

Figure 14. The slope located along the left bank of the downstream end of the Demo reach is colonized by a patchy distribution of native and non-native species.

Invasive weed species are present throughout the Demo reach. The primary weed species in the project reach are knapweed and oxeye daisy. These species are widespread with varying densities. The bare floodplain surfaces along the left bank support the highest densities, while the floodplain areas along the right bank support only patchy occurrences of both species. Toadflax is also present on the right bank point bar.

2.1.1 Current Limiting Factors

Based on the current conditions, the following causes are considered limiting factors to achieving the desired future condition:

- Cattle and ungulate browse is intense within the project reach, including the Demo reach; most susceptible trees and shrubs are being browsed. Continued removal of terminal and lateral buds and foliage has stressed many planted and naturally recruited shrubs and trees. This historical and continued pressure has resulted in plant communities which are missing younger age classes and therefore cannot function to provide stream bank stability or create structurally complex and diverse plant communities. Browse levels have not been regularly monitored in the project reach. However, based on observations made in December, 2007, it is estimated that greater than 90% of shrubs less than three feet in height are being browsed past the current year's growth.
- A large, smooth, constructed floodplain surface is adjacent to the channel in the Demo reach. This area comprises a large portion of the floodplain surface and provides limited microsites where desired woody vegetation can become established. This is limiting point bar plant community succession which is necessary for long-term stability of the reach. In addition, this floodplain surface is high relative to the channel and may not be completely accessed by bankfull flows. Because of this, many of the processes associated with flood disturbance that stimulate plant community succession are lacking.
- Instability of the slope adjacent to the downstream left bank results in rilling and erosion. This, combined with sediment deposition at the toe of the slope, creates conditions unsuitable for long-term vegetation establishment and poses a risk of sediment delivery to the channel.
- Competition from weedy species may be limiting desired plant establishment on floodplain surfaces within the reach.

2.2 Desired Future Condition

The desired future condition for the riparian and floodplain environment within the project reach, including the Demo reach is a dynamic, succession driven mosaic of plant communities capable of supporting a wide range of floodplain ecosystem functions. This is the type of environment present in many undisturbed riparian communities in large stream and river systems in the Kootenai River Basin and is the environment that was likely present before agricultural clearing and channelization occurred in the project reach. Historically, the lower Grave Creek valley consisted of a multiple channel system that developed within a broad, well-vegetated spruce wetland (General Land Office map dated March 16, 1896). This system likely meandered across a wide floodplain and supported diverse shrub and spruce wetlands (DEQ 2005). This is similar to the late successional stage described in Section 2.1.

The desired future condition of the project reach, including the Demo reach, would include the level of vegetative and structural diversity associated with varied age class stands of willow, cottonwood, and spruce communities, which are necessary for bank stability and floodplain function along a meandering, gravel-dominated, riffle pool channel. These plant communities would supply coarse woody debris sufficient to sustain instream habitat complexity. To successfully create and maintain a diverse mosaic of plant communities in the project reach requires acknowledging the role that fluvial processes play in determining plant community structure. Geomorphic and other disturbance processes influence the development of the riparian and floodplain ecosystem, ultimately determining the spatial pattern and successional development of riparian vegetation.

Because stream systems are dynamic, with natural disturbance processes playing a large role, achieving the desired future condition will take several years and require an adaptive, phased approach. The focus of this riparian revegetation plan is to set the reach on a trajectory that can take numerous paths, but will ultimately reach the desired condition. For this reason, implementing a monitoring program that observes changes in the channel, floodplain and riparian environments will be necessary to determine if the project is on this trajectory and achieving the project purpose and objectives.

For example, prior to achieving the desired future condition of a multi-aged, structurally diverse mosaic of riparian plant communities, observations of the treatments implemented in the project reach would help determine if conditions to support those desired plant communities are present. On point bars, this means microtopography is diverse and complex with large woody debris, coarse woody debris accumulations, and floodplain swales to capture sediments, seed, plant propagules, and create niches and microsites for plant community development. This would represent the as-built condition. Within one to two years of implementing such treatments, natural recruitment of pioneer woody vegetation should be present on some or all point bars. Within five to ten years of observing pioneer vegetation, stands of mature willows and pole cottonwoods would occupy a portion of point bars.

In other areas, young age class shrub stands should return within one to two years after excluding livestock grazing and wildlife browse from the project reach. In cottonwood stands, diverse shrub communities should develop and promote floodplain and channel stability within five years after excluding grazing and browse. On-going monitoring will help determine if the Demo reach is moving towards the desired future condition. A monitoring plan that includes the entire project reach is described in the 2008 Revegetation Plan (Geum Environmental Consulting 2008a).

Limiting factors that must be overcome to achieve the desired future condition for the Demo reach include:

- Grazing and browse pressure;
- Limited point bar plant community succession;
- Unstable conditions along the terrace slope; and
- Competition from weeds.

To achieve the desired future condition and project objectives, this revegetation plan includes strategies to address these limiting factors. Table 1 summarizes the current and desired conditions of these limiting factors and the proposed revegetation strategies to address each for the Demo reach. These strategies are described below.

2.2.1 Browse Pressure

Currently, riparian plant communities in the project reach consist of older age classes and woody species regeneration is being suppressed by livestock, deer and elk browse. To achieve the desired future condition, browse must be significantly reduced for at least five years to allow the existing seed bank to germinate and currently suppressed shrubs to establish.

This constraint has been addressed through the installation of an electric wildlife fence around the Demo reach and portions of the Phase One reach. Fence installation occurred in August 2008. Monitoring to assess the effectiveness of this treatment will occur during summer 2009.

2.2.2 Limited Point Bar Plant Community Succession

Simple, uniform topography on floodplain and point bar surfaces does not provide microsites that trap seed and plant propagules, nor does it promote scour and deposition needed to create and maintain microsites. Overbank flows rush over uniform floodplain surfaces without depositing sediments or organic materials, which are necessary in alluvial systems to build soil and promote vegetation establishment.

The project will address the lack of seedling establishment on floodplain surfaces by constructing floodplain swales, installing buried coir fascines where appropriate, and placing additional large woody debris in the floodplain where possible. In addition, point bar revegetation in the form of seeding and large containerized shrubs and trees will be done in areas where site conditions are appropriate. These treatments are described in more detail in Section 3 and Appendix A.

2.2.3 Unstable Slope

The unstable surfaces of the steep slope adjacent to the downstream left bank in the Demo reach inhibit plant community development along the slope as well as at the toe where eroding sediments accumulate and create frequent, minor disturbances. The risk of large sediment inputs to the stream is low, even though erosion of the terrace slope is occurring. The bankfull bench and vegetated soil lifts, constructed in 2006, create a buffer between the eroding slope and the channel. Even with this buffer, sediments from the eroding slope that have accumulated at the toe of the slope may be transported into the channel during high flow events or during heavy rain events.

This project will address this potential sediment source by enhancing vegetation at the toe of the eroding slope and on the bankfull bench. This will be accomplished by installing high density coir logs along the slope toe in conjunction with large container sized riparian shrubs and trees. The bankfull bench will be revegetated by applying organic matter in the form of top soil or compost and seeding with a diverse seed mix that includes fast establishing grass species for erosion control and a mix of desired native grass and forb species for long-term diversity. Small numbers of containerized shrubs and trees may also be installed directly on the bankfull bench surface. These treatments are described in more detail in Section 3 and Appendix A.

2.2.4 Weed Competition

Weed infestations throughout the project reach, including the Demo reach, have increased since the channel was reconstructed in 2001. A variety of invasive species are present and competition from these species may be a limiting factor for achieving revegetation objectives. Knapweed has established on most point bars, and this may limit the establishment of desired vegetation in these areas. Other invasive species, such as oxeye daisy and toadflax, are widespread and also pose the risk of limiting native vegetation establishment.

Weed competition within the Demo reach is addressed in this plan by implementing manual and chemical weed control measures, monitoring existing and future infestations, and creating conditions that support native vegetation establishment. These treatments are described in more detail in Section 3 and Appendix A.

Table 1. Summary of limiting factors identified for the Grave Creek Demo reach, existing and desired future conditions of those limiting factors and the strategies and techniques proposed to address them.

Limiting Factors	Existing Condition	Desired Future Condition	Strategies and Techniques to Address Limiting Factors
Browse pressure	Browse is limiting plant reproduction, survival and plant community succession throughout the project reach.	Mosaic of mature and young age class riparian and floodplain vegetation communities present on point bars and throughout the floodplain and riparian area. Sufficient structural diversity to protect young plants from excessive browse.	-Eliminate browse by cattle and wildlife for at least 5 years. -Long-term, active management of the riparian and floodplain area to allow desired plant communities to establish and mature.
Limited point bar plant community succession	Very little natural recruitment of desired woody vegetation is occurring on point bars.	Mosaic of young age class riparian and floodplain vegetation communities colonizing point bars and maturing as natural channel migration occurs.	-Eliminate browse by cattle and wildlife for at least 5 years. -Incorporate diverse microtopography and roughness features into point bar grading. -Create patches of diverse floodplain plant communities, through low maintenance revegetation techniques, including seeding and small numbers of large containerized plants. -Long-term, allow natural processes to function in a way that sustains a mosaic of riparian and floodplain plant communities.

Limiting Factors	Existing Condition	Desired Future Condition	Strategies and Techniques to Address Limiting Factors
Unstable slope	Currently, slope instability is limiting development of desired plant communities in the project reach and poses a risk as a sediment source to Grave Creek. Instability is apparent in the rilling, sloughing, and the lack of vegetation on the slope.	Mature riparian trees and shrubs are present on the bankfull bench below the slope. Vegetative cover on the terrace slope consists of mostly perennial native species that will stabilize the slope and limit erosion. Vegetation communities would have structural diversity and deep, binding root systems necessary to stabilize the slope and also filter any sediment that originates from the slope.	-Install coir log fascines at the toe of the slope to catch and filter sediment before it reaches the stream and to stabilize the slope toe. -Create microtopography and surface roughness on the bankfull bench below the terrace slope. -Create patches of diverse floodplain plant communities on the bankfull bench by applying organic matter, seeding and planting small numbers of large containerized plants. -Long-term, allow natural processes to function in a way that sustains a native riparian plant community.
Competition from weeds	Weedy species are well distributed throughout the project reach, with large infestations occurring on constructed point bars.	No large infestations of invasive species are present, although weeds will be present in small numbers. Mosaic of mature and young age class riparian and floodplain vegetation communities are present throughout the project are and are capable of outcompeting invasive species.	-Develop comprehensive, integrated weed management plan for Grave Creek Demonstration Phase, as well as Phase I and II. -Eliminate livestock grazing and wildlife browse for at least 5 years. -Create patches of diverse floodplain plant communities by seeding and installing small numbers of large container size plants. -Long-term, actively manage the riparian and floodplain area to allow desired plant communities to establish.

Section 3 Alternatives Analysis

Four alternatives were considered that could achieve the project purpose and objectives and set the Demo reach on a path toward achieving the desired future condition. Table 2 compares the four alternatives considered in terms of approximate costs, ecological benefit in terms of achieving project objectives, and approximate timeframe for achieving those objectives. Each alternative is described in more detail below.

3.1 Alternative 1: No action

Alternative 1 includes taking no additional actions in the Demo reach. If the no action alternative were chosen, natural processes such as scour and deposition, seed transport, plant colonization, and plant succession might still occur; but would not occur within a time frame that would protect the investment already made in restoration of the project reach. Under this alternative, browse pressure is the only limiting factor that would be addressed because treatments to address this factor have already been implemented. None of the other limiting factors described in Section 2 would be addressed.

This alternative would be the least expensive to implement; however, it is not certain if this alternative would achieve project objectives. Given time and relief from browse (provided by the electric wildlife fence), it is possible that native plant communities would establish and function in the Demo reach. However, because of the limited connectivity between the large floodplain surface near the upstream end of the Demo reach and the channel, it would be difficult for desired riparian and wetland plant species to establish. The eroding slope would continue to limit revegetation on the bankfull bench and be a source of potential fine sediment to the channel.

3.2 Alternative 2: Weed control

Alternative 2 includes the development and implementation of a long term weed management plan for the Demo reach. This alternative only directly addresses one of the limiting factors discussed in section 2.1.1 (competition from weeds); browse pressure would be addressed indirectly as noted in the Alternative 1 description. Alternative 2 includes some of the treatments included in the preferred alternative and may achieve some of the project goals over a longer timeframe. Weed control may positively influence native plant community establishment by reducing competition from weeds, but will not create other conditions (connected floodplain and microtopography) necessary to restore a functioning riparian plant community.

3.3 Alternative 3: Large scale revegetation

Alternative 3 includes implementing a large scale revegetation effort within the Demo reach by planting all areas where a riparian plant community is desired. This alternative would include many of the treatments in the preferred alternative, but would rely more heavily on nursery stock to restore the riparian plant community; as opposed to the preferred alternative, which is to create conditions so natural processes can produce a restored riparian plant community. This alternative could address all of the limiting factors and could achieve most of the project objectives, but would be more costly and potentially less effective than the preferred alternative. Planting large areas with nursery stock requires a significant initial investment including plants, labor, and other materials like brush blankets to suppress grass and forb competition. Maintenance would be an additional cost and would require regular staff resources during the first three growing seasons after installation. While planting some areas with native nursery stock is an effective revegetation strategy, it is most effective when small quantities of plants are concentrated in targeted areas that can be realistically maintained.

At some restoration sites, large scale planting is necessary because seed sources and conditions for plant establishment are not present. However, in riparian areas like Grave Creek, where natural processes are relatively intact and seed sources are present, the most cost-effective revegetation strategy is to use small amounts of plant material in places where they are needed to provide immediate functions like rooting stability or sediment filtration. The following (preferred) alternative incorporates that approach and addresses the constraints identified in Section 2.

3.4 Alternative 4: Preferred alternative

Alternative 4, the preferred alternative, includes both active and passive approaches to restoring desired riparian and floodplain plant communities within the Demo reach. This alternative was designed specifically to meet project objectives and addresses, to some extent, all of the limiting factors described in Section 2. This alternative relies primarily on natural recruitment of desired vegetation for long-term success. How the proposed treatments under this alternative relate to project objectives and the desired future condition is summarized in Table 1. The preferred alternative includes the following treatments:

- **Bioengineering** treatments, including coir log fascines to stabilize the toe of the slope and optionally in select floodplain swales (see below) where the moisture retaining properties of coir could improve the hydroperiod while naturally recruited cottonwoods and willows are becoming established.
- **Bankfull bench seeding and planting** below the slope to enhance the buffer between the slope and the channel.
- **Floodplain treatment** including construction of floodplain swales, large woody debris placement, and revegetation using small numbers of large, containerized plant material (5-10 gallon) and diverse seed mixes concentrated in constructed swale features with the most favorable growing conditions (organic matter accumulation and long hydroperiods). This will occur primarily on the left bank floodplain surface near the upstream end of the Demo reach that lacks microtopography and hydrologic connectivity with the channel.
- **Weed control** targeting areas with a high density of weeds such as point bars. A combination of manual and chemical control will be implemented. In sensitive areas, such as point bars where natural recruitment of native vegetation is occurring, weeds will be pulled by hand. Chemical weed control will be implemented in other floodplain areas where weeds are dense and few native species are present. Weed control requires a long-term commitment from project partners.

Details on treatment locations and quantities for the Demo reach are provided in Section 4.

Table 2. Comparison of alternatives considered for achieving project objectives in the Demo reach.

Alternative	Cost[1]	Ecological Benefit	Timeframe[3]
1	$0.00	If weeds are not controlled and erosion continues it is uncertain if the desired riparian and floodplain functions will develop over time. No identified limiting factors would be addressed under this alternative.	25-30 years
2	$15,000-$25,000	Narrow focus ecological benefit of reducing weed species. No guarantee that native species will replace the weed species if other revegetation actions do not occur in conjunction with the weed control effort.	25-30 years
3	$50,000	Similar ecological benefits to preferred alternative, but large quantities of planting and associated materials may limit natural recruitment and seed sources would not be as site-appropriate as naturally recruited plants. Higher maintenance costs.	5-10 years
4[2]	$30,000-$50,000	This alternative addresses all identified limiting factors and provides the following ecological benefits: -Jump start establishment of desired plant communities -Erosion control -Sediment storage -Long-term fish and wildlife habitat	5-10 years

[1]Costs are approximate and depend on actual quantities and materials used
[2]Preferred alternative
[3]The timeframe for each alternative is estimated and based on a variety of natural and other variables

Section 4 Project Implementation Plan

This section describes how the preferred alternative for the Demo reach will be implemented. To assign treatments within the reach, two floodplain surfaces were identified and labeled in Figure 15. Floodplain 1 is the upstream left bank floodplain and Floodplain 2 is the downstream right bank floodplain. Figure 15 shows the locations of proposed treatments within the Demo reach. Detailed descriptions of each treatment are provided in Appendix A. Treatment quantities by treatment area are described in Table 3.

Because floodplains are diverse, complex ecosystems characterized by highly dynamic processes and continuous change, the overall approach to project implementation is to implement treatments in phases, where each phase is dependent on how the site responds to earlier phases. For this reason, restoration of the riparian and floodplain ecosystem will require an approach that considers multiple timeframes and allows for flexible decision making that is driven by how the site responds to initial treatments. This is the approach that has been taken within the Grave Creek restoration project reaches to date and the treatments provided in this plan are based on what has been found to be effective in other project phase reaches. Original restoration strategies considered overall watershed processes of sediment supply and transport, and in response, appropriate channel form and dimensions were constructed. Revegetation treatments were implemented in response to observing a lack of natural vegetation recruitment and survival. These treatments had variable success the first year, and adjustments to treatments were made based on observing early results.

It is the intent of this project to continue this adaptive approach, where short term objectives focus on floodplain revegetation and creating conditions that support floodplain processes, such as native woody species recruitment. Longer term objectives focus on dynamic stability, defined as erosion and channel movement that occurs within natural ranges observed on alluvial river systems similar to Grave Creek.

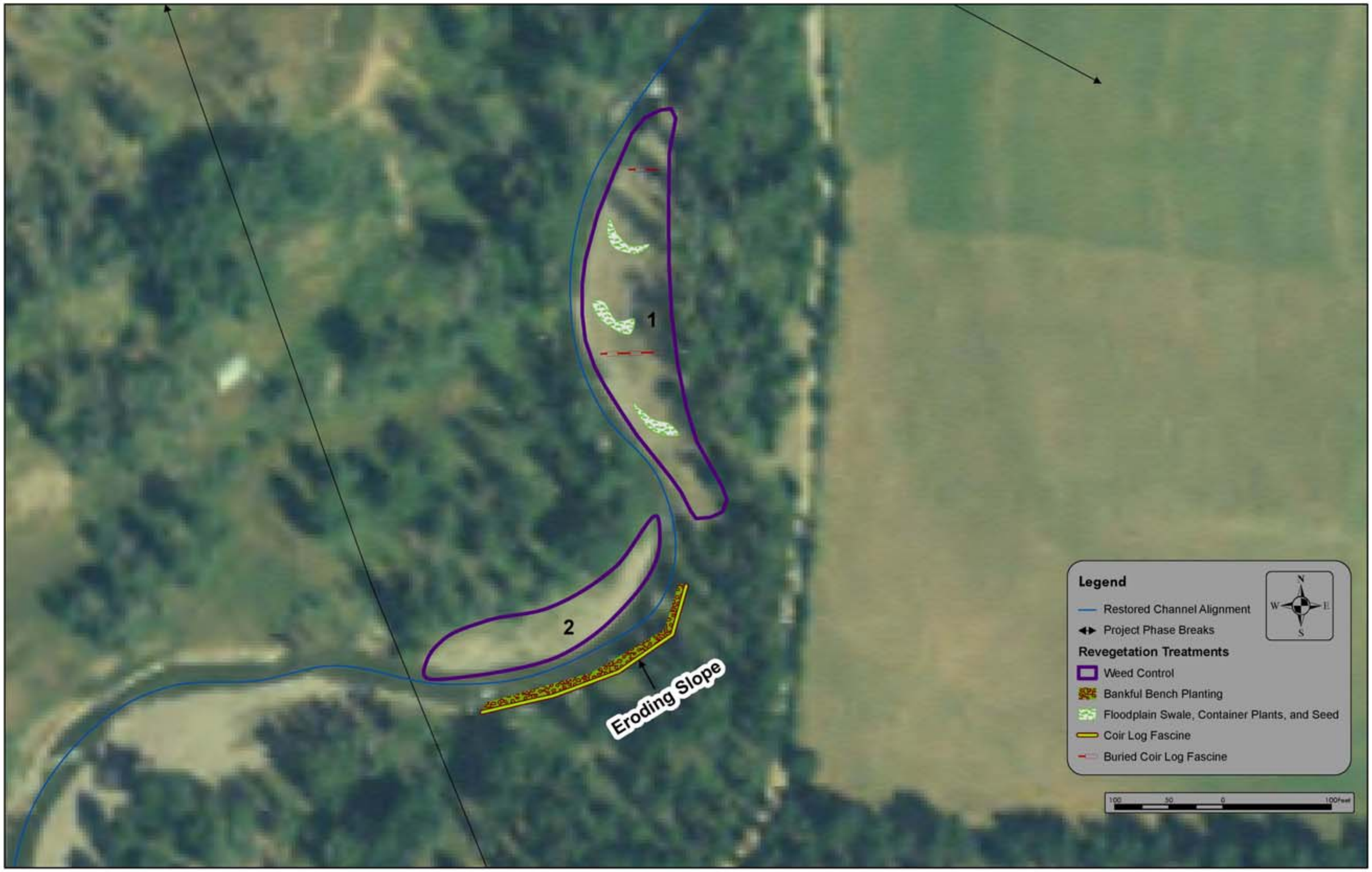

Figure 15. Locations of Grave Creek Demonstration Phase reach 2009 revegetation treatments.

Table 3. Preferred alternative treatment locations, quantities, and priority for the Demo reach.

Treatment Area	Treatment (See Appendix A for treatment descriptions)	Estimated Quantity
Floodplain surface 1	Floodplain Treatment	0.5 acre
	Weed control	0.5 acre
Floodplain surface 2	Weed control	0.2 acre
Bankfull bench and slope	Bioengineering: coir log fascine	300 ft
	Bankfull bench planting and seeding	0.15 acre

4.1 Project Phasing, Responsibilities and Funding

The treatments included in this plan represent the third phase of riparian revegetation and enhancement efforts within the Grave Creek project reach. Treatments are based on observing the effectiveness of treatments implemented in the first two phases of revegetation. These earlier phases were described in Section 2.

The *Grave Creek Riparian Revegetation and Monitoring Plan* describes how effectiveness monitoring data can be used to make decisions about future project phases. Additional monitoring data collected during 2009 will be considered as part of refining the Demonstration reach project design. While using techniques that have proven effective during earlier phases will result in a high likelihood of achieving project objectives, it is still likely that additional restoration work will be necessary after 2009. A long-term commitment by the land owner and KRN to maintain the project and monitor progress within the reach will be necessary to achieve project objectives.

In general, the following tasks are necessary to implement this riparian revegetation plan:

- Coordination and project permitting, including procurement for final design and implementation.
- Collect additional supporting data and refine recommended treatments and treatment quantities included in the preferred alternative. This includes developing final cost estimates.
- Project logistics, including procuring materials and retaining contractors.
- Implement riparian and floodplain restoration strategies and techniques using a phased approach.
- Monitor effectiveness of treatments and incorporate data into refining additional phases of treatments. By integrating monitoring into the implementation of the project and long-term management of the reach the chances of achieving the desired future condition will increase.

The treatments described in Table 3 would be implemented over a one year period. The project also includes continued monitoring of site response to restoration and revegetation treatments. Monitoring methods have been described in a previous document, *Grave Creek Riparian Revegetation and Monitoring Plan* (Geum

Environmental Consulting 2008a). Table 4 lists the specific tasks and estimated level of effort associated with implementing the project phases.

The entire Grave Creek project reach is located on private land owned by a single landowner. Access to work on the property has been granted by the landowner. There are various routes available to access the proposed treatment sites. Specific access routes used during project implementation will be coordinated with the landowner based on land management activities that may be occurring when the project is implemented, such as grazing or haying.

Table 4. Demo reach revegetation project phases, tasks, responsibilities and approximate hours to complete the project.

Task	Responsibility	Approximate Hours[1]
Demo Reach Revegetation Phase 1		
Coordination and project permitting	Kootenai River Network and partners	20
2009 Data collection and final design including final cost estimates	Contracted service	80
2009 Project logistics	Contracted service	40
2009 Project implementation tasks: Oversight Implementation (revegetation crew) Implementation (equipment contractor)	Contracted services	 40 150 30
Demo Reach Revegetation Phase 2		
2010 Monitoring (July)	Kootenai River Network and partners or contracted service	16-24
2010 Treatment refinement	Kootenai River Network and partners or contracted service	24-48
2010 Treatment implementation	Depends on results of project monitoring	40-80

[1]Hours are approximate and actual hours will be based on final design, responsibilities and other factors.

4.2 Permits and Regulatory Approvals

There are no permits, regulatory approvals, or easements anticipated to be needed to complete the project.

4.3 Project Monitoring

Effectiveness monitoring from previously implemented Grave Creek revegetation project phases, including the Demo reach, influenced the revegetation recommendations contained within this plan. The soil lifts constructed in 2006 in the Demo reach were monitored for effectiveness in August, 2008. Monitoring methods and results for Phase One and Two project reaches are described in two separate documents, the *Grave Creek Riparian Revegetation and Monitoring Plan* (Geum Environmental Consulting 2008a) and the *Grave Creek Riparian Revegetation As-Built and Monitoring Report* (Geum Environmental Consulting, 2008b). The methods included in these documents were also used to monitor the soil lifts in the Demo reach. Results of summer 2008 effectiveness monitoring for vegetated soil lifts within the Demonstration reach are summarized in Appendix C.

The results of the 2008 effectiveness monitoring in the Demo reach indicated that soil lifts were very effective at establishing woody vegetation immediately along the bank in front of the eroding slope. Because the immediate streambank appears stable, recommendations for revegetation treatments of the slope toe and bankfull bench are included in this plan.

The treatments included in this plan are also based on the results of effectiveness monitoring completed for treatments implemented in the Phase One and Phase Two project reaches. For example, monitoring data have shown that floodplain swales constructed in the Phase One and Phase Two project reaches create conditions that recruit cottonwood seedlings and support woody vegetation establishment by providing moisture, shade, and accumulating organic matter.

Effectiveness monitoring of the treatments included in this revegetation plan should be incorporated into the overall project adaptive management.

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Section 5 Project Schedule

Table 5 provides an overview of the proposed project schedule for the Demo reach revegetation project.

Table 5. Grave Creek Demo reach riparian revegetation implementation, monitoring and maintenance schedule.

Grave Creek Demo Reach Revegetation Project Schedule					
	2008	**2009**[2]			**2010**[2]
Project Task	W	Sp	Su	F	Su
Permitting and other coordination					
Final design of 2009 treatments incorporating results from previous monitoring					
Coordination and logistics for 2009 treatments					
Implement 2009 treatments[3]					
Monitor 2009 treatments and continue monitoring of earlier project revegetation phases[1]					

[1] Recommended monitoring is described in the *Grave Creek Riparian Revegetation and Monitoring Plan* (Geum Environmental Consulting Inc. 2008).
[2] Actual schedule will depend on project funding.

Section 6 Supporting Technical Documentation

Supporting technical documentation for the project can be found in the following reports and assessments:

- *Grave Creek Watershed Water Quality and Habitat Restoration Plan and Sediment Total Maximum Daily Loads* (DEQ 2005).
- *Conceptual Designs for Stabilization of Grave Creek near Eureka, Montana (*Water Consulting, Inc. 2000*).*
- *Grave Creek Phase One Restoration Project Assessment and Final Design Report (*Water Consulting, Inc. 2002*).*
- *Grave Creek Phase Two Final Design Report (*River Design Group, Inc. 2004*).*

The TMDL document summarizes numerous data sources for the Grave Creek watershed and provides information on many of the natural features of the project area, in addition to identifying the need for riparian restoration and enhancement.

Figures 1 and 2 (above) show overviews of the project area. Summary information on some of the natural features of the project area is provided below.

6.1 Natural Features

6.1.1 Soils

As reported in DEQ 2005, the Kootenai National Forest has characterized soils in the Grave Creek watershed by Land Type Associations (LTAs), which are a composite classification of landform, vegetation, habitat type, geology and soils. The primary LTA in the project reach is the Andic Dystrochrepts (103) or Alluvial terraces. These soils are characterized by gravelly silt loam in the upper surface layer, and gravelly very fine sandy loam in the lower 13 inches of the soil profile. In many areas, soils are generally loamy with moderate to high quantities of boulders, cobbles, and gravels. Deeper soils are typically present in valley bottoms where alluvial sediment and nutrient accumulation and higher biomass production and moisture results in greater rates of decomposition.

6.1.2 Vegetation

Vegetation in the project reach is described in Section 2.1. Additional information on vegetation in the watershed can be found in the DEQ TMDL document (2005). This document reports the results of a survey of the watershed completed in 1999 by the Kootenai National Forest, which used a forest and plant type association approach. Table 6 lists the forest associations included in the DEQ 2005 document that are present in the project reach. Other plant community types and successional stages are described in section 2.1.

Table 6. Summary of plant associations and Major Forest Type Associations of the Grave Creek watershed that occur in the project reach.

Forest Type (Association)	Major Trees	Major Natural Disturbance	Comments
Aspen sites	Quaking aspen	Fire	Rare, but located in small areas adjacent to the channel within the project reach
Agricultural land (hay, meadows, pasture)	N/A	N/A	All areas adjacent to the project reach are this cover type
Subalpine fir—Spruce/Menziesia	Supalpine fir, Engelmann spruce	Insect and disease, windthrow, fire	A riparian form of this community is the likely potential natural community in the project reach

The DEQ TMDL document (2005) describes how vegetation communities in the Grave Creek watershed have changed in response to natural and human-caused disturbances; in particular those associated with a variety of land uses, including agriculture, grazing and timber harvest. This document reports that the existing lower watershed riparian community is functioning below its historical potential, mainly due to disturbances associated with past and current land uses and the colonization of invasive species on stream banks and the adjacent floodplain.

6.1.3 Hydrology

As described in the DEQ TMDL document (2005), the Grave Creek watershed is approximately 74.2 square miles, with elevations ranging from 2,700 feet to 7,500 feet at the watershed divide. Mean annual precipitation is estimated to be over 63 inches at the highest elevations and approximately 23 inches at the confluence. Basin average annual precipitation is estimated to be 47.9 inches with the majority of the precipitation occurring as snow, which melts between April and June on most years. The hydrology of Grave Creek is characterized by snow melt runoff with peak stream flows occurring in May and June and low flows occurring from November through March. Flows occasionally peak during mid-winter rain-on–snow events, which can produce floods of significant magnitude in the Grave Creek watershed. Significant rain-on-snow events occurred in November 2005 and November 2006 in Grave Creek.

Table 7 is reproduced from DEQ 2005, and summarizes select bankfull and flood discharges for the Grave Creek watershed.

Table 7. Selected bankfull and flood discharges for Grave Creek (DEQ 2005).

Return period (years)	Discharge (cfs)
QBankfull	640-680
Q2	768
Q10	1,368
Q25	1,605
Q50	1,862
Q100	2,047

In addition to surface water, groundwater in lower Grave Creek is influenced by glacial outwash and alluvium deposits. These deposits create landforms in the lower Grave Creek watershed, which are capable of absorbing and releasing relatively large volumes of water per unit area. Groundwater exchanges in the lower reaches create gaining, losing, flow-through and parallel-flow reaches (DEQ 2005). Groundwater and surface water interaction also creates hyporheic zones, areas in which groundwater and stream water mix at the channel bed scale.

6.2 Applicable Statutes, Rules, Regulations and Standards

There are no applicable statutes, rules, regulations or standards associated with the project. Measures in the TMDL developed for the watershed are voluntary.

Section 7 References

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List of Appendices

Appendix A: Revegetation Treatment Descriptions

Bioengineering Treatments

Bioengineering treatments are used to encourage woody vegetation establishment in high priority areas, such as on newly established or constructed point bars. In some areas where bioengineering treatments are proposed, the targeted function is to catch and filter sediments.

***Coir log fascines**:* This technique includes placement of coir logs, combined with dormant willow cuttings in areas where it is difficult to establish vegetation. The purpose of this treatment is to establish woody vegetation along the toe of the eroding slope. Both the coir log and the vegetation that establishes will catch and filter sediment eroding from the slope. Coir logs consist of high density coir (coconut fiber) bales wrapped in a natural fiber netting. Coir is used for bioengineering because it stores water for long periods, and its durable fibers trap sediment and mimic soil matrices formed by living roots. Coir fibers biodegrade over approximately five to seven years, thus providing a short-term stable growing medium while native riparian plants establish. This treatment is proposed for one site in the project reach, along the toe of the eroding slope. The coir log fascine should filter sediment eroding from the slope and promote woody vegetation to establish and stabilize the toe of the slope over the long-term. Figure A-1 shows an example of this treatment used under similar conditions as proposed in this plan.

Figure A-1. Photograph of coir logs immediately after installation along the toe of an eroding slope and eight months after installation (inset). Plant material was not incorporated into the coir logs at this project site.

Buried Coir Log Fascines: This treatment consists of digging a narrow trench (approximately 2-4 feet wide and 1-4 feet deep) and installing coir and plant materials within the trench. The target depth for the trench is to intercept shallow groundwater, therefore, trench depths will vary. Dormant willow or cottonwood cuttings are placed vertically inside the trench along either one or both sides at a spacing of approximately 5 per foot. Medium density coir logs are then placed in the trench bottom near the base of the willow cuttings to retain moisture in the rooting zone (Figures A-2 and A-3). Coir logs may or may not require anchoring based on the trench depth (i.e. shallower trenches may require anchoring coir logs with stakes or duck-billed earth anchors). The trench is backfilled with enough fill so the coir log is buried completely and approximately ¾ of the willow cutting lengths are in contact with soil. Depending on the results of final design, this treatment may be used on Floodplain surface 1 to promote establishment of cottonwoods and willows by retaining moisture longer into the growing season.

Figure A-2. Photograph of buried coir log fascine floodplain treatment during construction.

Figure A-3. Photograph of buried coir log fascine floodplain treatment immediately after construction.

Bankfull Bench Planting and Seeding

This treatment includes adding organic matter, planting containerized shrubs and trees and seeding on the bankfull bench behind soil lifts installed in 2006 to create diverse riparian shrub communities and promote long term stability of this site. These benches have a reduced risk of erosion due to the presence of bioengineering and other bank stabilization structures. Because the bankfull bench was constructed with cobble substrate, organic matter in the form of topsoil or compost should be spread over the planting and seeding areas of the bench to provide more favorable growing media for the container plants and seed. In addition, compost can also be added to planting holes when large cobbles are the dominant substrate. Table A-1 provides a recommended species list for containerized shrub species to be used on the bankfull bench and in floodplain swales (see Floodplain Treatment). Tables A-2 and A-3 provide seed mixes to be used on the bankfull bench.

Table A-1. Recommended plant species mix for Grave Creek Demo reach bankfull bench and floodplain swale planting sites.

Genus	Species	Common Name	Size	Percent of Mix
Alnus	*incana*	Mountain alder	5 -10 gallon	25
Cornus	*stolonifera*	Red-osier dogwood	5 -10 gallon	25
Populus	*trichocarpa*	Black cottonwood	5-10 gallon	15
Salix	*drummondiana*	Drummond's willow	10x10x36 cm	20
Salix	*exigua*	Sandbar willow	10x10x36 cm	15

Table A-2. Recommended seed mix for construction disturbance and dry floodplain areas.

Genus	Species	Common Name
Gramminoids		
Agropyron	*riparium*	Streambank wheatgrass
Elymus	*trachycaulus*	Slender wheatgrass
Forbs		
Achillea	*millefolium*	Common yarrow
Epilobium	*angustifolium*	Fireweed

Floodplain Treatment

The floodplain treatment consists of constructing swales, placing large woody debris, and floodplain revegetation. Vegetation establishment on floodplain surfaces is necessary to create long-term stability within the reach, reduce the risk of accelerated erosion and provide habitat. Only small portions of the total point bar area needs to support woody plant communities to provide overall floodplain stability and function. This will ensure that as the channel continues to adjust and migrate in a downstream direction, there are vegetated islands within the point bar to provide stable points and colonize areas as they transition from newly deposited, pioneer bars to established floodplain areas. As this vegetation matures, it will transition to cottonwood or conifer dominated riparian areas that will provide long-term large woody debris inputs to the stream system. Two treatments are included to stimulate plant community development on floodplain surfaces: seeding and large containerized shrubs. Floodplain swales and large woody debris will create diverse microtopography which will provide a variety of niches for native woody vegetation by creating surfaces of varying depth and thus varying proximity to groundwater. Floodplain treatment will occur on Floodplain surface 1.

Constructed Swales*:* This treatment includes constructing depressions perpendicular to the channel, which minimizes the risk of depressions capturing and transporting flood waters (Figure A-4). Swales should be excavated to a depth of one to three feet depending on the surface elevation relative to channel features and swales should be approximately 10 feet wide and 20 feet long. A minimum buffer of 20 feet will be left between the edge of the channel and excavated swales. Material excavated for swale construction can be spread throughout the area to further enhance microtopography. Large woody debris will be placed within created swales, and/or partially buried adjacent to these swales to provide additional shade, create microsites, retain moisture and stimulate biological development within the soil. Adding roughness to floodplain surfaces will increase the ability of these surfaces to trap cottonwood and willow seed that naturally colonize exposed alluvial material.

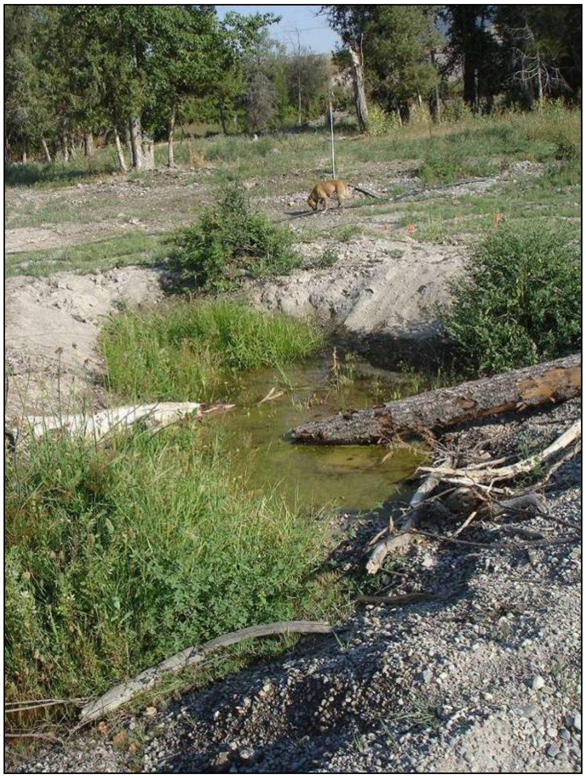

Figure A-4. Photograph of constructed floodplain swale five months after construction.

Large Woody Debris*:* This treatment includes placing larger diameter wood (10 inches or greater) on the floodplain surface. Larger pieces of wood increase surface roughness on bare floodplain surfaces which results in differential flow resistance that can cause scour during floods. This scour further increases topographic diversity and microsites where plants can become established. Like constructed swales, these scour areas will contribute to organic matter retention in the system. Larger diameter wood can be gathered and placed using an excavator, while smaller debris can be placed by hand. Smaller diameter woody debris can be placed in piles on uniform floodplain surfaces to trap sediments and entrain materials carried by flood waters. This treatment will be implemented to the extent that large woody debris is available.

Swale Seeding: This treatment consists of broadcast seeding in constructed swales that have conditions favorable for seedling development (Figure A-5). This treatment will accelerate the natural process of vegetation development in swales. Table A-3 provides the recommended floodplain swale seed mix for the reach.

Figure A-5. Photograph of constructed swale with conditions, such as late season moisture retention and large woody debris creating microsites, appropriate for supporting woody vegetation establishment.

Table A-3. Recommended seed mix for Grave Creek Demo reach floodplain swale seeding.

Genus	Species	Common Name
Shrubs and Trees		
Alnus	*incana*	Mountain alder
Betula	*occidentalis*	Water birch
Prunus	*virginiana*	Sandbar willow
Graminoids		
Agropyron	*riparium*	Streambank wheatgrass
Carex	*utriculata*	Beaked sedge
Carex	*stipata*	Sawbeak sedge
Deschampsia	*cespitosa*	Tufted hairgrass
Elymus	*trachycaulus*	Slender wheatgrass
Juncus	*balticus*	Baltic rush
Juncus	*ensifolius*	Dagger leaf rush
Glyceria	*grandis*	American mannagrass
Poa	*palustris*	Fowl bluegrass
Forbs		
Achillea	*millefolium*	Common yarrow
Epilobium	*angustifolium*	Fireweed

Large Containerized Plant Material: This treatment consists of installing small numbers of shrubs grown in 5-10 gallon containers. This sized plant material will have a well developed root system and large diameter stems better able to withstand browse pressure and provide immediate root stability to the site (Figure A-6). This treatment will be concentrated in the swales and behind the vegetated soil lifts below the terrace slope. Willow, cottonwood, and alder are the desired species for use in these areas; however, exact species will depend on plant availability. Table A-1 provides a suitable mix of species for Floodplain 1.

Figure A- 6. Photograph of large containerized plant material with well developed root system and large diameter stems.

Slope Stabilization

No treatments are proposed to directly treat the eroding slope face. A coir log fascine will be constructed at the toe of the terrace slope to act as a filter that catches sediment and seed. This treatment is described above under the Bioengineering section.

Weed Control

Weed control includes the development and implementation of a weed control program. This program should include all project phase reaches. Exact timing and weed removal methods will depend on the targeted species. For example, in sensitive areas, such as point bars where cottonwood seedlings are establishing, weed removal should be done by hand pulling. In other areas, such as floodplain terraces with high densities of weeds, herbicide application may be more effective and appropriate. Figure A-7 provides an example of hand removal of weeds in a sensitive floodplain area in the Phase Two project reach where cottonwood seedlings are present. Because the Demo Reach includes relatively small areas of infestation, hand pulling or digging of rosettes in the early spring is recommended.

Figure A-7. Photograph s showing a knapweed infested point bar and hand removal of knapweed from around cottonwood seedlings (inset).

Appendix B: Past Revegetation Treatments

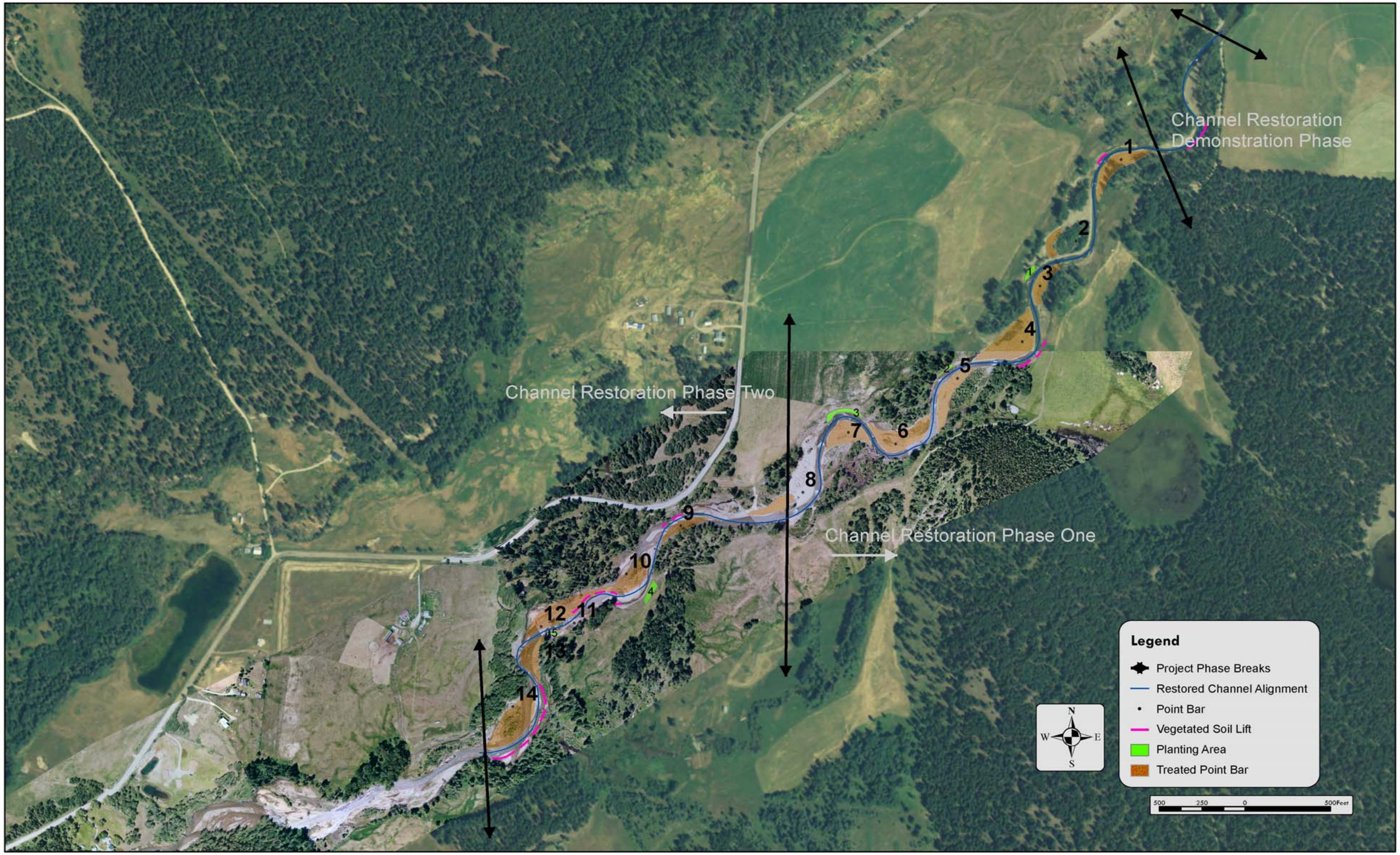

Figure B- 1. Locations of revegetation treatments in the Grave Creek project reaches implemented between Fall 2005 and Winter 2006.

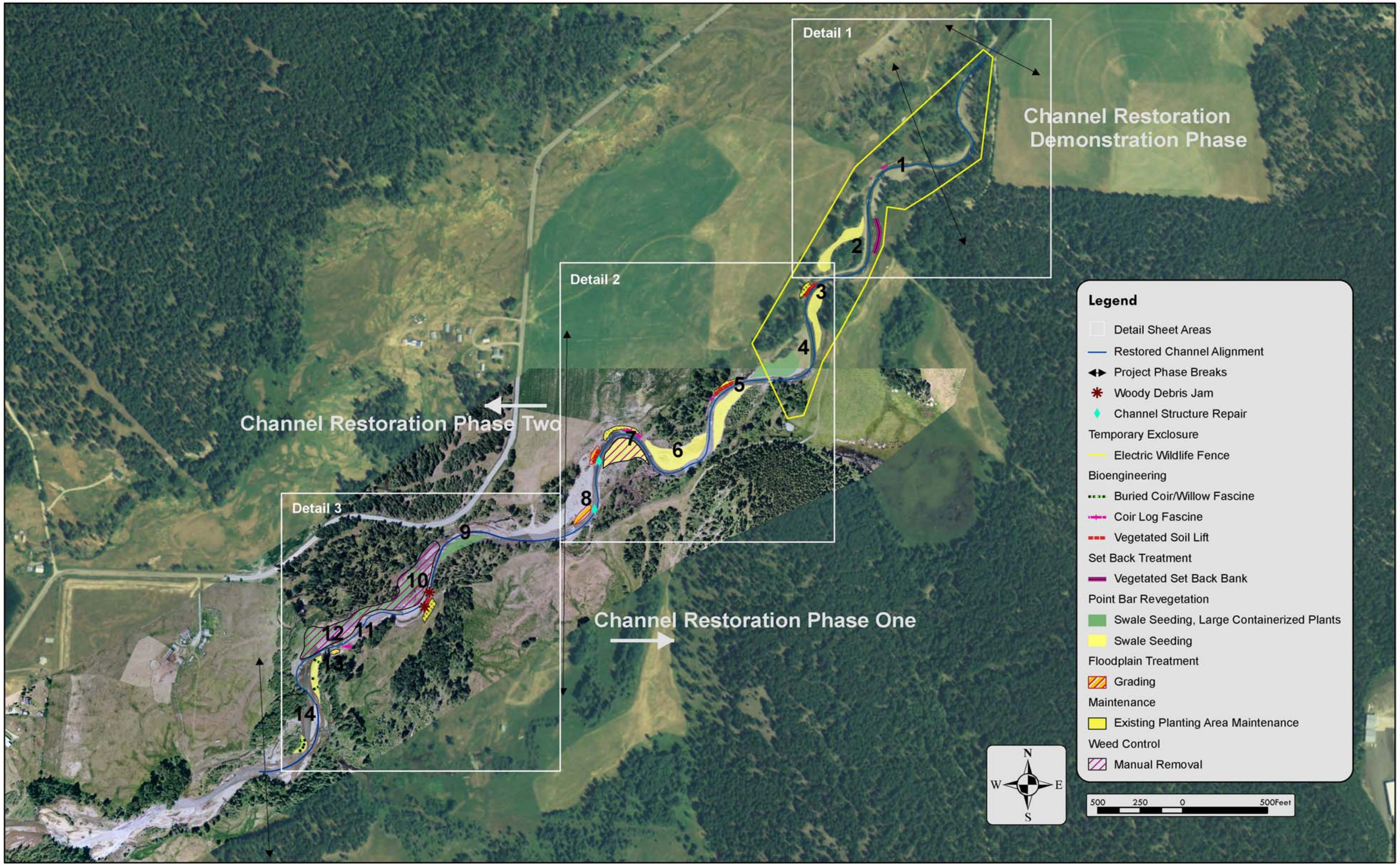

Figure B- 2. Locations of revegetation treatments in the Grave Creek Project reaches implemented during October 2008.

Appendix C: 2008 Demonstration Reach Monitoring Data

Table C- 1. Monitoring data collected for Demonstration reach vegetated soil lift during summer 2008 monitoring.

			Distance (feet)									
Soil lift ID	**Layer**	**Metric[1]**	**0-5**	**5-10**	**10-15**	**15-20**	**20-15**	**25-30**	**30-35**	**35-40**	**40-45**	**45-50**
Demo reach SL-2	1	Rips/tears (inches)	0	0	0	0	0	0	0	0	0	0
		Percent toe scour	0	0	0	0	0	0	0	0	0	0
		Percent cover willow	50	80	60	70	80	90	50	100	80	50
		Percent cover seeded species	10	5	1	1	1	1	1	1	1	5
		Percent cover other herbaceous species	1	5	1	1	1	1	1	1	1	5
		Percent cover weeds	0	0.5	0	0	1	1	1	1	1	5
		Number alive stems planted (container plants)	0	2	1	1	1	1	2	1	1	2
		Number dead stems	0	0	0	0	0	2	0	0	0	0
		Percent browsed	50	50	10	80	100	50	20	50	100	90
		Average shoot height (inches)	18	24	24	24	24	24	18	18	12	12
Demo reach SL-2	2	Rips/tears (inches)	0	0	0	0	0	0	0	0	0	0
		Percent toe scour	0	0	0	0	0	0	0	0	0	0
		Percent cover willow	40	30	50	30	40	10	20	30	20	70

			Distance (feet)									
Soil lift ID	**Layer**	**Metric[1]**	**0-5**	**5-10**	**10-15**	**15-20**	**20-15**	**25-30**	**30-35**	**35-40**	**40-45**	**45-50**
		Percent cover seeded species	30	20	10	10	10	20	10	10	10	10
		Percent cover other herbaceous species	20	40	35	40	20	20	40	50	50	10
		Percent cover weeds	1	5	5	5	5	1	5	5	5	10
		Number alive stems planted (container plants)	0	1	0	1	1	1	0	1	1	0
		Number dead stems	0	0	0	1	1	0	1	0	0	0
		Percent browsed	100	100	100	100	100	100	100	100	100	100
		Average shoot height (inches)	24	18	18	18	12	12	12	12	6	6

[1] Methods for monitoring metrics are described in: Geum Environmental Consulting, Inc, (2008a).